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Prefacio

Una cosa es hablar de ergonomía y otra muy distinta es entender de ergonomía, una palabra que enmarca bienestar, confort, productividad y en fin resultados. En otro artículo diseñado para una universidad colombiana había escrito que considero a la ergonomía como *"una necesidad absoluta de implementar dentro del contexto del desarrollo de los seres humanos, no solo en el ámbito laboral, sino en todas las actividades en las que tenga que ver una persona"*. Al ser una necesidad absoluta entonces siempre va a ser necesario aprender de ella un poco más, conocerla y sobre todo investigarla.

En esta obra se consideran varios temas relacionados con la identificación, evaluación, intervención y puesta en marcha de programas ergonómicos empresariales e institucionales en los cuales siempre estará presente el ser humano, desde el punto de vista integral, es decir en cuerpo y alma; de tal manera que se convierta en un ente productivo, sano y seguro.

La SEMAC cada año edita un libro de este tipo y lo indexa, el objetivo fundamental de esta gran labor es resaltar la importancia de la investigación en ergonomía y que no quede solo en una exposición, sino que permanezca abierto al conocimiento de estudiantes, consultores y toda aquella persona que quiera aprender sobre la aplicación de la ergonomía, es decir esté al alcance de toda persona de manera gratuita.

Los temas de esta edición son novedosos, interesantes y sobre todo dignos de considerarlos para futuras investigaciones en otros campos sin dejar de lado que gran falta nos hace a nuestras sociedades la investigación, su aplicabilidad y en muchos de los casos la normatividad deficiente en muchos países de Latinoamérica con respecto a otras regiones del mundo.

SEMAC le dio, una vez más, la importancia a estas obras y a sus autores, (profesores, investigadores, consultores, prevencionistas y estudiantes) quienes fueron escogidos por la Comisión Académica del Congreso la cual estuvo conformada por un grupo selecto de investigadores de México, Nicaragua, Honduras, Guatemala, Costa Rica, República Dominicana, Colombia, Ecuador, Perú, Bolivia, Uruguay, Chile, Argentina y Brasil.

En cuanto a los autores de los artículos cabe señalar que no son invitados especiales ni exclusivos, por el contrario son investigadores apasionados de la ergonomía que han presentado trabajos libres los cuales han sido aplicados en sus lugares de trabajo o estudio, los organizadores del evento han decidido abrir las puertas a todos los estudiosos de la Ergonomía siempre y cuando tengan como mensaje fundamental el dar a conocer que en América latina se hace investigación de la ergonomía con altos estándares.

La idea fundamental de este trabajo es difundir los avances en el tema de Ergonomía en Latinoamérica y sobre todo formar y formalizar la academia en la ergonomía, generando espacios en los que el lector se ubique dentro del universo de la investigación.

Al considerar a la ergonomía como multidisciplinaria, estamos hablando que se deben integrar varios aspectos, es así como tenemos trabajos relacionados con sectores: Industriales, agrícolas, de salud, construccion, pesca

Dialogando con algunos autores de los artículos me han manifestado que el proceso investigativo les ha llevado desde dos años hasta seis meses de constante sacrificio para sacar a la luz trabajos fiables que aporten nuevos conocimientos y aplicaciones creativas.

Esta obra pretende mostrar mediante los procesos investigativos, la gestión de la ergonomía con enfoques no solo físicos sino mentales y sociales que influyen dentro del bienestar de los miembros de las empresas y organizaciones

Iván López E.
Responsable Comisión Académica ULAERGO

CONTENT

DESIGN

ENVIRONMENTAL CONDITIONS

FATIGUE

INDUSTRIAL ERGONOMICS

INTERDISCIPLINARY STUDIES

MANUAL MATERIAL HANDLING

WORK DESIGN AND ANALYSIS

WORK EVALUATION

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DIFFERENCES IN ANTHROPOMETRIC INDICATORS OF BODY COMPOSITION BY AGE AND GENDER IN A SAMPLE OF THE CAMPECHE POPULATION

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Resumen Los trastornos musculoesqueléticos (TME) representan un problema de salud a nivel mundial, siendo la principal causa de incapacidad en el ámbito laboral. Los movimientos realizados por los trabajadores y la carga biomecánica aplicada durante la realización de las tareas, el diseño de las herramientas, así como el diseño y la distribución del espacio de trabajo, son elementos importantes a considerar para adaptar las tareas a las diferentes capacidades que presentan los trabajadores que las realizan. La relación entre las dimensiones corporales y muchos de estos espacios y objetos generalmente no se ajustan a las necesidades antropométricas. Una problemática en México es la falta de perfiles antropométricos que permitan diseñar espacios adecuados. El presente estudio, forma parte de una investigación en curso, que en su primera fase implica la caracterización de la población económicamente activa del norte del estado de Campeche. El objetivo de este estudio es determinar si las diferencias en los indicadores antropométricos de composición corporal que se presentan por género y edad, de una muestra de la población económicamente activa del norte de Campeche, son significativas. Se realizó un estudio transversal sobre una muestra estratificada de 380 sujetos (275 hombres y 105 mujeres) de 15 a 65 años en el estado de Campeche. Utilizando la ANOVA y la prueba Tukey post hoc se identificaron varios subconjuntos homogéneos entre los grupos de edades de cada una de las variables estudiadas, en donde las diferencias de las medias no fueron significativas. Se concluyó que no había diferencias significativas para la estatura entre los grupos de mujeres de 15 a 29 años y de hombres de 60 a 65 años; para el peso, entre los grupos de hombres y mujeres de 15 a 19 años y de 60 a 65 años; para el porcentaje de grasa corporal, entre los grupos de hombres y mujeres de 15 a 29 años tenían los menores porcentajes de grasa, mientras que los grupos de mujeres de 30 a 65 años tenían los mayores porcentajes de grasa corporal, mostrando una diferencia significativa. Por su parte, los grupos de hombres de 30 a 59 años tenían porcentajes de grasa corporal similares. Al comparar el porcentaje de masa muscular entre los grupos de edad y de género, las mujeres de mayor edad (30-59 años) presentaban un menor porcentaje de masa muscular en comparación con los hombres más jóvenes (15-29 años). Sin embargo, los grupos de mujeres de 15-29 años y de hombres de 30-49 y 60-65 años no presentaron diferencias significativas entre sí.

Palabras clave: Indicadores antropométricos, Diferencias de género, diferencias de edad

Relevancia para la ergonomía: La aportación es mostrar las diferencias de género y edad que se presentan en la población de Campeche, para contar con información objetiva que permita realizar el diseño de puestos de trabajo, herramientas, maquinaria y equipos que se adapten a las características, tanto de hombres como mujeres.

Abstract: Musculoskeletal disorders (MSDs) represent a worldwide health problem, being the main cause of disability in the workplace. The movements performed by workers and the biomechanical load applied during the performance of tasks, the design of tools, as well as the design and distribution of the work space, are important elements to consider in order to adapt tasks to the different capabilities of the workers who perform them. The relationship between body dimensions and many of these spaces and objects generally do not adjust to anthropometric needs. One problem in Mexico is the lack of anthropometric profiles that allow the design of adequate spaces. The present study is part of an ongoing research, which in its first phase involves the characterization of the economically active population of the northern part of the state of Campeche. The objective of this study is to determine if the differences in the anthropometric indicators of body composition presented by gender and age of a sample of the economically active population of northern Campeche are significant. A cross-sectional study was conducted on a stratified sample of 380 subjects (275 men and 105 women) aged 15 to 65 years in the state of Campeche. Using ANOVA and the post-hoc Tukey test, several homogeneous subsets were identified among the age groups for each of the variables studied, where the differences in the means were not significant. It was concluded that there were no significant differences for height between the groups of women 15-29 years and men 60-65 years; for weight, between the groups of men and women aged 15-19 years and 60-65 years; for the percentage of body fat, between the groups of men and women aged 15-29 years had the lowest percentages of fat, while the groups of women aged 30-65 years had the highest percentages of body fat, showing a significant difference. Meanwhile, the groups of men aged 30-59 years had similar body fat percentages. When comparing the percentage of muscle mass between age and gender groups, older women (30-59 years) presented a lower percentage of muscle mass compared to younger men (15-29 years). However, the groups of women aged 15-29 years and men aged 30-49 and 60-65 years did not present significant differences between them.

Keywords. Anthropometric indicators, Gender differences, Age differences

Relevance to Ergonomics: The contribution is to present the gender and age differences present in the population of Campeche, in order to have objective information that allows the workplace design, tools, machinery and equipment that are adapted to both men and women characteristics.

1. INTRODUCTION

Anthropometry is considered a fundamental discipline in the workplace, in relation to safety and ergonomics (Barahona-Casa & Cabezas-Heredia, 2021; Valero Caballero, 2015). Anthropometric measurements serve as a basis, for the evaluation and ergonomic design of workstations, tools, machinery and personal protective equipment, resulting in safer and more user-friendly work environments (Del Prado-Lu, 2007). The movements performed by workers and the biomechanical load applied during the performance of tasks, the design of tools, as well as the design and distribution of the workspace, are important elements to consider in order to adapt tasks to the different capabilities of the workers performing them (Mistarihi, 2020).When these elements are not taken into consideration, musculoskeletal disorders (MSDs) occur, causing absenteeism, decreased productivity, modification in the quality of life, (Agila-Palacios et al., 2014), and in some cases temporary or permanent disabilities (Gómez Ramos et al., 2018).

Also, there are studies proving that body composition indicators that exceed standardized limits, have a significant association with the prevalence of MSDs in both men and women (S. K. Das & Suman, 2016; Vega-Fernández et al., 2021). According to WHO (2021), MSDs represent the most frequent cause of disability in 160 countries, Mexico included, and where cases of work-related MSDs, reported from 2011 to 2020, have increased every year, causing disabilities associated with these and are expected to continue to increase in the coming decades(Instituto Mexicano del Seguro Social, 2020).

The main causes that lead to the appearance of MSDs are those tasks in which certain postures must be maintained for a certain time, maintaining static efforts and that do not offer possibilities of postural variation (Bao et al., 2020; B. Das, 2019; Hossain et al., 2018). Likewise, those activities that require movements outside the angles of comfort or the lifting and manipulation of loads or repetitive movements; or surfaces that do not offer a stable surface or that are subject to vibrations (Ordóñez-Hernández et al., 2021). The relationship between body dimensions and many of these spaces and objects generally do not match anthropometric needs (López et al., 2019). A fundamental ergonomic principle that should always be kept in mind when designing workspaces and activities, is the adequacy to the capabilities and limitations of the users, and not the other way around.

Anthropometry has been widely used to design safe and sustainable products and workplaces. However, it is common for designers to need direct guidelines and dimensions, which are often lacking, for specific design situations (Castellucci et al., 2020). Anthropometric data are often presented in tables summarizing percentile values, separated by gender, for a specific population, making it difficult for designers to generate applications for mixed populations, such as industrial settings.(Viviani et al., 2018) In one of its classic fields of research and application, studies have been conducted aimed at obtaining anthropometric data whose use contributes to the increase in efficiency, safety and comfort, in human activities (Avila-Chaurand et al., 2007).

To create an optimal workplace for the task and the person, the anthropometric characteristics of the human being need to be taken into account in the design process as proven in several studies (İşeri & Arslan, 2009). The main purpose of knowing the characteristics of body composition and anthropometric dimensions of the population that will use a facility, is that most users can use the spaces, machines and tools without difficulty, avoiding that they adopt inadequate positions or make efforts or movements that, in the long term could cause some injury or musculoskeletal disorder (S. K. Das & Suman, 2016; Vega-Fernández et al., 2021). Ideally, one would like 90% or 95% of users to be able to use a facility or equipment without any problem, considering then that one has a virtually universal design or that one has universal operability (Avila-Chaurand et al., 2007).

2. OBJECTIVES

To determine the significant differences in anthropometric indicators of body composition by gender and age of a sample of the economically active population of northern Campeche.

3. METHOLOGY

This chapter is part of an ongoing research for the design of a predictive model of anthropometric changes in the population and a correlational model of grip strength and manual twisting of the economically active population of the state of Campeche.

The first phase involves the anthropometric characterization of the population. Here we present an analysis of the gender and age differences found in the anthropometric indicators of body composition, analyzing height, weight, percentage of body fat, percentage of muscle mass and bone density.

3.1 Study design and participants

This is a cross-sectional study conducted on a stratified sample of 380 subjects (275 men and 105 women) aged 15 to 65 years in the state of Campeche. The sample was randomly selected by convenience.

The inclusion criteria for the present investigation were that the individual participant was biologically male or female, was in the age range of 15 to 65 years and was a second-generation resident of the state of Campeche. Participants were informed about the purpose of the study, were given a verbal description of the procedure, and were asked to sign a letter of informed consent to participate in the study. Subsequently, the interview was conducted to obtain demographic data and then the anthropometric evaluation was performed.

3.2 Data collection

The data collected for the research consisted of 4 descriptive dimensions of body composition, which are the only ones that will be analyzed in this chapter, 52 anthropometric measurements consisting of body lengths, diameters, widths, reaches and angles, and 4 strength measurements. During data collection, two independent measurements were taken for each dimension for each subject. If the difference between the two measurements exceeded the acceptable level, a third measurement was taken to ensure the accuracy of the records. The descriptive dimensions of body composition consisted of height, weight, percent body fat, percent muscle mass, and bone density. Bioimpedance was selected as the measurement method because it is considered a safe, inexpensive, accurate and noninvasive method that provides data on a person's body composition (Garcia-Soidan et al., 2014; Gutiérrez & Beneit, 2011; Ortega González et al., 2018; Quintero Alarcón et al., 2022).

Height was measured with an ErgoTech Mexico portable stadiometer model ErgoMeasure. Following the protocol applied by Hernandez-Arellano et al. (2016), participants keep standing upright, barefoot, wearing light clothing, perpendicular to the ground with the arms resting at the sides of the body in an upright position and the head located in the Frankfort plane. To collect information on weight, body fat percentage, muscle mass percentage and bone density, a specialized H.U.T. model HBBSVD-2559 digital scale was used, which has a Strain-Gauge system with 4 high-precision sensors to measure body fat and water, muscle mass, bone density, minimum required kilocalories and body mass index. The maximum capacity of the scale is 180 kg with a measurement division of 100g. To perform the measurement, after collecting sociodemographic information and measuring height, the scale was configured with the subject's information on sex, age and height. The subjects stepped on the scale without shoes, jewelry or watches that could interfere with the reading, wearing light clothing, with their arms resting at the sides of their bodies and their heads positioned in the Frankfort plane.

3.3 Statistical Analysis

The data collected were analyzed using SPSS statistical software. In the statistical analysis performed, the mean, median, standard deviation and range of each variable were calculated for each stratum. ANOVA and Tukey post-hoc statistical tests were performed. For all statistics analysis, a 0.05 level of confidence was used.

4. RESULTS

4.1 Descriptive Statistics

The mean values obtained for height in the analysis of all male and female participants were 162.5 ± 7 cm for men and 151.1 ± 6.4 cm for women. Table 1 presents the statistical analysis of height for each age stratum showing the differences between men and women.

Table 1. Descriptive analysis of height for each stratum of the sample.

Height (cm)	Men 15-19	Women 15-19	Men 20-29	Women 20-29	Men 30-49	Women 30-49	Men 50-59	Women 50-59	Men 60-65	Women 60-65
Mean	165.3	155.5	165.6	153.1	160.2	148.9	160.2	148.2	154.3	145.2
Median	164.3	155.2	164.7	152.6	158.8	148.3	160.6	148.8	153.5	145.8
Standard deviation	7.0	5.3	6.0	7.1	6.4	5.1	5.8	4.5	4.5	4.5
Range	31.3	24.8	24.2	27.1	27.2	25.3	25.0	16.6	14.7	12.4
Minimum	150.7	144.5	153.1	139.6	146.8	137.8	147.2	138.8	149.5	139.5
Maximum	182.0	169.3	177.3	166.7	174.0	163.1	172.2	155.4	164.2	151.9

The mean values obtained for weight in the analysis of all male and female participants were 75.9 ± 14.9 kg for men and 66.1 ± 13. 8 kg for women. Table 2 presents the statistical analysis of weight for each age stratum comparing the differences between men and women.

Table 2. Descriptive analysis of weight for each stratum of the sample.

Weight	Men 15-19	Women 15-19	Men 20-29	Women 20-29	Men 30-49	Women 30-49	Men 50-59	Women 50-59	Men 60-65	Women 60-65
Mean	69.6	60.0	77.7	60.1	78.7	69.4	77.8	78.5	68.3	72.9
Median	64.5	58.4	76.2	60.6	77.7	67.0	75.3	79.8	68.0	79.5
Standard deviation	14.9	14.0	14.5	11.0	14.7	12.3	15.7	12.7	9.8	15.5
Range	54.3	52.9	77.5	48.5	86.4	57.9	57.5	43.1	30.4	37.4
Minimum	46.4	40.8	58.9	36.9	52.8	47.8	55.8	61.2	55.6	49.5
Maximum	100.7	93.7	136.4	85.4	139.2	105.7	113.3	104.3	86.0	86.9

The mean values obtained for body fat percentage in the analysis of all male and female participants were 26.3 ± 6.1% for men and 31.7 ± 7.8% for women. Table 3 presents the statistical analysis of body fat percentage for each age stratum comparing the differences between men and women.

Table 3. Descriptive analysis of body fat percentage for each stratum of the sample.

Body fat %	Men 15-19	Women 15-19	Men 20-29	Women 20-29	Men 30-49	Women 30-49	Men 50-59	Women 50-59	Men 60-65	Women 60-65
Mean	21.4	25.6	24.9	27.2	29.0	34.8	29.7	40.7	28.9	40.4
Median	21.9	24.7	24.5	27.1	28.1	34.6	29.8	40.6	30.3	43.5

Standard deviation	5.5	5.6	5.6	4.7	5.3	6.4	5.7	6.2	3.6	7.6
Range	18.9	22.5	30.6	17.3	26.7	31.9	20.6	19.8	10.5	17.2
Minimum	13.1	17.1	16.8	18.6	18.2	22.7	22.9	31.8	22.6	30.0
Maximum	32.0	39.6	47.4	35.9	44.9	54.6	43.5	51.6	33.1	47.2

The mean values obtained for muscle mass percentage in the analysis of all male and female participants were 35.2 ± 3.7% for men and 32.2 ± 3.6% for women. Table 4 presents the statistical analysis of muscle mass percentage for each age stratum comparing the differences between men and women.

Table 4. Descriptive analysis of muscle mass percentage for each stratum of the sample.

Muscle mass %	Men 15-19	Women 15-19	Men 20-29	Women 20-29	Men 30-49	Women 30-49	Men 50-59	Women 50-59	Men 60-65	Women 60-65
Mean	38.1	35.0	36.3	34.4	33.6	30.6	33.2	28.3	33.4	27.9
Median	38.1	35.1	36.6	34.6	34.0	30.7	33.4	28.5	32.4	26.9
Standard deviation	3.4	2.4	3.4	2.3	3.1	2.9	3.3	2.7	2.1	3.3
Range	11.1	10.1	18.5	8.3	15.2	14.5	12.1	10.2	6.2	7.7
Minimum	32.0	29.1	23.0	30.5	24.9	21.8	25.1	23.3	30.9	24.5
Maximum	43.1	39.2	41.5	38.8	40.1	36.3	37.2	33.5	37.1	32.2

Finally, the mean values of bone density in the analysis of all male and female participants were 3.0 ± 0.2 kg for men and 2.1 ± 0.1 kg for women.

Table 5 presents the statistical analysis of bone density for each age stratum comparing the differences between men and women.

Table 5. Descriptive analysis of bone density for each stratum of the sample.

Bone density (kg)	Men 15-19	Women 15-19	Men 20-29	Women 20-29	Men 30-49	Women 30-49	Men 50-59	Women 50-59	Men 60-65	Women 60-65
Mean	38.1	35.0	36.3	34.4	33.6	30.6	33.2	28.3	33.4	27.9
Median	38.1	35.1	36.6	34.6	34.0	30.7	33.4	28.5	32.4	26.9
Standard deviation	3.4	2.4	3.4	2.3	3.1	2.9	3.3	2.7	2.1	3.3
Range	11.1	10.1	18.5	8.3	15.2	14.5	12.1	10.2	6.2	7.7
Minimum	32.0	29.1	23.0	30.5	24.9	21.8	25.1	23.3	30.9	24.5
Maximum	43.1	39.2	41.5	38.8	40.1	36.3	37.2	33.5	37.1	32.2

4.2 Statistical comparison of strata

The ANOVA analysis was performed for the whole sample comparing the height between men (162.5 cm) and women (151.1 cm) showing significant differences being greater for men (F: 42.877, p:0.000). The Tuckey post-hoc analysis identified 4 homogeneous groups in which there were no significant differences between strata (See Table 6). However, it can be observed that the two strata grouping women between 15 and 29 years do not present significant differences with the stratum of men between 60 and 65 years. In fact, the comparison of height between women aged 15-19 years and men aged 60-65 years, are found in two subsets as it could be seen in Table 6.

Table 6. ANOVA HSD Tuckey analysis of height between stratums of the sample.

HEIGHT (cm)	Subset for alfa = 0.05			
	1	2	3	4
Women 60-65	147.5667			
Women 50-59	148.1833			
Women 30-49	148.8562			
Women 20-29	153.14	153.14		
Men 60-65		155.3	155.3	
Women 15-19		155.5114	155.5114	
Men 50-59			160.1588	160.1588
Men 30-49			160.1816	160.1816
Men 15 – 19				165.269
Men 20 – 29				165.5617
Sig.	0.121	0.969	0.269	0.15

The ANOVA analysis was performed for the whole sample, comparing the weight between men (75.9 kg) and women (66.1 kg) obtaining significant differences being higher for men (F: 10.524, p:0.000). The Tuckey post-hoc analysis to compare weight between groups, it was possible to identify 2 subsets in which there were no significant differences between strata. As for the comparison by age groups it could be seen in Table 7, no significant differences were found between the 7 mixed groups of age in one set and 8 mixed groups on the other set. It is worth noticing that the groups of men and women aged 15 to 19 years and 60 to 65 years were found in both subsets and no significant differences were found.

Table 7. ANOVA HSD Tuckey analysis of weight between stratums of the sample.

WEIGHT	Subset for alfa = 0.05	
	1	2
Women 15-19	60	
Women 20-29	60.138	
Men 60-65	68.15	68.15
Women 30-49	69.4205	69.4205
Men 15-19	69.6379	69.6379
Women 60-65	71.4889	71.4889
Men 20-29		77.6702
Men 50-59		77.8294
Women 50-59		78.5333
Men 30-49		78.6959
Sig.	0.212	0.326

In the ANOVA analysis carried out to the entire sample, comparing the of body fat percentage between men (26.3%) and women (31.7%) obtaining significant differences being higher for women (F: 29.072, p:0.000). The Tuckey post hoc analysis, four subsets can be distinguished where differences were not significant among strata. It can be observed that the groups of men and women aged 15 to 29 years have the lowest percentages of fat, while the groups of women aged 30 to 65 years have the highest percentages of body fat, presenting a significant difference. Meanwhile, the groups of men from 30 to 59 years of age are found in two of the subgroups.

Table 8. ANOVA HSD Tuckey analysis of percentage of body fat between stratums of the sample.

% BODY FAT	Subset for alfa = 0.05			
	1	2	3	4
Men 15-19	21.4241			
Men 20-29	24.9196	24.9196		
Women 15-19	25.5914	25.5914		
Women 20-29	27.192	27.192		
Men 60-65		28.1667		

Men 30-49		28.9918	28.9918	
Men 50-59		29.6647	29.6647	
Women 30-49			34.8	34.8
Women 60-65				37.0333
Women 50-59				40.6889
Sig.	0.063	0.243	0.059	0.052

The ANOVA analysis for muscle mass percentage performed to the complete sample, the comparison between men (35.2%) and women (32.2%) obtained significant differences being higher for men (F: 29.536, p:0.000). The Tuckey post hoc comparison of the percentage of muscle mass (see Table 9), five homogeneous subsets in which there were no significant differences between strata. As expected, older women have a lower percentage of muscle mass compared to younger men. However, it is worth pointing out that the groups of women aged 15-19 and 20-29 years and men aged 30-49 and 60-65 years are present in two different subsets, with no significant differences between them. These 4 groups present similar percentages of muscle mass.

Table 9. ANOVA HSD Tuckey analysis of percentage of muscle mass between stratums of the sample.

% MUSCLE MASS	Subset for alfa = 0.05				
	1	2	3	4	5
Women 50-59	28.3222				
Women 60-65	29.4222				
Women 30-49	30.626	30.626			
Men 50-59		33.1706	33.1706		
Men 30-49		33.5612	33.5612	33.5612	
Men 60-65			33.8167	33.8167	
Women 20-29			34.4163	34.4163	
Women 15-19			34.9857	34.9857	
Men 20-29				36.2804	36.2804
Men 15-19					38.1393
Sig.	0.334	0.074	0.679	0.133	0.648

In ANOVA analysis for all the sample, in the comparison of bone density between men (3.0 kg) and women (2.1 kg) there were significant differences, being greater for men (F:318.778, P: 0.000). As it can be appreciated in Table 10, in Tuckey post hoc analisys for bone density comparison, four subsets were identified in which the differences were not significant: the groups of women aged 15-59 years (P: 0.918); the group of women aged 60-65 years (P: 1.000); the group of men aged 15-49 years and 60-65 years (P: 0.176); and the group of men aged 20-65 years (P: 0.123).

Table 10 ANOVA HSD Tuckey analysis of bone density between stratums of the sample.

BONE DENSITY (Kg)	Subset for alfa = 0.05			
	1	2	3	4
Women 15-19	2.0886			
Women 20-29	2.11			
Women 30-49	2.1219			
Women 50-59	2.1611			
Women 60-65		2.4778		
Men 15-19			2.9483	
Men 60-65			2.9667	2.9667
Men 20-29			3.0478	3.0478
Men 30-49			3.0857	3.0857
Men 50-59				3.1118
Sig.	0.918	1	0.176	0.123

5. CONCLUTIONS

In this study, descriptive data on body composition characteristics of a sample of the population of the northern part of the state of Campeche were collected and compared. All the variables analyzed (height, weight, body fat percentage, muscle mass percentage and bone density) presented significant differences between the subsets formed by the different age strata of men and women, but the groups within the subsets did not show significant differences. It was possible to observe subsets where the mean value of the variable of the stratum of young women had no significant differences with the values of older men in the last stratum.

For height, the groups of women between 15 and 29 years of age did not present significant differences with the group of men between 60 and 65 years of age. For weight, the groups of men and women aged 15-19 years and 60-65 years did not show significant differences. As for the percentage of body fat, the groups of men and women aged 15-29 years had the lowest percentages of fat, while the groups of women aged 30-65 years had the highest percentages of body fat, showing a significant difference. Meanwhile, the groups of men aged 30-59 years had similar body fat percentages. As might be expected, when comparing the percentage of muscle mass between age and gender groups, older women (30-59 years) presented a lower percentage of muscle mass compared to younger men (15-29 years). However, it should be pointed out that the groups of women aged 15-29 years and men aged 30-49 and 60-65 years did not present significant differences between them.

Finally, the research presents descriptive values of body composition characteristics, showing that there are significant differences depending on age. This information provides objective information to be taken into account for the design of tasks requiring strength and work spaces that consider the morphological characteristics of the population.

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APPLICATION AND COMPARISON OF NASA TASK LOAD INDEX METHOD (NASA-TLX) WITH AND WITHOUT WEIGHTING IN A STUDY

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Resumen: El objetivo principal de esta investigación fue obtener los índices de carga mental de trabajo aplicando el método NASA-TLX, para así realizar la comparativa de los resultados tanto con y sin ponderación. Se aplicó una encuesta de 21 preguntas a 50 estudiantes de la Universidad Autónoma de Ciudad Juárez. Se midió el rendimiento escolar de los estudiantes en tres distintos niveles de carga, obteniendo las puntuaciones e las dimensiones y el índice de carga de trabajo con o sin ponderación, aplicando pruebas estadísticas que muestran diferencias en los datos obtenidos. El rendimiento en base a los resultados fue mayor en la forma Tradicional del método NASA-TLX que la versión RAW, considerando así esta versión como menos confiable.

Palabras clave: Carga, Mental, NASA-TLX, RAW, Ergonomía.

Relevancia para la ergonomía: Observar el comportamiento de datos y sus diferencias aplicando el Método NASA-TLX con y sin ponderación, en la evaluación del trabajo ergonómico.

Abstract: The main objective of this research was to obtain the mental workload indexes applying the NASA-TLX method, in order to make the comparison of the results both with and without weighting. A survey of 21 questions was applied to 50 students from the Autonomous University of Ciudad Juárez. The school performance was measured in three different levels, obtaining the dimensions scores and the workload index with or without weighting, applying statistical tests that show differences in the data obtained.any questions about the format, direct it to the SEMAC Academic Committee. The performance based on the results was higher in

the Traditional form of the NASA-TLX method than the RAW version, thus considering this version as less reliable.

Keywords. Workload, Mental, NASA-TLX, RAW, Ergonomics.

Relevance to Ergonomics: Observe the behavior of data and their differences applying the NASA-TLX Method with and without weighting, in the evaluation of ergonomic work.

1. INTRODUCTION

The mental workload is defined as the number of mental demands (information processing of the environment from previous knowledge, memory activity, reasoning and finding solutions, etc.). in a person to achieve a specific result. The connection between the demands of their work and the mental elements that they have to face such demands, formulates the mental workload (Almirall Hernández & Alvarado Hernández, 2004; Juan et al., 2016).

At present, the mental workload has implied changes in industrial tasks, with the introduction of new technologies high cognitive demands were created, which causes side effects such as stress and possible health risks, affecting the person's performance, productivity and possible errors when executing tasks (Alferez-Padron et al., 2018; Arce & Silvia, 2012; Charria O et al., 2011; Young et al., 2015). Therefore, it is considered a field of research of great importance (Ayaz et al., 2012; DiDomenico & Nussbaum, 2008).

In recent years, some degree of agreement has been reached regarding the content of subjective mental workload, and the result is three major dimensions or factors: (a) Aspects related to the temporal pressure of the task (available time, the time required); (b) The amount of processing resources required by the task (mental, sensory, type of task) and (c) Aspects of an emotional nature (fatigue or frustration) (Annett, 1998). The high school mental load is extreme exhaustion of the routines and the student's work. It occurs in the decrease in work skills and a clear opacity of the individual's intellectual functions (will, memory, attention, and perception)

For the evaluation of the mental workload, there are methods that allow obtaining the mental workload level, like the NASA Task Load Index Method (NASA-TLX) (Hart & Staveland, 1988). This method can be used in two ways to obtain the level of mental workload (with and without weighting). That is, with weighting, the score obtained will be multiplied x 100 and divide this result by 20 to have a converted score of each of the dimensions, to finally perform the multiplication of the weight of the dimensions by the converted score, obtaining the score weighted end.

Finally, the sum of the weighted score values is performed, divided by 15 and this new value is the global work index. While in the case of performing the method without weighting, the weighting process is eliminated completely or by weighing the subscales and then analyzing them individually.

The value of the global work index will indicate according to its value the levels of mental load in the evaluation of the task. The index obtained will be used in this investigation to observe their behavior and differences between them, making statistical comparisons of the data obtained with the support of statistical software.

2. OBJECTIVES

The objectives of this research are 1) obtain the mental workload index with the NASA-TLX method and 2) to compare the results obtained with and without weighting.

3. METHODOLOGY

3.1 Study Design

The type of research will be exploratory and cross-sectional, where the global mental load index will be calculated, capturing the data of the people evaluated, following with analytical research for the presentation of results and their comparison, as well as statistical analysis.

3.2 Delimitation

This research is carried out in Ciudad Juarez, Mexico, which is limited to the evaluation of tasks where there is a mental workload involved. Measuring school performance at the facilities of the Autonomous University of Ciudad Juarez, the mental workload index will be obtained with the support of the NASA-TLX method and its comparison with and without weighting.

3.3 Sample

The sample consisted of 50 volunteers - students from the Autonomous University of Ciudad Juarez, a survey was applied to assess workload and school fatigue, according to the following inclusion criteria: No cardiac or respiratory problems, hypertension, or injuries in the last year prior to the experiment. Not having performed strenuous exercises in the two days prior to the session. Not having drunk alcohol two days before the experiment sessions and nonsmokers. During the experiment, participants could be excluded if they manifest any upper or lower extremity musculoskeletal discomfort, headache, or mental exhaustion. Subjects will wear comfortable clothing such as: tennis shoes, jeans or pants, cotton or polyester shirt and cotton socks. The average age of the study participants was 20 years old (Std. Dev. 1.01), all students from the Autonomous University of Juárez City. Participation time in the experiment was between 10 and 15 minutes per participant.

3.4 Materials and Methods

3.4.1 Identification and Ways to Use the NASA-TLX Method

The identification of the different ways to use the NASA-TLX method was obtained through a literature review in the area of ergonomics - human factor, in scientific databases such as ScienceDirect, Sage Journals, SciFinder, SciELO, Dialnet, MDPI, Research Gate, etc. The keywords were used in the search: "method, NASA-TLX, RAW, mental, workload, weighted, evaluation, cognitive, study, ergonomics".

3.4.2 Evaluation Survey

The survey consists of evaluating the 6 different dimensions of the NASA-TLX Method (mental demand, physical demand, temporal pressure, effort, performance, frustration) where each person evaluates and obtains an individual score. Three different levels of mental load were applied in the evaluations of school performance, considering the high, medium and low level respectively to measure school performance. The person is asked to answer among the 15 binary combinations and choose the heaviest one, where the weight of each dimension will be obtained. Which can be applied to evaluate any task that generates mental workload.

3.4.3 Data Analysis

IBM Statistical Package for Social Science (SPSS) program for Windows version 23 was used for statistical analysis and ANOVA test was applied.

4. RESULTS

This research was based on examples of research using NASA-TLX in practical situations like school performance evaluation, like in the study by Yuan-mei et al., (2010). And to analyze the mental load in practical examples of surgeons in the research by Ruiz-Rabelo et al., (2015) & B. Zheng et al. (2012) as well as finding the mental load index in pilots and workers (Díaz Ramiro et al., 2010; Y. Zheng et al., 2019). The results were captured using both forms of evaluation of NASA-TLX, analyzing the performance, presenting comparative tables and a statistical analysis.

4.1 Data from NASA-TLX

Table 1 shows the individual result of the calculation of the workload index with and without weighting, encompassing the results per person and in the two different forms of evaluation of NASA-TLX.

Table 1. Individual Results of the NASA-TLX Survey

PERSON	*WORKLOAD GLOBAL INDEX (WITH WEIGHT)*	*GLOBAL WORKLOAD INDEX (WITHOUT WEIGHT)*
1	*92*	*80*
2	*82*	*76*
3	*80*	*70*
4	*49*	*46*
5	*76*	*66*
6	*68*	*66*
7	*64*	*53*
8	*80*	*70*
9	*76*	*66*
10	*50*	*46*
11	*84*	*73*
12	*62*	*60*
13	*80*	*76*
14	*84*	*70*
15	*50*	*56*
16	*86*	*73*
17	*74*	*63*
18	*81*	*80*
19	*70*	*60*
20	*88*	*80*
21	*77*	*66*
22	*82*	*76*

23	*74*	*73*
24	*66*	*63*
25	*85*	*73*
26	*65*	*56*
27	*90*	*80*
28	*86*	*80*
29	*57*	*63*
30	*80*	*60*
31	*89*	*73*
32	*84*	*70*
33	*73*	*66*
34	*66*	*60*
35	*77*	*73*
36	*64*	*63*
37	*74*	*63*
38	*76*	*76*
39	*66*	*60*
40	*78*	*70*
41	*72*	*63*
42	*72*	*66*
43	*69*	*73*
44	*89*	*86*
45	*52*	*43*
46	*76*	*76*
47	*86*	*70*

48	*65*	*73*
49	*88*	*80*
50	*48*	*40*

Table 2 shows the mean, the total number of the sample and the standard deviation of the load indices analyzed.

Table 2. Statistics of the Analyzed Sample

Weighing	Mean	N	Std. Deviation
WithWeighting	74.3470	50	11.63173
Unweighted	67.6000	50	10.16954
Total	70.9735	100	11.38631

4.2 ANOVA Statistical Test

The ANOVA test was applied in the statistical software, where the workload index data was used without and with weighting, using a 95% confidence interval, resulting in Table 3 below.

Table 3. ANOVA Statistical Test Result.

			Sum of Squares	df	Mean Square	F	Sig.
Value * Weighing	Between Groups	(Combined)	1138.050	1	1138.050	9.535	.003
	Within Groups		11697.113	98	119.358		
	Total		12835.164	99			

5. CONCLUSIONS

The results obtained in the comparisons showed that the performance was better in the Traditional form of NASA-TLX, where effects such as frustration, general tiredness and mental discomfort were present in both evaluations. Where the NASA-TLX method in its Traditional form, obtained a higher level of global workload index compared to the RAW form of the method in most of the comparative tests.
The two different forms of evaluation of the NASA-TLX method showed significant differences and a slight difference in their means, the evaluated subscales accurately establish the specific source of workload variation of the evaluation. The weighted score shows the value of each of the factors as workload generators and their subjective importance. In the results presented by Byers et al. (1989), Grier (2015) & Schmidtke (2020), differences were found in the global workload index.between the approaches used in the investigations, mentioning the NASA-TLX.

Traditional approach as more suitable for measuring workload. The mental workload index obtained in the two forms of evaluation reflects the overall value of the research, where actions are needed to be recommended according to the level obtained to reduce the mental workload and therefore, the level of mental load achieved can be cataloged in the evaluation. With this research and based on the other authors, it tells us that the RAW form offers an undervalued global workload index, not giving an ideal evaluation in the scores offered by the Traditional form of the NASA-TLX method.

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THE EMPLOYMENT OF THE USABILITY FRAMEWORK IN THE TOOLS WAREHOUSE

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Resumen El presente proyecto tiene por objetivo mejorar la administración del almacén de fixturas localizado dentro del proceso de producción mediante la utilización del enfoque usabilidad, elemento de la ergonomía cognitiva. Para ello, se desarrolló una metodología buscando disminuir su tiempo de búsqueda y transporte dentro de dicho almacén. Ésta constó de tres fases identificando la problemática, indagando el comportamiento de los colaboradores y descubriendo la frecuencia de la utilización de dicho almacén. Se observaron las actividades realizadas de forma rutinaria, se hicieron encuestas de su uso involucrando a cada uno de los colaboradores que las utilizan y se establecieron los tiempos de su recorrido considerando el almacenaje y el lugar de utilización. Como resultado de la intervención para generar la solución a la problemática, se reacomodaron las fixturas utilizadas en un nuevo mueble considerando una localización específica para cada una de ellas. Además, dicho mueble fue relocalizado en un espacio cercano a su uso. La reducción del tiempo requerido para su búsqueda y transporte y la reducción de los tiempos muertos por su búsqueda fueron resultados de la intervención realizada. Esto, a su vez, puso en manifiesto la ventaja de utilizar nuevos enfoques para solucionar problemáticas existentes dentro de los sistemas productivos incluyendo los aspectos humanos a través de la usabilidad.

Palabras clave: Empresa aeroespacial, ergonomía cognitiva, fixtura, tiempo de ciclo, usabilidad

Relevancia para la ergonomía: La usabilidad tiene diversos objetivos dentro de su competencia de aplicación, por ello se decidió probar su valía en un contexto de extremo valor para las empresas, como lo es el inventario en proceso. Por tal razón, dentro de la metodología se utilizaron tres métodos para recaba inforamción que, a su vez, permitieron explorar diversas formas para confirmar el valor de la aplicación del concepto de usabilidad en el contexto mencionado. Se encontró que la usabilidad puede impactar en la distancia de recorrido de los materiales, tiempo en las operaciones y en la satisfacción de los usuarios del inventario en proceso.

Abstract (Spanish/English, this order): The objective of this project is to improve the administration of the fixtures warehouse located within the production process through the use of the usability approach, an element of cognitive ergonomics. For this, a methodology was developed seeking to reduce their search and transport time within mentioned warehouse. The methodology consisted of three phases identifying the problem, investigating the behavior of the collaborators and discovering the frequency of use of the mentioned warehouse. The activities carried out routinely were observed, surveys of the use of the fixtures were carried out involving each of the collaborators who use them and the travel times of the fixtures were developed considering their storage and place of use. As a result of the intervention to generate the solution to the problem, the fixtures used in a new piece of furniture were rearranged considering a specific location for each of them. In addition, mentioned piece of furniture was relocated in a space close to the use of the fixings. The reduction of the time required for the search and transport of fixtures and the reduction of downtime for the search for fixtures were results of the intervention carried out. This, in turn, highlighted the advantage of using new approaches to solve existing problems within production systems, including human aspects through usability.

Keywords. Aerospace company, cognitive ergonomics, fixture, cycle time, usability.

Relevance to Ergonomics: Usability has various objectives within its application competence, for this reason it was found to prove its worth in a context of extreme value for companies, such as the inventory in process. For this reason, within the methodology, three methods were used to collect information that, in turn, allowed exploring various ways to confirm the value of the application of the concept of usability in the aforementioned context. It was found that usability can impact the distance traveled by materials, time in operations and the satisfaction of users of the inventory in process.

1. INTRODUCTION

Note: For reasons of confidentiality and ethics, the name of the company, product studied and various elements of the initial project have been changed in the document to ensure their anonymity.

This project was developed to improve the administration of the temporary warehouse used to register and control the fixtures currently used and those that are about to be integrated into the secondary area of client N in the EM company. This company manufactures components for aircraft electrical parts using high-end injection molding machines and most of its customers are in the aerospace industry. For this reason and due to the number of customers, a large number of these are used in its processes for the various products that are manufactured. For these reasons, there is currently a perception of problems when trying to use them in these processes, they are not found since they are lost inside their warehouse or on the production lines. According to the comments made by its users, this happens because there is no management and control procedure, hence the project seeks to manage its use by standardizing commented procedure using the usability approach in a way that various indicators such as search time and travel distances are reduced.

The foregoing is based on the consideration in managing the resources available to companies for their productive activities. This can be partially observed in the control of the tools and equipment, this is because they have a cost and a value within mentioned processes. In addition, its shortage can have an impact on the productivity of the company within production times. In this particular case, the temporary loss of fixtures results in increased downtime in the production process. For example, figure 1 shows the cabinet used for the temporary storage of fixtures and where they are supposed to be placed once they are used in the process.

Figure 1. Fixture cabinet

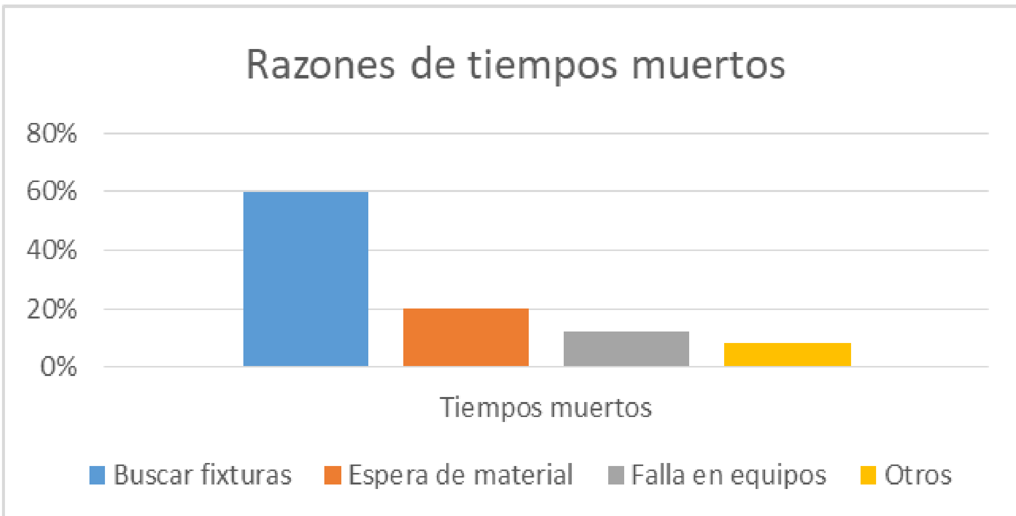
Source: direct

For these reasons and considering that within the company there are problems similar to those shown, the project was concentrated in the area or client called N and later the knowledge acquired will be transferred to other areas of the company. This area was chosen because it has operations similar to other areas and the products produced represent a high percentage of the income of the EM company. Therefore, the company seeks to reduce its costs in these processes. Specifically, the area has 30 fixtures, three of which are used for each part number or manufactured product. For its recognition within the processes and in reference to mentioned product, a symbology is used that begins with FIX accompanied by the progressive numbers 001, up to 030. Each certain number of progressive numbers are used for a product that is clearly defined in the process. For example, the fix FIX-001 represents FIX (fix), 0 (product number), and 01 (progressive number of the fix). This symbology was determined, in common agreement, by the Quality, Engineering and Production Managers.

On the other hand and in reference to its use within the production process, 120 pieces per hour are obtained showing that production standards are not met. An analysis of the main causes was carried out and it was found that downtime was the main cause and, in turn, its origins have various reasons, which are presented in figure 2.

As it is presented and in common agreement, only the project focused on idle times since social and technical aspects are involved in the production process. Here, the staff that, administers and manages those aspects, can be elements that could have an influence on technical aspects within the production processes, proposing ergonomic aspects as an approach to be used and, particularly, cognitive ergonomics expecting to reduce errors when control commented fixtures for impacting on search times and distances traveled.

Figure 2. Downtime in the process



Fuente: directa

2. LITERATURE REVIEW

1.1 Cognitive Ergonomics

Ergonomics is a scientific discipline that helps to understand the interactions between humans and other elements of a system, optimizing human well-being and work efficiency (IEO). Ergonomics is the discipline applied to facilitate the execution of daily work, avoiding fatigue and having human well-being as a priority. According to Leiros (2009) ergonomics has three major domains of specialization: physical, cognitive, and organizational. The first is related to physical activities at work; the second, to the mental processes required by the work and the third, to the social interaction within the work.

As is the subject of our interest, cognitive ergonomics focuses on specifying and giving recommendations for adapting the design of information supporting to certain user characteristics such as: perceptual input processes (detection, classification, pattern recognition, etc.); central cognitive processing (memory, reasoning, problem solving, etc.), and perceptual-motor processes (more related to response and execution systems) (Romero Medina, 2007; M. Murray, et al, 2019). This is in consideration of the fact that vision is the most important sense for the human being, since through it, the environmental information and their meanings by which it interacts are perceived. In other words, for a work activity, light and vision are needed (Moreno Jimenez, et al, 2001). In addition, the visual area is the portion of space in which objects can be perceived simultaneously when looking at a fixed and immobile object (Medrano Muños, 2007).

In addition, the sight stands out as the link between the system and the person; therefore, in the vision, the shapes, sizes, arrangement of objects and ambient lighting must be considered, delving into the adaptation of products and environments to the psychological characteristics and limitations of people, specifically the information processing capabilities of the brain (Romero Medina, 2006). It is relevant to mention that the possible theoretical frameworks and methodological principles are still in an evident stage of construction and development. It is not surprising that, at the current level of science, where numerous traditional branches of knowledge have found strong links (sometimes not suspected a decade) with other branches and fields of application, new approaches and methodologies can be used in search of a better understanding (Almirall Hernández, 2015). Thus, prospective ergonomics emerged, which is an interdisciplinary approach of researchers and doctors from very diverse fields united by the same objective, and part of a general basis for a modern conception of health and safety at work (Almirall Hernández, 2015).

For example, visual indicators, visual information devices or visual displays, are technologies used to present information, which can be digital, analog, signs or illuminated advertisements and display screens (Medrano Muños, 2007).

1.2 Usability

This term has been used in various contexts and was introduced in the area of computing and has subsequently been used in the quality of products (Nielsen, 1993); in addition, it has been used within the design processes of products and services (Avila-Chaurand, 2013). In the same way, it deals with those processes that allow the planning and design of usability questionnaires with the purpose to guarantee the quality of the final product. Associated with these processes are their application methods, which are characterized by their formal or informal applications (Nielsen, 1993).

Along these lines, various authors (Floría Cortés, 2000; Bravent, et al, 2014) have presented various areas of application of usability questionnaires and have explored various ways of being able to evaluate it. In this area, Nielsen [9] has presented a complete vision on the use of it with the purpose of supporting all design activities, for example. In the same way, its application methods are characterized by being formal and informal.

Likewise, a set of alternative usability inspection methods to the formal usability testing methods have been proposed. These methods are heuristic evaluation, cognitive monitoring, formal usability inspections, interdisciplinary monitoring, feature inspection, consistency inspection, and standards inspection, among others (Nielsen, 1993).

This is with the particular purpose of being able to evaluate the administration of the temporary warehouse where the fixtures are located within the work area, this paper explores an application of the usability framework

1.3 Inventories and Internal Control Systems

Inventory management emerges as the means to balance different risks, such as frustrating the expectations of the client regarding the deliveries of products and services, the risk implicit in its management and the expenses caused by disorder and instability in schedules manufacturing. Moreover, the risk and expenses of diverting money into merchandise that can go bad, go out of style or deteriorate, among others (Drucker, 2013; Luna, 2011).

This is because they help in the activities of organizations, or, where appropriate, they can refer to the assets that companies have to generate income or are about to become such income. In this line, they are deeply linked with the activities of mentioned production systems in order to provide adequate growth strategies within the market in which they are located (Luna, 2011; Barquero, 2013).

This will allow security for the achievement of the objectives set and for their achievement in terms of efficacy, efficiency and effectiveness in the activities carried out. This includes internal control that is required to provide confidence. Thus, it reduces errors and those irregularities that could potentially occur in order to take the appropriate measures to reduce them in a short time. It is to respond to the needs shown in the environment. It is particularly expected in managing the temporary store containing the fixtures.

3. METHODOLOGY

1.3 Problem Identification

This phase is related to the logical expression of the nature of the problems detected in order to subsequently find possible solutions specifying the nature of what is studied, the constituent parts of those problems and the various ways of being able to measure and evaluate their parts. Therefore, the visualization of the problem was the result of an internal audit during the validation of the AS9100 Rev D Standard. This standard suggests and emphasizes that any tool, fixture or equipment that interacts with the product must be controlled and monitored. Likewise, it points out that it is necessary to weigh its value within the productive system and its cost, in itself, that allow evaluating if the tools, fixtures or equipment are missing on a certain occasion. Consequently, productivity can be affected in practical terms such as downtime for thus taking the appropriate measures as a prevention perspective.

The study is called a casual study and it is intended to delineate a causal relationship between the variables; particularly, it included the context of use and the relationships of the tools, fixtures and equipment within the production system. The experimental designs have made it possible to establish these causal relationships between the variables under study. However, in the daily practice of social research, experimental designs are often used within surveys. Here, the populations under study are subjected to experimental control and are selected through the survey technique, but for greater validity it is important to identify and separate the information of the experimental design and that of the survey. Therefore, in this project, the survey and the interview were methods to find these causal relationships in a simple way and considering values of normal use.

1.3 Investigation

This phase included the direct observation of the user paying attention to the work method and the analysis of the responses made during the interviews, among others, as presented below. It is relevant to mention that the project was carried out in consideration of ethical and confidentiality aspects to comply with social norms of respect and social coexistence.

Observation. This consisted of observing the form(s) of interaction of the participant carrying out their daily activities within the work area. This was to understand their context and the various activities carried out. The total time accumulated during the observation of routine activities was 50 hours.

Focus group discussion. This consisted of collecting data through scheduled interviews in groups of five to eight people, allowing opinions and ideas to be obtained, as well as their discussion to assess their satisfaction. Three sessions were performed accumulating six hours.

Interviews. These consisted of discussing certain topics related to the satisfaction of the temporary warehouse containing the fixtures and that allowed improving its administration. Five interviews were carried out accumulating seven hours.

Surveys. This consisted of the participant answering a list of structured questions focused on understanding the context of their use and the administration of their temporary storage. This contained nine topics and was made to six participants who authorized to participate in the project. Among the topics considered were the lighting of the area; the correct identification of fixtures; knowledge of the objective of the project; the clarity of the labels used in your identification; the clear identification of production areas; knowledge of the location of use of these; the accessibility to the cabinet or temporary storage of them; the design of the cabinet in consideration of the physical limitations of the users (ergonomic factors), and the proper use of signs indicating the location of the temporary warehouse.

1.3 Periodicity

This phase was limited to carrying out and considering the moments in which the survey was carried out in two moments of time. The first was taken prior to the intervention performed and was considered in a single moment of time. The second was after the intervention and during the project they were carried out in three moments of time with a separation of one month between them. The first was a week after the intervention. Figure 3 shows the survey carried out throughout the project.

Figure 3. Applied survey

Encuesta sobre elementos visuales

El presente cuestionario tiene como objetivo analizar la importancia de las ayudas visuales en el área de trabajo para facilitar el mismo de cierta manera.

A continuación, se presenta un conjunto de preguntas para ser valoradas de acuerdo con la propia experiencia y teniendo en cuenta la siguiente escala:

En desacuerdo	Poco de acuerdo	De acuerdo	Totalmente de acuerdo
1	2	3	4

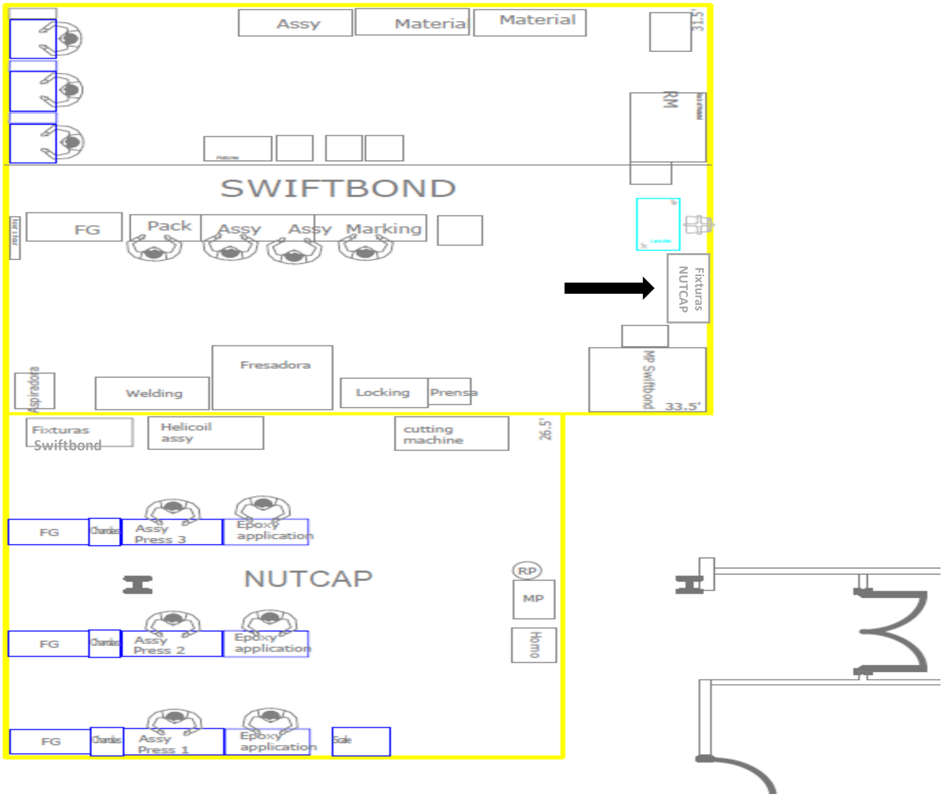
Lee atentamente cada inciso y responda con sinceridad, recuerde que es una encuesta anónima.

N	INCISOS	VALORACION				Observaciones
		1	2	3	4	
1	El área de trabajo se encuentra bien iluminada.					
2	Las herramientas, fixturas y/o equipos se encuentran bien identificados.					
3	Tengo claro el propósito de identificar los equipos, herramientas y fixturas del área.					
4	Considero que el tamaño de las etiquetas se ve claramente.					
5	Las estaciones de trabajo se encuentran bien identificadas.					
6	Localizo con facilidad las herramientas y fixturas en mi área de trabajo.					
7	Considero que tengo un fácil acceso a las herramientas, equipos y fixturas de mi área.					
8	Me parece que la altura de los gabinetes y/o estantes es la adecuada, de modo que no me cause fatiga o dolor en el cuerpo al alcanzar una herramienta o fixtura.					
9	Los letreros o carteles me ayudan a identificar donde se encuentran las herramientas y fixturas que necesito.					

Source: direct

This allowed to have results according to the context and to establish causal relationships between the variables considered. Likewise, and considering the times, it was relevant to consider the distribution of the plant to show the location of the temporary warehouse prior to the intervention. This is presented in figure 4.

Figure 4. Layout



Source: direct

4. RESULTS

It is relevant to mention that during the execution of the project several work meetings were necessary to inform the activities required before, during and after the intervention. During the intervention, the lighting of the area was treated as an industrial safety issue using the corresponding standard for its adaptation. Regarding the symbols used to name them, the fixtures were named by the managers, as mentioned in section 1. Regarding the labels of the fixtures, they were created using the standard regarding the use of colors in industrial safety and emphasizing its size for quick reading. Regarding the location of the cabinet, aspects of plant distribution were considered, focusing on reducing travel distances and the area supervisors, industrial safety and manufacturing engineers participated.

The design of the temporary warehouse or cabinet considered the average height of the users. Along the same lines, the fixtures with the highest demand were placed at a height related to their ease of handling and the height of the users, and those with the least demand, in lower places and heights, but considering their weight. This was related to the manual handling of loads and the ergonomic factors standard. For easy location within the work area, a sign was placed at the top to be viewed from any point located in the work area, see figure 5.

Figure 5. Fixture cabinet

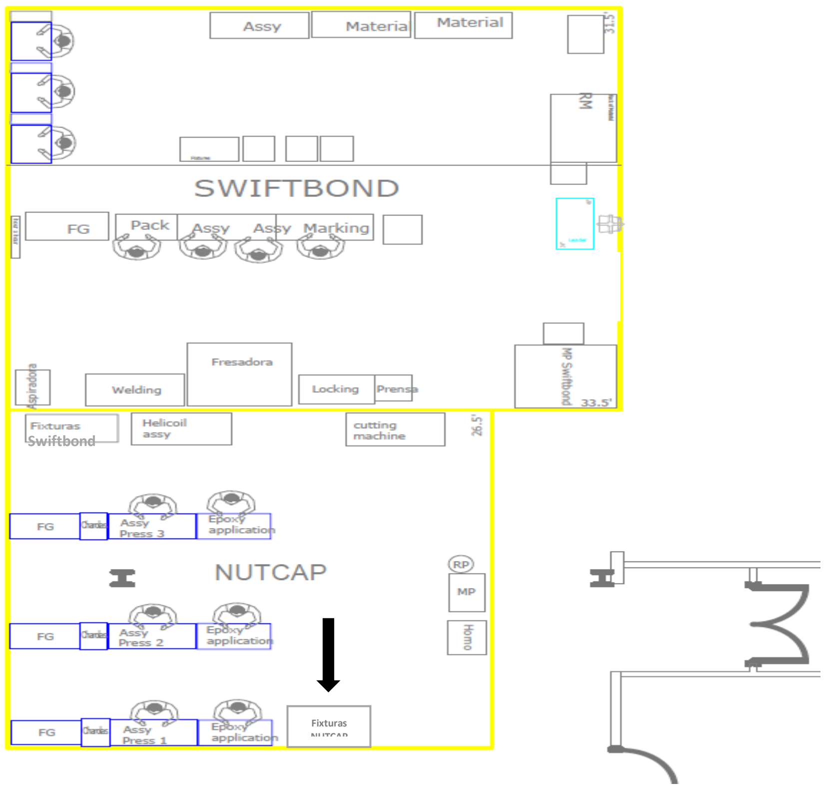
Source: direct

This, in turn, made it possible to place the location cards inside the temporary warehouse of each of the fixtures used to facilitate their traceability within the work areas. The labels used the colors indicated in the standard referring to these and used in industrial safety. Among the traceability, the possible states of location were considered, such as: in process, engineering or repair.

In the same way, the relocation of the temporary warehouse, visualized in figure 6, shows the proximity of the work stations within the production area, reducing the time for its access and, hoping to also reduce the fatigue due to manual handling of loads.

In addition, once the visual improvements were applied, various results were obtained that show changes and improvements in the work area, such as the reduction of downtime by approximately 40%, thus increasing the amount produced per hour from 120 to 139 pieces. Also, job satisfaction through the measurement of their perception of the various safety elements and as indicated in section 3.2. The results of the initial survey and the average in the three moments of time, after the intervention, are shown in table 1.

Figure 6. Relocation of fixture cabinet (layout)



Source: direct

Table 1. Results of applied surveys

Preguntas	Objetivos	Valoraciones promedio antes	Valoraciones promedio despues
1 El área de trabajo se encuentra bien iluminada.	*Iluminacion*	3.5	3.8
2 Las herramientas, fixturas y/o equipos se encuentran bien	*Correcta identificacion*	1.8	3.3
3 Tengo claro el propósito de identificar los equipos,	*Proposito del estudio*	3.5	4.0
4 Considero que el tamaño de las etiquetas se ve claramente.	*Claridad en etiquetas*	1.3	3.5
5 Las estaciones de trabajo se encuentran bien identificadas.	*Identificacion de areas*	2.7	3.0
6 Localizo con facilidad las herramientas y fixturas en mi área de	*Correcto point of use*	2.2	2.8
7 Considero que tengo un fácil acceso a las herramientas, equipos y	*Accesibilidad*	2.5	2.8
8 Me parece que la altura de los gabinetes y/o estantes es la	*Ergonomia en point of use*	2.7	3.0
9 Los letreros o carteles me ayudan a identificar donde se encuentran las	*Letreros visuales*	2.7	3.5

Source: direct

In the same way, the productivity obtained by these changes and in terms of the distance traveled in close relation to it, is presented in tables 2 and 3.

Tables 2 y 3. Time studies

Estudio de tiempos proceso actual				
Ciclos	Proceso			Total
	traslado	Buscar fixtura y tomar	traslado	
1	12.08	14.87	13.56	40.5
2	10.98	13.79	11.42	36.2
3	10.46	13.85	11.08	35.4
4	10.85	14.36	10.97	36.2
5	10.19	14.09	10.88	35.2
			Promedio	36.69

Estudio de tiempos nuevo proceso				
Ciclos	Proceso			Total
	traslado	Llenar datos y tomar	traslado	
1	3.74	4.3	4.12	12.16
2	3.56	5.49	3.89	12.94
3	3.68	5.01	4.08	12.77
4	3.43	4.71	3.94	12.08
5	3.91	5.13	4.32	13.36
			Promedio	12.66

Source: direct

Before the intervention, the process is carried out in 36.69 seconds and after the intervention, 12.66 seconds.

5. CONCLUSIONS AND RECOMMENDATIONS

The project was carried out considering small changes to have small improvements. For this, different activities were carried out and not considering major transformations to avoid internal competitions in the company. However, the methodology used gave the opportunity to use various methods to obtain data and facilitate its analysis. This was an advantage that helped, mainly, to facilitate the intervention and generate changes, initially, in the area of interest.

The results obtained were able to verify the value of each of the phases used in the methodology and in close relation to the theoretical aspects considered. The representatives of the company, at the time, were satisfied with the results obtained since the outlined objective was achieved and exceeded the expectations placed on it. Downtime was reduced and productivity rates were increased and, in turn, provided the background for two subsequent activities, facilitating process validation processes in future audits and being able to repeat the methodology used in other areas.

In addition, there were other benefits from the intervention performed. For example, up to the time of preparing this document, no fixtures have been reported lost due to mishandling or out of their established place. This consequently reduced the costs related to lost fixtures.

In the same way, another secondary benefit was job satisfaction on the part of the participants since this project could be carried out due to their individual and group contributions.

For these reasons, it is recommended to continue using the strategy used since there are expansion plans and it is expected that the demands of the products made in area N may increase the complexity of the process. This is directly related to the number of products to be manufactured and, consequently, to the number of fixtures to be used.

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MENTAL FATIGUE

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Resumen: La humanidad ha evolucionado a un ritmo acelerado producto a los grandes avances en la automatización e informatización que demandan un elevado trabajo mental. Estas condiciones han posibilitado la aparición en las últimas décadas de un conjunto de nuevas formas de trabajo, que a pesar de que se les atribuyen diversas ventajas sobre las formas tradicionales, no dejan de contar con innumerables factores de riesgo a la salud del trabajador que son desconocidos por la novedad del tema. La presente propuesta tiene como objetivo fundamentar fisiológicamente la aparición de la fatiga mental y sus consecuencias, las normas internacionales relacionadas con el tema de la fatiga mental, los principales modelos e indicadores empleados para la valoración de la fatiga mental y posibles medidas para reducir la fatiga mental en el ámbito laboral. Se enmarca en una de las directrices de trabajo establecidas por la Asociación Internacional de Ergonomía (IEA): la Ergonomía Cognitiva. La investigación constituye un estudio teórico de la fatiga mental en el contexto laboral, es de tipo descriptivo y recopilatorio, a través de revisión bibliográfica del tema. Para ello se realiza una búsqueda sistemática a través del buscador Google Académico, los repositorios de tesis de pregrado de Ingeniería Industrial de la Universidad de Matanzas y repositorios de tesis de doctorados en Ciencias Técnicas en Cuba. Se emplea como herramientas el software VOS viewer para un análisis bibliométrico y representación gráfica de la información recopilada, así como también el gestor bibliográfico EndNote. Se muestran como resultados los elementos teóricos vinculados a la aparición de la fatiga mental, se identifican indicadores biomoleculares, fisiológicos, psicofisiológicos y psicológicos para la valoración de la fatiga mental de trabajo, así como modelos respaldados en la experiencia investigativa de investigadores del tema. También se identifican medidas organizativas a nivel empresarial e individual que permiten prevenir episodios de fatiga mental que perjudiquen la salud del trabajador. La adecuación del trabajo mental a las capacidades del hombre resulta muy compleja dada la gran cantidad de variables que intervienen, por lo que resulta de vital importancia identificar los posibles riesgos que puedan afectar la salud del trabajador en puestos de trabajado con elevadas exigencias cognitivas y prevenir los mismos para lograr una calidad de vida en el ámbito laboral.

Palabras clave: fatiga mental, esfuerzo cognitivo, indicadores, trabajo mental

Relevancia para la ergonomía:

- La integraciòn y complementación de un conjunto de elementos teóricos y prácticos que fundamentan el estudio de la fatiga mental.
- El análisis de los principales indicadores individuales utilizados para la valoración del trabajo mental a partir de las experiencias recopiladas por los autores en el análisis de la literatura nacional e internacional.
- La propuesta de medidas a diferentes niveles organizativos para prevenir los efectos negativos de la fatiga en el ámbito laboral.
- La publicación del estudio brinda un material docente para el estudio del tema en asignaturas relacionadas con la Ergonomía y Seguridad y Salud en el Trabajo.

Abstract:

Humanity has evolved at an accelerated pace as a result of the great advances in automation and computerization, which demands high mental work. In recent decades, the emergence of a set of new forms of work, which despite the fact that various advantages are attributed to them over traditional forms, do not cease to have innumerable risk factors for the health of the worker that are unknown due to the novelty of the subject. The objective of the present proposal is to provide a physiological basis for the appearance of mental fatigue and its consequences, the international standards related to the subject of mental fatigue, the main models and indicators used for the assessment of mental fatigue and possible measures to reduce mental fatigue in the workplace. It is part of one of the work guidelines established by the International Ergonomics Association (IEA): Cognitive Ergonomics. The research constitutes a theoretical study of mental fatigue in the work context, a descriptive compilation through a bibliographic review of the subject. For this, a systematic search is carried out through the Google Scholar search engine, the repositories of undergraduate thesis of Industrial Engineering of the University of Matanzas and repositories of doctoral theses in Technical Sciences in Cuba. The VOS viewer software is used as tools for a bibliometric analysis and graphic representation of the information collected, as well as the EndNote bibliographic manager. The theoretical elements linked to the appearance of mental fatigue are shown as results, biomolecular, physiological, psychophysiological and psychological indicators are identified for the assessment of mental fatigue at work, as well as models supported by the investigative experience of researchers on the subject. Organizational measures are also identified at the company and individual level that allow preventing episodes of mental fatigue that harm the health of the worker. The adequacy of mental work to the capacities of man is very complex given the large number of variables involved, so it is vitally important to identify the possible risks that may affect the health of the worker in jobs with high cognitive demands and prevent the same to achieve a quality of life in the workplace.

Keywords: mental fatigue, cognitive effort, indicators, mental work

Relevance to Ergonomics:

- The integration and completion of a set of theoretical and practical elements that support the study of mental fatigue.
- The analysis of the main individual indicators used for the assessment of mental work from the experiences collected by the authors in the analysis of national and international literature.
- The proposal of measures at different organizational levels to prevent the negative effects of fatigue in the workplace.
- The publication of the study provides teaching material for the study of the subject in subjects related to Ergonomics and Occupational Health and Safety.

1. INTRODUCTION

Scientific-technical development has led to qualitatively different changes in working conditions. More and more often man finds himself before professions that, unlike what happened until the beginning of the twentieth century, demand from the worker not physical strength but attention, vigilance and control of the process.

From this historical context, changes occurred which transformed the concept of work and the role of the human factor. Changes which marked considerably the management of human resources, mainly by the new requirements imposed on the worker in the age of information.

Exceeding the limits of mental abilities can be as harmful or more detrimental to the normal development of work than exceeding physical abilities, since a job with mental characteristics is usually accompanied by greater responsibility, which can derive from an error in the performance of a worker in an accident of great consequences, as in boiler operations, or in quality control points (Viña, 1987). Doctors or teachers are not exempt from these new requirements. Even staff working in the broad service sector, in direct contact with the customer, are subject to additional stresses stemming from their sometimes very pressing demands.

The large number of variables involved in the origin and evolution of mental fatigue has caused disparity of criteria around its definition, however it is oftendefined as the transient loss of the ability to perform a job, following the prolonged realization of it (Almirall, 1987). More simply d temporaryreduction of mental functional efficiency (NTP 179).

2. OBJECTIVES

1. To explain the physiological origin the appearance of mental fatigue and its consequences.
2. To present the international standards related to the issue of mental fatigue.
3. To analyze the main models and indicators used for the assessment of mental fatigue.

4. To describe possible measures to reduce mental fatigue in the workplace.

3. METODOLOGY

The research is a descriptive compilation. A systematic review of scientific documents and articles in both Spanish and English is carried out, dedicated to the physiological basis of the appearance of mental fatigue and its consequences, international standards related to the topic of mental fatigue, the main models and indicators used for the assessment of mental fatigue and possible measures to reduce mental fatigue in the workplace. VOS viewer software and EndNote X7 are used together for map creation and graphical representation.

First, a Search is carried out in Google Scholar, of documents and publications with respect to the topics under study. Search which was done in both Spanish and English. Subsequently, the same procedure is carried out in the repositories of undergraduate theses of Industrial Engineering of the University of Matanzas and repositories of doctoral theses in Technical Sciences in Cuba. It is introduced as the language of the studies that were first in Spanish and later in English. The bibliographic references of the selected articles are also analyzed in order to rescue other studies potentially included for the review. To proceed with the selection, the abstracts and keywords of each article and, if necessary, the complete articles are reviewed in order to decide if it is relevant to this topic. The full texts of the articles are reviewed and those that are most related to the topic are collected. Systematic reviews collect information on authorship, year, introduction, sources of information, and conclusions.

For the work with the bibliometric maps, it is necessary to use the EndNote X7 where the authors, years, title and keywords of the bibliography used are collected. The EndNote files are exported in RIS format to be able to incorporate it into the VOS viewer software and through it represent the keywords, as well as a bibliometric analysis and the graphic representation of the information collected by different authors.

4. RESULTS

Basically the process of mental work consists of the following stages (Almirall, 2009; Alonso Becerra, 2007):

- Receipt of information:

The one executed by sensory receptors, mainly vision and hearing, although senses such as touch, smell and taste can intervene in certain professions.

These stimuli must be within the range of sensitivity of the receiving neurons so that their process of conversion into a nerve impulse can begin, whose fundamental characteristic is that, regardless of their electromagnetic character, in vision, chemical in the case of taste and smell, as well as mechanical in touch and hearing, they are transformed intoa small electric current. The delay of this stage is between 1 and 38 ms.

- Transmission of the sensory receptor to the Central Nervous System (CNS):

Once the stimulus is received, captured by the sensory receptor and converted into electric current, it begins to move through the neurons that connect it to the CNS, that is, the nerves. Its intensity will depend on the magnitude of the stimulus.

The final destination of their nature: those that do not require high information processing, such as vegetative functions or stereotyped actions, will be carried to the spinal cord and lower structures of the brain. The stimuli that do require interpretation, analysis, comparison with previous experiences or even associations with feelings or values will be directed to the higher structures of the brain, specifically to certain diffuse regions of the cerebral cortex, with particular importance in the frontal lobe, maximum expressionof the evolution of species. The delay of this stage is between 2 and 100 ms.

- Information Processing:

Regardless of where it is directed in nerve impulse, there is a group of neurons responsible for responding to the stimulus received. Those that by their nature, are directed towards the medulla or lower regions of the brain, their processing is very fast, even reflex, because the neurons responsible for responding to the stimulus are already connected. This process is known as dynamic stereotyping and is generated as a result of the successive repetition of stimulus and its consequent response. It justifies the importance of training to start a new job.

Those stimuli that, due to their complexity, are directed to specific regions of the cerebral cortex, are received by neurons that interpret the nerve impulse, compare it with past experiences, analyze it and decide the response they will provide. They are the ones who make the decisions for an order to be executed. The delay of this stage is between 70 and 300 ms.

- Transmission of the CNS to the effector:

Once the decision is made in the CNS, another nerve impulse, the bearer of the order, is generated and travels through the nerves to the executors: muscles or glands.

It is of interest that, when this nerve impulse is directed towards the lower extremities to activate the muscle, it takes a significantly longer time than when the response is through the hands, since the speed of its conduction ranges from 0.5 to 130 m / s, depending on the thickness of the nerve fiber. This is a factor to be taken into account in the design or selection of certain means of production in which reaction time is essential to avoid accidents. The delay of this stage is between 10 and 20 ms.

- Effector:

Relevant is the motor response because it is the main way to control the vast majority of work activities. Each muscle group has its latency period, that is, the delay in responding to the order.

The muscles of the legs and feet have a much longer period than that of the hands and fingers which make it convenient to assign them functions whenit is required of little time. The delay of this stage is between 30 and 70 ms.

Figure 1 shows the graphic representation of the structures committed to mental work.

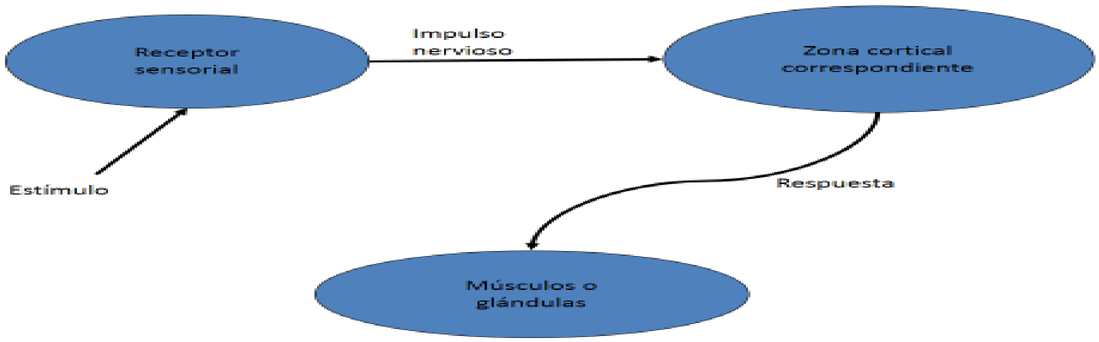

Figure 1. Graphic representation of structures committed to mental work.

4.1. Physiological and psychological foundations of mental fatigue

In the CNS there is a special nerve formation that exercises the role of a mechanism that regulates the state of the entire system called: Reticular Formation. This, due to its functional properties, modulates the general state of the system, providing a level of activation depending on the interpretation made of the stimulus received.

This structure is arranged vertically along the CNS, exercising a dynamic and systemic function. That is, in the face of emerging situations, the organism mobilizes its response mechanisms.

The mentioned structure maintains a close functional relationship with the endocrine system and the immune system through visceral innervation and the humoral pathway. Reason why is entrusted with important vital functions.

The great difficulty that arises in the approach to mental fatigue studies lies in the fact that the preparation made by the whole organism to face the intense stimuli coming from the outside, whether of any nature, is the preparation for action.

For thousands of years, the predisposition to action was man's defense mechanism to face and defend himself from a hostile environment. This preparation involves the cardiovascular, endocrine, sensory, digestive, respiratory system, in short, its systemic character compromises multiple sub-systems of the organism with the sole purpose of being ready for action.

Some of these manifestations are:

- Increased heart rate, blood pressure, and respiratory rate to meet oxygen and nutrient demands at the cellular level.
- Increased sweating to promote thermoregulation from the metabolic heat gain that will occur with muscle contraction due to the inefficiency of the musculoskeletal system in converting the energy released at the cellular level into work.
- Increases in the levels of cholesterol, triglyceridesand glucose to have ready the fuel capable of satisfying the high energy expenditure.
- Alterations in the sensory organs.

However, the answer of modern man, in many of the current professions, is not action, so the preparation carried out does not have its natural trigger. This is the case of professions such as doctors, teachers, managers, pilots, police, bankers, laboratorians, among many other professions.

In a study by Acosta Prieto and García Almeida (2021), based on the bibliographic search and the use of Vos viewer software, the co-occurrence of 239 keywords (with the occurrence of 1) is related to identify the professions most studied by researchers in the area of Cognitive Ergonomics. As shown in Figure 2 la profession that resulted in greater density was that of nursing that surpassed the others with a total of 58 occurrences, followed by health personnel such as doctors, psychologists, technicians in the health area, dentists, surgeons and anesthesiologists with 37 and teachers with 30 occurrences. To a lesser extent there are students with 7 occurrences, military with 4 and drivers with 3, the other professions present an occurrence of 1 to 2.

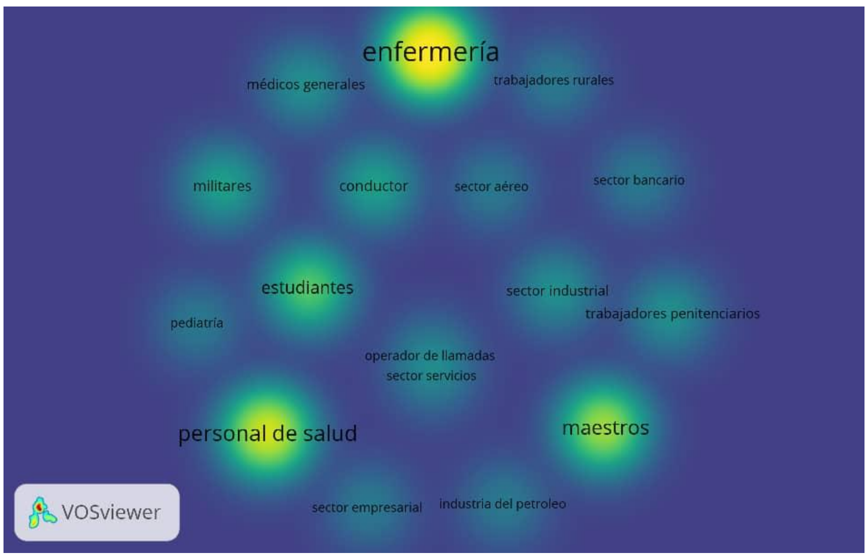

Figure 2. Density map showing the main professions cited in the bibliography.

This gap in the professions existing today causes, often in the long term, various diseases and disorders of a very diverse nature.

It is important to highlight the role played by the individuality of the patterns of response to tensions maintained for a long time.

Man refracts the stimulus in his personality, with the multiple variables that make it up, manifesting a certain response. This explains how in the face of identical stimuli there are different responses of individuals.

Figure 3 shows a group of factors that shape mental workload and its effects (de Arquer, 1999).

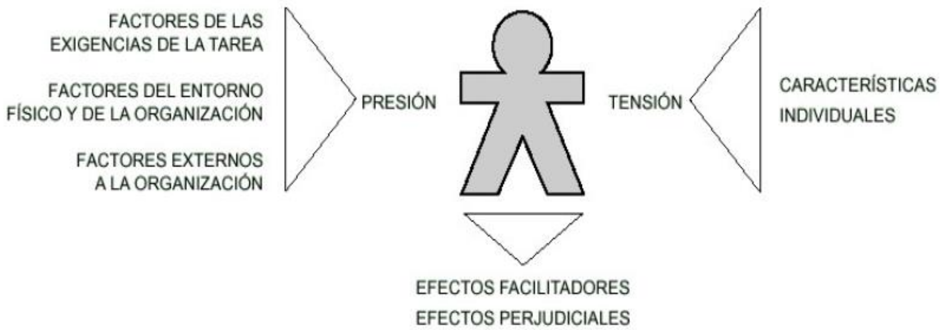

Figura 3. Pressure and tension factors that affect the individual and their effects.

4.2. Classification of types of mental fatigue

With fatigue there is a progressive weakening of the endurance capacity of the person subjected to intense and / or prolonged effort. The classification of mentalfatigue patients according to Arquer (1995)::

- Intellectual fatigue: In professions that demand information processing, document interpretation, report writing. Creative activities or technological innovations are included in this category.
- Nervous fatigue: It appears rather in works of a very repetitive nature and with a very fast production rate, typical in chain lines. It is conditioned by the pressure of the demands of customers, or of the managers. The urgency to fulfill the task and the little time available is one of its causes.
- Sensory fatigue: many jobs whose demands on the organs of the senses are high: inspection work, laboratory, computer scientists, tasters, musicians or even workers exposed to constant noise or bad smells.
- Psychological fatigue: sand generate in jobs that demand a lot of responsibility and speed in decision making. Psychosocial pressures exerted by autocratic management styles, unfavorable human relationships or mobbing are frequent causes of the appearance of this type of fatigue.
- Emotional fatigue: typicalof professions that require expressing oneself in public or receiving very strong stimuli, both positive and negative. It is to which the artists, teachers, managers, demands of the "scene" are exposed. Doctors and in general health personnel, who day by day deal with patients and family members are exposed. The personality plays a determining role in its intensity, which justifies the varied responses to equal stimuli.

There are professions in which several of the aforementioned classifications are present.

4.3. Human Health Effects of Mental Fatigue

Today's lifestyles are increasingly demanding of mental efforts. It is no longer only the psychological demand derived from the profession: it is the internet at home, television, reading the press or the car. All point more and more to less physical exertion and more mental work. A little more than a century is not enough for man's adaptation to these new conditions.

The slogan that "the substitution of physical and mental effort favors the health of the worker in all circumstances" is only valid when they are limited to cognitive abilities. Otherwise, their harmful effects are worse.

For thousands of years, in the slow process of adaptation of man to the environment, muscle contraction was decisive for his survival.

What can a little more than 100 years represent for such a sharp change in living conditions? Could it be pretended that in that short span of time, the human response, which had always been preparation for action, was different? They continue to prepare themselves just like the ancestors in the face of intense emotions, but the current response is not physical, but mental. This justifies a huge group of symptoms and pathologies of a very non-specific nature. In some cases, product of the accumulation of glucose, triglycerides or cholesterol in the circulatory system that was not metabolized. In other cases, cardiovascular disorders due to greater segregation of adrenaline, noradrenaline or dopamine. The nervous tensions maintained gravitate on the CNS causing alterations of a very diverse nature.

In a study by Encinas Alemán (2021) shown in Figure 4, the bibliographic study map is presented based on the co-occurrence of 100 keywords with occurrence 1 and 33 items, 6 groups; in it the consequences of mental fatigue that the literature collects are shown, where it was observed that occupational accidents, demotivation, cardiovascular diseases and memory errors stood out from the others and proved to be the most worrying negative effects on the health and well-being of the worker. However, other consequences such as kidney disorders, stiff joints and sleep apnea are not addressed in greater depth.

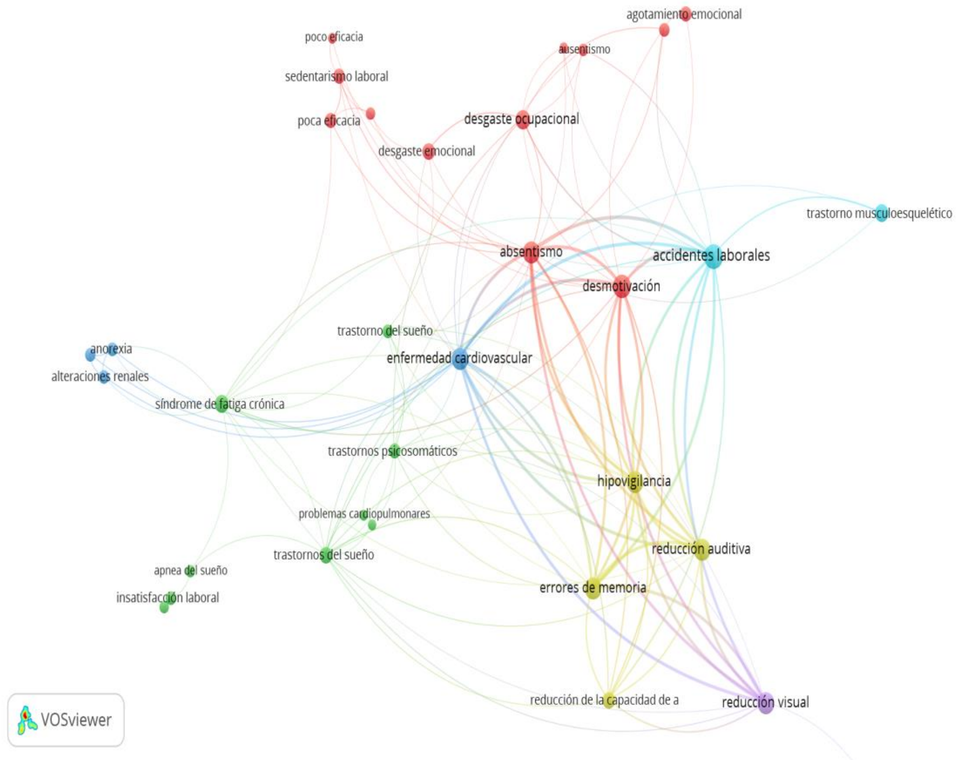

Figure 4. Bibliometric map on the consequences of mental fatigue.

Based on the identification of the consequences associated with mental fatigue and in accordance with Viña and Gregori (1987), the following pathologies are associated with workers with cognitive demands in their workplace: ulcers, migraine, anxiety, frustration, ischemia, cardiovascular disorders, atherosclerosis, diabetes, digestive disorders, especially gastritis, asthma, dermatological diseases, sexual dysfunctions and even cancer.

People who have chronic diseases such as: diabetes, heart failure, ischemic heart disease, cerebral vascular diseases, in situations of stress can manifest a worsening of these diseases.

Another aspect of approaching the negative effects that mental work produces in man is given by the syndromes that appear. Several classifications have been made according to their characteristics:

- Burnout syndrome
- Chronic fatigue syndrome (Yuppie Flu)
- Information fatigue syndrome (Technostress)

By way of summary, the negative effects that can be manifested defined by Carvalho and García (2011) are:

- Low worker productivity.
- Increase in occupational accidents

- The difficulty in maintaining quality according to established standards.
- Decreased sensations
- Decreased motor coordination
- Difficulty speaking
- Difficulty concentrating

4.4. Sources of mental pressure that affect the individual

Among the main sources of mental pressure that affect the individual according to de Arquer (1999), Ferrer (2006) and Salvendy (2012) can be found:

1. The requirements of the task:

- Sustained attention to one or more sources of information.

- Number and quality of the information to be processed and the sources of information, how available they are, the inferences that exist.

- The level of responsibility that has the decision to be made.

- The work-rest regime: working hours, breaks, shift work.

2. Working conditions: It is of the utmost importance that in the organization, they strive and work to guarantee the optimal conditions that enable the good performance of the work, for this it is necessary to create an environment that facilitates the perception and attention of each person who works in the area, maintaining adequate control over some elements that may prevent the fulfillment of the desired objectives, such as:

- Excess Noise.
- Poor design of the lighting system.
- Unsuitable thermal conditions.
- Poor air quality.

3. Individual characteristics: Each person has different levels of tolerance and / or reaction to fatigue, which explains the variations observed in the performance and health of workers in similar activities.

In general, skills and aptitudes, general health and personal needs and lifestyle can be highlighted, as well as age, level of preparation for the task, personality characteristics, motivation, satisfaction and interest.

4.Social and organizational factors, taking into consideration the criteria of Blakman Briones (2014):Among the elements of the organization that can affect the worker are: management styles, conflicts, social relations, communication, management of stimuli, promotion policies, possibilities of improvement and teamwork.

4.5. Individual indicators used for the assessment of mental work

Very diverse and varied indicators to assess mental fatigue have been applied more or less frequently by researchers; however, there is agreement that these are grouped into 4 levels: biomolecular, physiological, psychological and psychophysiological. The studies consist of applying the indicators before and after subjecting the individual to cognitive demands that may or may not cause the presence of mental load, that is, an experimental design is established during the working day with pre-test and post-test. After obtaining the data, the comparison of paired samples is developed, which makes it possible to determine if the indicator behaves with significant differences and in this way to be able to infer if there is presence of mental fatigue.

- Biomolecular indicators

Biomolecular indicators include measuring a nutrient or its metabolites in blood, feces or urine or measuring a variety of compounds in blood and other tissues that are related to nutritional status. The most frequently studied asindicators of mental work are cholesterol, triglycerides and glucose.

a) Cholesterol:

Its main biological function is to serve as the basis for the synthesis of steroids and bile acids. For this and other reasons, such as its wide distribution in the body, and its role in the pathogenesis of arteriosclerosis, it has been the most studied of this group of lipid substances.

b) Triglycerides

They constitute the main form of reserve of fatty acids in the body; they accumulate in large quantities in fat cells and circulate in the blood as part of lipoproteins.

They have a double origin:

- Exogenous: synthesized in the small intestine, from fat from the diet.
- Endogenous: synthesized by the liver, from different sources (glucose, fatty acids, etc.) and under the influence of various stimuli.

c) Glucose

Its oxidative metabolism provides most of the energy used by the body, its concentrations range this 70 and 100 mg / dl on an empty stomach.

Glucose is transformed through the metabolic pathway by glycolysis, which plays a key role in energy metabolism, by providing an important part of the energy used by most organisms.

In experiences carried out through biochemical tests, an increase in blood levels of these biochemical indicators has been observed after performing mental work. Presumably, in the systemic preparation of the organism for the performance of physical work there has been an increase in them.

According to Ferrer (2006) no proportional relationship has been found between the measured parameter and the level of mental load, however Basantes Vaca (2016) analyzed this situation in applicants and professional drivers, specifically from the study of variables such as: cholesterol, triglycerides, glucose and apolipoprotein B; a comparison between before and after performing the cognitive task show significant differences in these biomolecular indicators.

- Physiological level

Physiological indicators are used under the assumption that the mental load of a task can be assessed through the degree of physiological activation. Some disadvantages are appreciated where their enormous implementation requirements stand out, the poor acceptance they receive from the subjects participating in the evaluation and, most importantly, the doubts about their validity as indices of the mental load of work.

However, several of them of relative use and acceptance will be commented.

a) Heart rate variability (V.F.C.)

The physiological indicator most associated with mental effort, although it has also been controversial.

V.F.C. is an alteration in the degree of excitability of cardiac tissues as a result of a variation in the origin of the excited electrical stimulus.

The experiences carried out have shown a tendency to decrease in subjects exposed to cognitive efforts.

The physiological origin of this decrease is attributed to various circulatory reflexes.

Another cause is different vasomotor reflexes, which as a result of variation in vagal tone, may be the cause of sinus arrhythmia and suggest that these variations may be caused by CNS ataxia, perhaps influenced by the action of Reticular Formation.

The magnitude of their variation is largely compromised by individual factors, external factors, which is probably the cause of the controversial results found.

There is a fairly general consensus that the V.F.C. is sensitive to mental effort at the starting point of various experiences made in professions that involve the CNS.

Recent research has suggested that V.F.C may even reflect, before any other indicator, the intensity of mental exertion, even momentarily.

According to Ferrer (2006), HRV depends on the value of Heart Rate, and temperature, among others, so its specificity is eliminated. It is also an expensive technique because it is necessary to obtain the frequency spectrum of the R-R intervals through Furier analysis, although it can also be done manually, if you have the electrocardiographic record.

It is calculated from the following expression:

$$VFC \equiv \frac{Intervalo.m\grave{a}x - Intervalo.\min}{Intervalo.medio}$$

(1)

b) The electroencephalogram

The electrical activity of the cerebral cortex has a direct relationship with the processes of information acquisition and processing.

In cortical activity, four different frequency rhythms have been identified:

- Alpha: between 8 and 13 c.p.s.
- Beta: between 14 and 30 c.p.s.
- Delta: between 0.5 and 3.5 c.p.s.
- Theta: between 4 and 7 c.p.s.

In these studies, the alpha waves have been observed greatly diminished and even disappear when the subject has a mental activity and increase when he enters a state of relaxation close to drowsiness.

However, the authors of these studies (Ferrer, 2006) propose that their validity is not very high because:

- It has not always decreased during mental tasks. Sometimes it increases.
- The different levels of mental load are not established.
- Long-term variations are difficult to interpret.

Finally, they point out that it is an invasive technique since it requires placing electrodes on the scalp and requires a very complex computer system.

- Psychophysiological Level

a) Simple Reaction Time (TRS):

Defined as the time between the reception of the stimulus and its consequent response.

The characteristic of this mode of reaction time is that a single stimulus corresponds to a single response.

The TRS is able to show the functional deficit produced as a result of prolonged activities with high emotional load and with the participation of the visual analyzer.

In addition to the delays in which TR can be broken down, it is influenced by individual characteristics.

The TRS is increased when the activity requires a considerable mental load and therefore the fatigue is greater.

Values considered normal are around 0.5 s.

b) Redundant Simple Reaction Time (TRSR):

It can be appreciated when the information carried by a stimulus reaches the subject through two different sensory channels. The most frequent are hearing and vision simultaneously. Used in pressure safety signals in steam boilers, in fire alarm signals and all those means of production that require high quality for their safety.

Their time is slightly less than the TRS and increases with mental work.

c) Complex Reaction Time (CRT)

In these reaction times there can be several well-determined stimuli and several well-fixed responses, each response is associated with a single stimulus; but the subject can also be asked to respond only to one of the stimuli, or to some. CRT is longer than TRS for usual stimuli, as demonstrated by early studies by Baxter (1942) and Sidowski, Morgan and Eckstrand (1958). Although all the factors mentioned above regarding TRS intervene in CRT, there are some that acquire a preponderant place in the present case, or may even be the most specific of these times, so there is a prolongation of time in relation to TRS; this is particularly the case for psychic factors, so it turns out that CRT is of great interest to psychology (Rodríguez Prado, 2010; Viña and Gregori, 1987).

The only disadvantage it has is that the level of precision and accuracy of the individual is put into play by having to recognize different stimuli, which can affect the excessive increase in the variation of CRT between before and after the development of an activity with cognitive demands.

Based on studies carried out by Gómez Yanes (2019), the AMIS software is created, whose acronym meansteration in milliseconds of interfaces and sounds, it allows to assess the presence of mental fatigue in the person in which it is applied through the use of the psychophysiological indicator reaction time in three variants: Simple Reaction Time, Redundant Simple Reaction Time and Complex Reaction Time; with which you can compare the behavior of certain people when developing cognitive activities. Figure 5 shows the AMIS software menu and its variants for measuring reaction time.

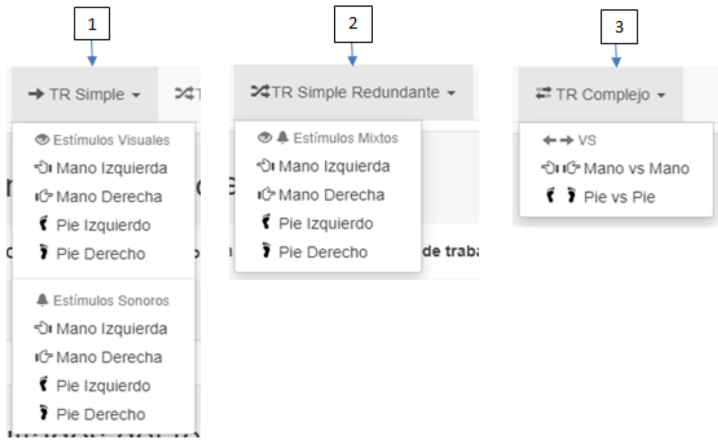

Figure 5. AMIS software menu to measure different variants of Reaction Time.

d) Tactile Discrimination Threshold (UDT):

The minimum distance in which it is possible to distinguish two tactile stimuli that are remarkably sensitive to changes in the level of activity of the CNS, which allows it to be introduced as an indicator of mental fatigue.

In experiences carried out it has shown a significant decrease in the acuity of touch when there is an overload of the visual analyzer, although it has also shown sensitivity in other professions of a cognitive nature.

Tactile sensitivity varies considerably in different regions of the skin, so for practical reasons, the inner region of the forearm has been used for measurement. In this area its values at rest oscillate between 13-18 mm, increasing between 6-8 mm with mental workload, according to the average values found in numerous experiences.

To evaluate it, the conversion of a king's foot with two blunt tips, adapted to a stesiometer, can be used.

e) Chromatic Discrimination Frequency (CDF):

It consists of determining the minimum frequency at which the chromatic composition of a disc that gradually decreases its speed is discriminated.

The FDC is a parameter of excitability of the visual pathways and presumably of the entire CNS, because although it has only been used until now in workers whose professions demand the help of the visual analyzer, it may be able to reflect the general dysfunction of this system, since the nonspecific characteristic of Reticular Training affects all the sensory and motor functions of the organism.

The average values in experiences in laboratorians, teachers, chemists, punters have been 10 612 rpm after 8 working hours, while at the beginning they have been 8 240 rpm in studies of García (2017).

In research by Domínguez García et al. (2020) a set of improvements to the equipment is proposed to optimize its operation, figure 6 shows the equipment used to measure the indicator.

Figura 6. Equipment to measure the FDC

e) Galvanic Cutaneous Resistance (RGC)

Consists of determining the level of decrease in the electrical resistance of the skin, as a result of the increase in sweating, which, being an electrolyte, facilitates the passage of current.

The evaporation of sweat plays a decisive role, together with peripheral vasodilation, in the maintenance of thermoregulation. Its increase is explained by the fact that, in emerging situations, an increase in the metabolic level is expected to support the muscle contraction essential for action and therefore it is necessary to counteract this increase in heat to maintain the thermal balance.

Two electrodes placed on the palm and back of the hand detect the increase in theintensity of the electric current.

f) Depth Perception

This psychophysiological indicator has been, of those selected, the least recurrent in the literature. However, its poor empirical support has shown satisfactory results.

The test is carried out with a device called Caja Gover, which consists of three rods arranged vertically, the two of the fixed ends and that of the mobile center, which is operated slowly and continuously by the experimenter. In research by Martínez Baez et al. (2020) a set of improvements to the equipment is proposed to optimize its operation, in figure 7 the final design version of the Gover Box is shown.

Figura 7. Gover box to measure Depth Perception indicator.

The lighting level inside the Gover Box was set at 400 luxes.

The subject evaluated is located 2 meters from the Gover Box and by an opening conveniently located in front of it must indicate when he observes the three rods aligned as exactly as possible. A scale shows the deviations found with respect to perfect alignment, the result of which is expected to be greater when the individual is fatigued.

- Psychological Level

There is a wide variety of subjective and/or psychological procedures that are useful for assessing mental load. One of the most recognized is the Yoshitake Test.

A simple survey that assesses very subjectively the feeling of fatigue felt by the individual was designed by Carvalho and García (2011), which takes into account aspects that are necessaryto incorporate into the analysis. Below are some of the questions shown in the survey:

1. Do you feel tired in your body?
2. Do you feel tired in your legs?
3. Do you have a desire to lie down?
4. Do you feel difficulty thinking?
5. Do you get tired when talking?
6. Do you feel unable to fix your attention?
7. Do you hold incorrect positions?
8. Do you feel dispersion in your attention?
9. Do you feel difficulty expressing yourself?
10. Do you feel difficulty organizing your ideas?

4.5.1. Analysis of the most limited usage indicators

One of the most important aspects is the analysis of those indicators that have had a less frequent empirical endorsement. This allows the selection of those that have had more reliable results, since the validity of some of them is disputed. It is appropriate to point out that in this science due to the novelty of the subject it addresses, the cost of the equipment it uses, the relatively small number of institutions that study the problem and the level of specialization of human resources it requires, the literature does not include a large number of practical studies. Therefore, an analysis will be made of the causes that have limited its use and that different authors in one way or another, have explicitly or implicitly pointed it out.

a) For responding very markedly to other demands of the organism (physical exertion, pathological states, etc.):

- Rhythm
- Respiratory Rate
- Blood pressure

b) Due to difficulties in experimental control (since it is difficult to achieve dietary control in the subjects evaluated):

- Biomolecular indicators: Variation of cholesterol, triglycerides and glucose

c) For being techniques that require more complex equipment

- Evoked potentials.
- Electroencephalography.
- Galvanic Cutaneous Resistance.

d) For constituting techniques that are included in functional levels that current technology already incorporates:

- Associated Simple Reaction Time
- Manual Dexterity
- Critical Frequency of Fusion.

e) Less used indicators

- Eye activity
- Pupillary diameter
- Flicker frequency

For the assessment of mental work and to be able to infer the degree of affectation of the individual by the mental load carried out, it is essential to incorporate variables of the 4 levels mentioned above: biomolecular, physiological, psychophysiological and psychological. Note that this assessment is made from the deviations of the parameters of each level evaluated with respect to its values in the resting state.

Finally, it should be noted that, due to the novelty of the subject, there are divergent criteria, doubts and even criteria opposed to the sensitivity of the aforementioned indicators to cognitive efforts.

4.6. General models for valuing mental work

The mental work evaluated only from the deviations found in the aforementioned indicators is very poor. It is necessary to select and integrate them so that the result is more reliable.

In this sense, several general models have been developed that will be briefly discussed below:

a) SWAT "Subjective Work Load Assessment Technique"

This indicator was developed by Reid et al. (1981) due to the need for a workload measure with known metric properties, useful in work situations.

SWAT collects data in a non-intrusive manner and uses a scaling procedure known as a set. Get answers in a work situation using three descriptors for each of the three factors with which you operationally define the mental load of work. This approach minimizes the time required to give answers in the scoring phase and reduces the number and complexity of descriptors that the person must memorize. However, it presents two problems: it is not very sensitive for low mental workloads and needs a lot of time for the first phase of building the scale.

This technique captures the multidimensional nature of the mental load, which can be explained by three factors:

1. The workload by aspects of temporary type ("time load'): available time, time margins.

2. Mental effort load: decision making, estimates and calculations, attending to sources of information, immediate and long-term memory, etc.

3. The psychological stress load, that is, by anything that contributes to the confusion, frustration and anxiety of the worker: motivation, training or training, fatigue, health, mental state, fear of physical harm, fear of failure, tension, ignorance of work, disorientation and physical stressors: temperature, vibrations, noise, etc., which even to a moderate degree, can involve a greater effort of the person and some discomfort or irritation.

The stages where the method is developed are:

Scale construction phase: People are familiarized with the descriptors and data are obtained regarding how these dimensions are combined to create each specific personal impression of workload. The person is asked to order different (hypothetical) activities based on their perception of the workload. For each activity you must specify the specific distribution of load across the three dimensions. This data is transformed into a workload range scale ranging from 0 to 100.

Scoring phase: Information about the workload associated with the performance of an activity is collected by assigning a score from 1 to 3 in each of the three dimensions. The scale value associated with this combination (obtained in the previous phase) is therefore assigned as the workload value for such an activity.

b) NASA-TLX (Task Load Index):

Method developed by Hart and Staveland (1988). It is the technique used in NASA to evaluate the mental load and in its six dimensions of charge.

Like SWAT, the implementation procedure consists of two phases.

Weighting phase: Prior to the performance of the task, it consists of making the 15 binary comparisons of the 6 dimensions, choosing, from each pair, the one that the subject perceives as the greatest source of load. For each dimension a weight is obtained that is given by the number of times it has been selected in binary comparisons. This weight can vary between 0 (the dimension has not been chosen in any of the comparisons) and 5 (the dimension has been chosen in all the comparisons in which it appeared).

Assessment phase: Immediately after performing the task, the subject has to estimate, on a scale of 0 to 100, divided into intervals of 5 units, the mental load of said task due to each of the 6 dimensions.

With the data obtained in these two phases, an overall index of the mental load of the task is calculated.

c) LEST Method (Laboratory ofEconomics and Sociology of Work)

Suitable for situations where the work is very varied. The purpose is to elaborate a diagnosis of working conditions from the information obtained from the observation guide. In addition, it allows the comparison between the results predicted through the LEST matrix (the subjective) and the expression of the workers regarding their job (the objective) (Morral, 2010).

The information serves as the basis for developing histograms that show the unsatisfactory conditions existing in the position being analyzed. The evaluation factors and parameters that are analyzed in LEST are shown in Table 1, which is a summary of the information obtained from the observation guide of the method.

Table 1. Workload Factors identified by LEST method.

Workload factors	**Elements to be evaluated**
Physical Environment	Thermal environment, noise, lighting, vibrations
Physical Load	Static load (postures), dynamic loading
Mental Load	Pressure of time, complexity-speed, attention and thoroughness
Psychosocial aspects	Initiative, social status, communications, cooperation, product identification, duration, type, existence of breaks

d) MAPFRE Foundation's Double Task Method.

It seeks to measure, indirectly, what is the fraction of mental capacity that is not used in a given task (main task).

The method is based on the notion of "residual capacity" or unused during work that requires a load lower than the maximum capacity of the subject. It consists of giving a second job (secondary task) until saturating the capacity of the operator, evaluating the deterioration of the test.

The choice of the second task must be adjusted to each case, in such a way that it will be limited to the following conditions:

- The ability to work will not vary.
- It will not interfere with the main task.
- It must be gradual and ponderable.

e) Tabulated method

It collects all those factors that, to a greater or lesser degree, can intervene in the load and / or mental fatigue and give them the form of a questionnaire so that each of them can be answered on an assessment scale of intervention in our task (much, much, normal, little and very little)

In this way, and taking into account the time of task or global work that is going to be carried out, the characteristics of the individual and the knowledge about the considerations that must be taken into account about the load and mental fatigue, to be able to determine which are those factors (of which their level of intervention in the analyzed task has already been evaluated) that are considered to be influencing to a greater degree for what a "weight" will be given according to its importance in the intervention

The final objective will be to intervene in those factors that have greater weight, in such a way that an attempt is made to reduce their intervention to lower values. To the extent that you are able to intervene in a greater number of factors with the minimum your degree of intervention in the task, you will be high load and reduce influencing the reduction of the load and mental fatigue.

f) Cooper - Harper rating scale

Figure 8 presents the scheme of assessment of mental load by Cooper and Kelly (1993), modified by Skipper, with which a rapid assessment of the mental workload to which workers are subjected can be established.

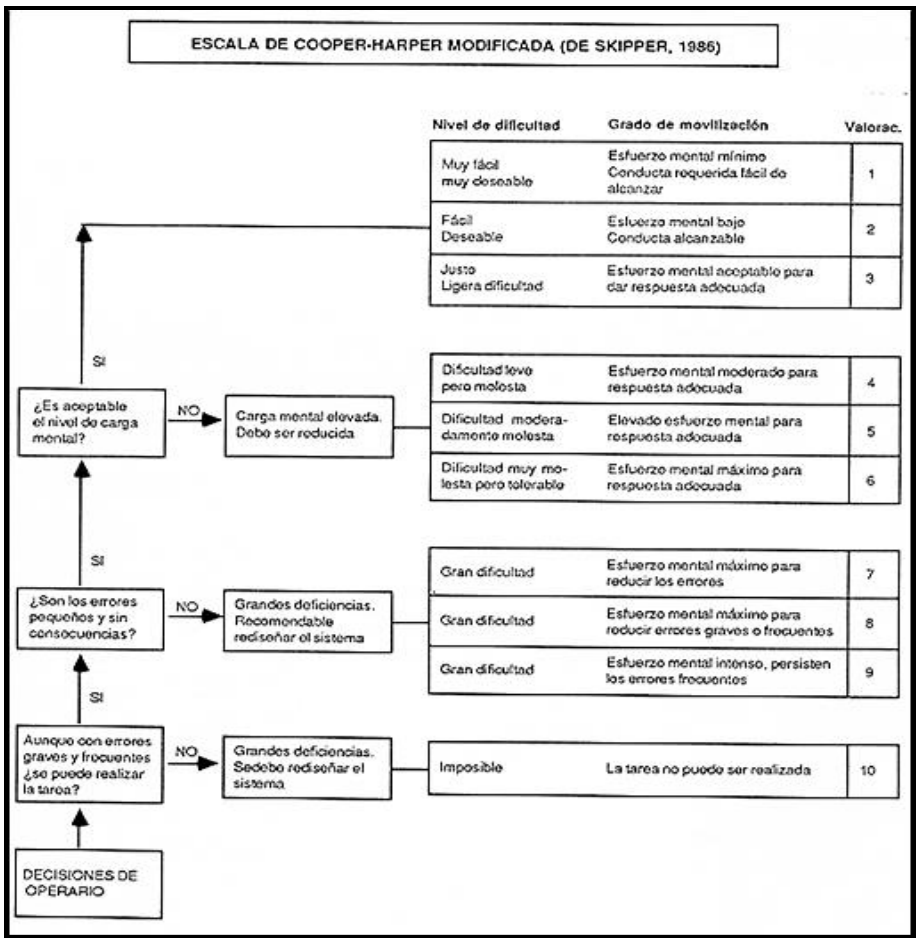

Figure 8. Cooper Harper scale.

As has been seen, the main models used to assess the mental workload are fundamentally based on the subjective interpretation made by the ergonomist of the subjects evaluated. On other occasions the source of information is surveys applied to the workers themselves

This introduces an enormous bias to these techniques by not considering indicators of a physiological or psychophysiological nature unrelated to subjectivity.

This way of obtaining information leaves open a gap to doubt which may be influenced, like all techniques based on criteria of individuals, by several factors such as the convenience of responding according to their interests, ignorance or misinterpretation of what is asked or interpreted, the interest or motivation of the evaluated, among others.

Below is a model, which, although more complex, in its application eliminates these shortcomings:

g) Model to value mental work Garcia (2017)

The model is applied in the normal work situation "before" and "after" performing the cognitive task.

Include variables of the three functional levels of man: physiological, psychophysiological and psychological.

Each subject will undergo the following selected experimental tests:

Physiological level :

- Heart Rate Variability.

Psychophysiological level:

- Simple Reaction Time.
- Complex Reaction Time.
- Frequency of Chromatic Discrimination
- Tactile discrimination threshold
- Depth perception

Psychological level

- Survey "Subjective Feeling of Fatigue".

With the results obtained, we proceed to the statistical analysis of all the variables evaluated together from the discriminant Analysis technique, valid to differentiate universes created from the integration of their variables.

For this, 3 universes are created:

a) The one formed by the variables taken at the beginning of the Working Day

b) The one formed by the variables taken at the end of the Working Day

c) The one formed by the worst values of the variables regardless of whether they were at the beginning or at the end of the Working Day.

With these values, they are analyzed in the SPSS computer statistical package. That universe that the statistical procedure shows that is closest to the universe formed by the worst values of the evaluated variables is considered the worst, which is expected to be formed by the variables taken at the end of the Working Day.

4.7. Proposal for measures to reduce mental effort

Unlike what happens in physical work, where energy consumption is the target factor used to evaluate fatigue and is evaluated in physical units such as calorie, Joule or Watt, in mental work these energy increases do not occur with high mental workloads. The human brain, which adequately consumes 25% of all oxygen, does not increase its values in intense intellectual activities, indicating that it does not increase its metabolic levels in the face of these demands. That is why the approach to the study of mental fatigue is assessed from the deviations observed in those somatic, sensory, metabolic, psychological or endocrine structures after the prolonged performance of a cognitive activity, which introduces a high degree of subjectivity.

Established as a premise the subjective of these evaluations will be made a group of recommendations:

- Reduce the information load of the person, as well as facilitate the acquisition of the necessary and relevant information to perform the task.
- Offer the necessary training, instructing her systematically, training her.
- Organize work times to avoid pressures and therefore pressures derived from the fear of failing to fulfill the task.
- Avoid time work regimes that involve many consecutive hours of work, followed by prolonged breaks: shifts of 24 hours of work for 72 or 48 hours of rest.
- Create favorable environmental conditions such as noise, lighting, heat or spaces.
- Promote favorable psychosocial climates that include: management styles, work environment, communication, motivation, teamwork, among others.
- Analyze the possibility of staff rotation alternating physical and mental activities, diversify the load on the sense organs, intersperse active or active-productive pauses.
- Request information, records, forms, among others, as simple as possible.
- In the design or selection of the means of production consider the participation of several sensory organs.

5. DISCUSSION/CONCLUSIONS

Several studies clearly demonstrate a link between mental fatigue, development andthe course of many diseases.

Fatigue affects three different essential levels, givingstake its unity of action, where it coincides with the criterion of Ramos Rettis (2017):

1. Physiological level, with its decrease in the activity of the organism and decrease in performance in the work plane. Sweating, muscle tension, palpitations, tachycardia, muscle tremors, stomach discomfort, breathing difficulties, dry lips, swallowing difficulties, headaches, dizziness, feeling nauseous, etc. occur.

2. Psychological level, with a feeling of discomfort accompanied by a courtship of functional alterations, which develop symptoms of worry, fear, insecurity, difficulty deciding, fear, negative thoughts, difficulties in thinking, studying, or concentrating.

3. Psychophysiological level, considered as an intermediate state between the previous two.

It is concluded that mental fatigue is a mechanism created by the organism before the realization of an activity that is not at the level of the capacity of the individual either by the accumulation of activities, characteristics and complexity of it which can require time, results, have a level of importance, capacity, knowledge and preparation of the individual to execute the task, where the relationship between the experience and skills of the individual intervenes. Another element that can cause fatigue is the predisposition to perform the activity due to the absence of resources and conditions to develop it, characteristics of the environment,

environment or organization, personality of the individual or real-time situation of the individual either extra work environment such as family aspirations.

Overwork causes the presence of physical and mental fatigue, decreased ability to concentrate and drowsiness or loss of sleep and appetite, need to use anxiolytics and / or other drugs, weight loss and / or increase in body weight, episodes of crying, feeling of sadness, depression headaches, joint pains and others, apparently arising from work or its excess (De los Santos & Carmona Valdés, 2018).. It is highlighted that these symptoms can progress through memory lapses, confusion, depression, anxiety, heart problems and even organic brain syndromes (Nascimento et al., 2019; Pérez-Fuentes et al., 2019). When fatigue is evident, the person decreases the strength, speed and precision of movements; which leads her to do certain things at the wrong times or the wrong things at the right time. When it causes reduced accuracy, excess mental load retards sensory responses, increasing the irregularity of responses and the occurrence of errors (Iida, 2005; Maia et al., 2019).

If the economic consequences of work stress are analyzed, high expenses and losses derived from the cost of stress are quantified; increase year by year, generally determined by increasing rates of absenteeism, low productivity, occupational accidents, incessant increase in profit and what is more important, the impact on the mental and physical health of individuals, which although they can be quantified by health expenses, are actually invaluable, since the quality of life and life itself should not have indices (Álvarez Cuesta et al., 2016; Favatto & Both, 2019; Lemos et al., 2019)..

It is necessary to create a culture in occupational safety and health where the curative approach and prevention are equated. For this, knowledge must be expanded in four logical units of daily work: theory, methodology, interactions and instrumental development (Almirall & Marroquín, 2016).

To analyze the magnitude of a problem it is necessary to create the bases and mechanisms that make it possible to measure it and in this way become aware of the imminent danger that can cause the object being studied, that is why the use of indicators to assess mental work has become a way to establish comparisons and evaluations between the before and after of an activity with cognitive demands, allowing to identify if there is presence of mental load in individuals from the results obtained.

Very diverse and varied indicators to assess mental load have been applied more or less frequently by researchers; however, there is agreement that these are grouped into four levels: biomolecular, physiological, psychological and psychophysiological according to authors such as Viña and Gregori (1987),De Arquer and Nogareda (2000), Cuixart (2000), Alonso Becerra (2007), Carvalho and García (2011), Basantes Vaca (2016), García (2017), among others. The indicators of more limited use are identified, which allows the selection of the indicators used in the research: Heart Rate Variability, Simple Reaction Time, Tactile Discrimination Threshold, Depth Perception and Yoshitake Test, this is due to the high sensitivity and feasibility of its measurement, the good results achieved in previous research and technological possibilities.

As it could be analyzed, the main models used to assess the mental workload are fundamentally based on the subjective interpretation made by the ergonomist of the subjects evaluated. On other occasions the source of information is surveys applied tothe workers themselves, andit introduces an enormous bias to these techniques by not considering indicators of a physiological or psychophysiological nature unrelated to subjectivity. This way of obtaining information leaves open a gap to doubt which may be influenced, like all techniques based on criteria of individuals, by several factors such as the convenience of responding according to their interests, ignorance or misinterpretation of what is asked or interpreted, the interest or motivation of the evaluated, among others. Therefore, the most important model based on the on integration of indicators and although it is more complex, in its application it eliminates the shortcomings of the previous ones is the modelo to assess mental work proposed by García (2017)..

The adaptation of mental work to the capacities of man is very complex given the large number of variables involved such as: individual differences, environmental conditions, accurately determining the magnitude of the demands of the task and organizational factors. Notice when talking about mental fatigue the term "valuation" is used and not "dedetermination". And, until the present, it cannot be otherwise.

Achieving the adjustment of the demands imposed by work on man so that his capacities are not exceeded constitutes the basis forpreventing or eradicating the problem.

Through different techniques, the worker can be provided with resources to cope with work stress when organizational measures do not work. Interventions can and should be directed towards the structure of the organization, communication style, decision-making processes, functions and tasks at work, the physical environment, and methods of training workers. The basis for reducing mental fatigue is to improve communication, increase the participation of workers in decisions regarding work, improve environmental conditions, and the variety and stimulation of work tasks must also be considered (Valencia & Enríquez, 2019).

Coinciding with the criteria of Mansilla and Favieres (2017), animportant aspect for the prevention of work stress is the increase in social support for organizations, favors the cohesion of work groups and trains supervisors to adopt an attitude of help with subordinates since social support not only reduces vulnerability to work stress but also its negative effects. It is prudent to include indicators in occupational health surveillance. Investing in prevention of work stress is a cost saving for the company, which means placing it in an advantageous condition compared to the competition.

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USABILITY EVALUATION WITH VISUALLY IMPAIRED USERS IN THE LEARNING CONTEXT: A SYSTEMATIC REVIEW

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Resumen Las personas con discapacidad visual se enfrentan a una amplia gama de barreras entre las cuales se encuentra el acceso a la educación. En los últimos años, se ha visto un aumento en el uso de Tecnologías de Información y comunicaciones (TIC), en la educación. El uso de esas tecnologías para el aprendizaje, demanda que cuenten con ciertas características que las conviertan en herramientas para los estudiantes. Una de las características importantes de estos sistemas es la usabilidad, la cual permite que usuarios puedan cumplir objetivos específicos. El objetivo de esta revisión es identificar los diferentes atributos que conforman el concepto de usabilidad, así como las herramientas de evaluación utilizadas en los sistemas de aprendizaje utilizados por estudiantes con discapacidad visual. Con este fin, se realizó una revisión sistemática utilizando Google Scholar. Los términos utilizados fueron *visual impairment "School platform" OR "learning system" "usability evaluation".* En ella se obtuvieron más de 2300 resultados iniciales, los cuales, fueron sometidos a diferentes criterios de inclusión y exclusión. Finalmente se obtuvieron 10 artículos, en los cuales se evaluaron diferentes sistemas relacionados con la enseñanza. Entre estos se encontraron; sistemas de aprendizaje abierto, sitios web universitarios, bibliotecas digitales y sistemas de enseñanza. Los atributos medidos fueron; eficiencia, eficacia, satisfacción, facilidad de aprendizaje, memorabilidad, accesibilidad, utilidad percibida y facilidad de uso. Las herramientas utilizadas van desde; entrevistas, cuestionarios de elaboración propias, cuestionarios estandarizados, pruebas de usabilidad con usuarios, observación, pensando en voz alta y recorrido cognitivo. A pesar de que se encontró una gran cantidad de artículos de evaluación de usabilidad, son pocos los que la evalúan tomando en cuenta a estudiantes con discapacidad visual. Y no se observaron métodos establecidos que respondan a las necesidades y características de la población. Es importante que, como diseñadores, consideremos las características y necesidades de los usuarios, así como el objetivo de las plataformas, para poder mejorar el proceso de aprendizaje en el uso de estos recursos.

Palabras clave: Evaluación de usabilidad, discapacidad visual, sistema de aprendizaje

Relevancia para la ergonomía: Los trabajos revisados plantean cómo, el buen diseño de las plataformas y recursos de aprendizaje puede mejorar el desempeño y la inclusión de los estudiantes con discapacidad visual. El conocer los atributos correctos y los métodos adecuados para la evaluación de usabilidad en esta población en específico, nos puede ayudar como diseñadores, a elaborar propuestas más inclusivas para los usuarios. Se deben incluir en el proceso de diseño, evaluaciones de usabilidad de las plataformas, para así, facilitar el proceso de aprendizaje y mejorar la calidad de vida de los estudiantes.

Abstract: People with visual impairment face a wide range of barriers, including access to education. In recent years, there has been an increase in the use of Information and Communication Technologies (ICT) in education. The use of these technologies for learning demands that they have specific characteristics that make them useful for students; one of the essential characteristics of these systems is usability, which allows users to meet specific objectives. The objective of this review is to identify the different attributes that make up the concept of usability, as well as the evaluation tools used to evaluate learning systems used by students with visual impairment. To this aim, a systematic review was conducted using Google Scholar. The terms used were *visual impairment "School platform" OR "learning system" "usability evaluation".* More than 2300 initial results were obtained, which were subjected to different inclusion and exclusion criteria. Finally, ten articles were selected, in which different systems related to teaching were evaluated. Among these were open learning systems, university websites, digital libraries and teaching systems. The articles measured were efficiency, effectiveness, satisfaction, ease of learning, memorability, accessibility, perceived usefulness and ease of use. The tools used included interviews, self-developed questionnaires, standardized questionnaires, usability testing with users, observation, thinking aloud and cognitive walkthrough. Although many usability evaluation articles were found, few evaluate usability with visually impaired students in mind. And no established methods that respond to the needs and characteristics of the population were observed. It is important that, as designers, we consider the characteristics and needs of the users, as well as the purpose of the platforms, in order to improve the learning process in the use of these resources.

Keywords. Usability evaluation, visual impairment, learning system.

Relevance to Ergonomics: The reviewed works show how the correct design of learning platforms and resources can improve the performance and inclusion of students with visual impairment. Knowing the appropriate usability evaluation methods in this population can help us as designers develop more inclusive proposals for users. Platform usability evaluations should be included in the design process to facilitate learning and improve students' quality of life.

1. INTRODUCTION

A report on blindness, published by the World Health Organization (WHO) in 2020, states that at least 2.2 billion people are visually impaired. An additional one billion face a wide range of barriers, including a lack of access to education and information. The study *Strategic Approaches to ICTs in Education in Latin America and the Caribbean*, published by UNESCO in 2013, points out the increase in recent years in the inclusion of ICTs in learning. Several studies point out that these, favor students' self-regulation and academic performance (Hu et al., 2018; Skryabin et al., 2015). However, WHO (2011) highlights that non-accessible teaching materials represent a barrier for students with disabilities. Therefore, the use of these technologies, if they do not have the accessibility feature, could represent more of a barrier than help for these users. Mayoral et al. (2019) point out that, through knowledge of the use of ICT, teachers can have a greater number of tools to enrich students' learning.

Usability is defined in ISO 9241-11 as the degree to which a product can be used by specific users to achieve particular objectives with effectiveness, efficiency and satisfaction in a specific context of use. Enriquez et al. (2014) talk about usability, which can be measured by different attributes: memorability, accessibility, number of errors, ease of learning, among others.

Perceived usability greatly affects the effectiveness of student learning and the overall learning experience and is therefore an important requirement of educational software. Current forms of evaluation are often customized by each developer, this leads to the fact that the effort in measuring usability may be wasted by not having a consistent and consolidated model.

2. OBJECTIVES

- Identify the different components used to define usability, in the assessment with visually impaired users, within the learning context
- Identify the tools used for usability assessment, with visually impaired users, within the learning context.

3. DELIMITATION

A search was conducted using Google Academic, including articles from 2018 to this year. According to information on its website, this engine indexes full text and metadata of scholarly literature, including books, abstracts, academic editors' opinions, online repositories, and scientific journals, among others.

4. METHODOLOGY

A descriptive study was conducted based on a systematic review and analysis of original articles. The phases of a systematic review by Arksey and O'Malley were used as a basis

Table 1. Methodology Summary

Phase	Summary
I	Drafting of the question
II	Establishment of inclusion and exclusion criteria
III	Review and selection of studies
IV	Data extraction
V	Analysis and reporting of results

4.1 Phase I

After the elaboration of the objectives, the research question was defined. What are the components considered in the literature for the evaluation of usability in the context of the education of visually impaired students?

4.2 Phase II

The search terms were set: visual impairment "School platform" OR "learning system" "usability evaluation." Which yielded 2350 results. Subsequently, various selection criteria were applied, delimiting the years of publication, resulting in 931 documents. Excluding citations and patents, 871 results were obtained. Then 91 articles were discarded because they were not researched articles. In addition, 28 were discarded because they were unavailable or freely accessible.

Subsequently, studies by topic were excluded; 31 articles were discarded because they were not usability assessments, 400 did not evaluate learning management platforms or systems, and 293 did not include people with visual impairments in their evaluations.

4.3 Phase III

Ten studies were found, which evaluate different interfaces or platforms related to the education of people with visual impairment. All the documents were read followed by a review of the inclusion and exclusion criteria. Additionally, a comparative map of users, system and evaluation tools was made.

4.4 Phase IV

In this phase, the different articles found were analyzed, which evaluated different learning means. These include management systems, accessibility tools for management systems, and educational websites. All studies involve visually impaired users, highlighting the importance of their participation throughout the design process. The studies assess students at different levels of education, from basic education to higher education.

4.5 Phase V

The different methods used to evaluate usability were compiled, as well as the results obtained with them, which are presented below.

5. RESULTS

Ten research articles were reviewed, which took into account different inclusion criteria to form their participant groups; some worked exclusively with groups of students with visual impairment (Alnfiai & Alhakami, 2021; Bintaleb & Al Saaed, 2020; Kamaghe, 2021; Ojeda-Castelo et al., 2021; Xie et al., 2020) others included students with different disabilities (Azeta, 2018; Maboe et al., 2019; Nahar et al., 2021) others included students with visual impairment and experts without visual impairment ((Laeeq & Memon, 2021; Şahin Kölemen & Üyesi Ergün AKGÜN Bahçeşehir Üniversitesi, 2022). Mostly higher level was assessed, however studies with basic level participants were also included (Bintaleb & Al Saaed, 2020).

Among the different learning-related systems that were evaluated in the articles, we found; Braille teaching applications (Nahar et al., 2021), open education systems (Azeta, 2018; Şahin Kölemen & Üyesi Ergün AKGÜN Bahçeşehir Üniversitesi, 2022), institutional websites (Maboe et al., 2019), institutional digital libraries (Xie et al., 2020), and Learning Management Systems (Alnfiai & Alhakami, 2021; Bintaleb & Al Saaed, 2020; Kamaghe, 2021; Laeeq & Memon, 2021; Ojeda-Castelo et al., 2021).

Table 2. Usability components and evaluation tools

Author	Usability Framework	Evaluation tools
Şahin Kölemen & Üyesi Ergün AKGÜN Bahçeşehir Üniversitesi, 2022	Efficiency, effectiveness and satisfaction.	Usability test, completed tasks, number of movements, post-test interviews.
Laeeq & Memon, 2021	ISO/IEC 9126-4: Efficiency, effectiveness and satisfaction.	Usability test, percentage of tasks, resources used, SUS Questionnaire

Author	Usability Framework	Evaluation tools
Kamaghe, 2021	Usefulness, satisfaction.	Tasks completed on time, SUS Questionnaire
Ojeda-Castelo et al., 2021	Not specified	Cognitive walkthrough combined with thinking aloud. UEQ applied to students
Nahar et al., 2021	Nielsen (1992) Efficiency, ease of learning, memorability, errors and satisfaction.	Observation during the test, post-test self-completed questionnaire
Alnfiai & Alhakami, 2021	WCAG 2.0 for accessibility	Interview
Bintaleb & Al Saaed, 2020	Efficiency, effectiveness and satisfaction	Two standardized questionnaires, observation, pre-test and post-test interviews, Morae software.
Xie et al., 2020	Ease of use, satisfaction, usefulness	Thinking aloud protocol and post-study interviews.
Maboe et al., 2019	Not specified	Time to perform a task
Azeta, 2018	ISO 9241-11: Efficiency, effectiveness and satisfaction.	Questionnaire of own elaboration

5.1 Usability components

The authors analyzed list different components of usability, consider the three main elements and integrate some more. The following is a description of the various definitions found in the texts and ways to measure the attributes.

1. Satisfaction. Nahar et al. (2021) define satisfaction as the subjective opinion of users during use. Laeeq and Memon (2021) handle the definition of satisfaction as a state of mind that comes with comfort and ease of use. Kamaghe (2021) assessed the attribute using the SUS questionnaire. On the other hand, the percentage of favorable and unfavorable comments from users was also considered for evaluation (Laeeq & Memon, 2021).

2. Efficiency. The efficiency of use indicates a high level of productivity achieved by users within a specified time after learning to use the system (Nahar et al., 2021). It is also defined as the resources used to achieve or complete a goal with accuracy or precision (Laeeq & Memon, 2021). It is an attribute that can give to notice if users solve tasks without much effort (Ojeda-Castelo et al., 2021). Sahin & Üyesi (2022) evaluated the level of efficiency of the platform according to the time spent and the number of movements when performing the tasks requested from the participants. It is also presented as the result of measuring task completion time (Bintaleb & Al Saaed, 2020; Kamaghe, 2021) Laeeq & Memon (2021) evaluate it by the percentage of errors or the time to finish a desired goal.

3. Effectiveness: Sahin & Üyesi (2022), considered the successful completion of the tasks requested to the participants. Bintaleb & Al Saaed (2020) calculated the attribute by the number of errors and assists required by the user to perform the task. Laeeq & Memon (2021) measured it by the accuracy or precision to achieve the desired goal, i.e., the percentage of goal achieved per unit of time.

4. Ease of learning: Ease of learning refers to how easy it is for users to understand how to use the system, enabling them to do productive work (Nahar et al., 2021).

5. Usability: Usability, or perceived usefulness, has been defined and used to accept new information technologies and web technologies (Xie et al., 2020). It is considered as one of the main attributes of usability and is generally adopted as a subjective measure (Booth,1989).

6. Memorability: This refers to the user's ability to remember the steps of the system (Nahar et al., 2021).

7. Ease of use: Ease of use is defined as the user's perception of how easy it is to use a system. The TAM model indicates that it is strongly related to the acceptance of a new system (Xie et al., 2020).

8. Accessibility: Alnfiai & Alhakami (2021), take the definition of ISO 9241, in which the attribute is defined as "the ability of a product, service, environment or equipment to be used by a wide range of people with very different abilities".

5.2 Usability evaluation tools

There are different tools to assess usability, ranging from quantitative methods such as different standardized questionnaires, to qualitative methods such as interviews, cognitive walkthrough, etc. The methods most used in the reviewed works are presented below.

1. Interviews: Interviewing is one of the most common ways we use to understand our peers (Fontana, 2000). In this process, the role of the researcher involves not only obtaining answers, but also learning what questions to ask and how to ask them (Taylor & Bogdan, 1996:101). Alnfiai & Alhakami (2021), included in their interviews closed-ended and open-ended questions related to the tasks in the system to be evaluated. Şahin & Üyesi (2022), conducted interviews with visually impaired people and subject matter experts. Bintaleb & Al Saaed (2020), conducted pre-test and post-test interviews. Xie et al. (2020) conducted pre-search interviews to elicit users' levels of subject matter knowledge for each assigned task. Additionally, post-search interviews were conducted in which users' perceptions of ease of use, the usefulness of help functions, and system satisfaction levels were asked.
2. Questionnaire: Ferrando (2003) defines the questionnaire as "a research tool conducted on a sample of subjects representative of a broader collective, which is carried out in the context of everyday life, using standardized interrogation procedures, in order to obtain quantitative measurements of a wide variety of objective and subjective characteristics of the population". Azeta (2018) used a self-developed questionnaire in which he assessed satisfaction, effectiveness and efficiency. Nahar et al. (2021) developed a questionnaire based on usability goals established during their design process. Xie et al. (2020) applied previous questionnaires to solicit subjects' demographic information, knowledge of the system and search, and use of assistive technology. Participants in this study had to answer questionnaires related to usability, user experience, self-determination, and cognitive load. Ojeda-Castelo et al. (2021) used different self-made questionnaires related to usability, user experience, self-determination, and cognitive load. Laeeq & Memon (2021) applied the SUS to find out students' opinions about the system being tested (existing and proposed). Kamaghe, J. (2021) conducted a self-developed questionnaire to collect data on the knowledge and use of the platform and post-intervention conducted a SUS with the objective of finding out the problems presented by the users.
3. Thinking aloud: Xie et al. (2020) used the method, complementing it with transaction logging to learn about user behavior, critical situations and comments on functions. Ojeda-Castelo et al. (2021), carried out a cognitive walkthrough with users, to which they added the thinking aloud method, which allowed them to collect users' opinions and at the same time to have a record of their comments during the process.
4. Usability tests: Also called tests with real users (Ortiz et al., 2017) aim to detect the problems that are encountered in the performance of tasks and are based on observation. In them, users interact with a product and different factors are measured; they are generally performed in a controlled environment (Portigal, 2013). All the analyzed studies performed usability tests; however, different measured factors could be observed: completed tasks (Kamaghe, 2021; Laeeq & Memon, 2021), resources used (Laeeq & Memon, 2021), number of movements (Şahin Kölemen & Üyesi Ergün AKGÜN Bahçeşehir Üniversitesi, 2022).

6. CONCLUSIONS

Derived from the search process of the articles, it can be concluded that the evaluation of learning platforms or resources, in students with visual impairment, is scarce. As it can be observed, the literature found in the literature found, there are different definitions of usability, ranging from those proposed by authors such as Nielsen (1992), based on standards such as ISO 9216-4, to attributes chosen at convenience or based on different instruments.

Despite the importance and need for accessibility in the evaluated population, only one author included the attribute as part of the concept of usability. Although the importance of accessibility in educational resources is considered, the pertinent evaluations are not carried out to be able to affirm or conclude that the designs are accessible. This could indicate that there is an opportunity to improve the usability levels of the platforms, taking accessibility into account in their evaluation.

As previously mentioned, Enriquez et al. (2014), state that usability can be measured with different attributes and the tools may vary depending on the evaluator and the project's needs. Reviewing the results found in this search, we can notice that, even for measuring usability in a population as specific as students with visual impairment, there are no established tools that consider the characteristics and needs of this population. The review

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ANALYSIS OF MENTAL WORKLOAD AND MUSCULOSKELETAL DISCOMFORT IN PUBLIC TRANSPORTATION DRIVERS IN CIUDAD JUAREZ

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Resumen: En Ciudad Juárez, México, el servicio del transporte público carece de condiciones seguras y ergonómicas, atribuidas al estado de las calles, estado de las unidades y al manejo por parte de los conductores. Otros factores estresantes presentes en los conductores son las largas jornadas laborales, turnos rotativos, violencia laboral, tráfico vehicular y los relacionados con su estado de salud. Esta investigación pretende determinar las fuentes de carga mental de los conductores, así como las molestias musculoesqueléticas más frecuentes, además de la frecuencia de agresiones experimentadas. La metodología cuenta con 6 fases. En las primeras fases realizó una búsqueda bibliográfica y se determinaron evidencias de desempeño de los conductores, violencia laboral, su estado de salud, condiciones de las unidades y número de usuarios. En la cuarta fase, se implementaron los métodos Marley y Kumar y NASA TLX. En las etapas finales se determinaron las principales fuentes y el nivel de carga mental, así como las molestias musculoesqueléticas. Como resultado se caracterizó a los 27 conductores por medio de indicadores sociodemográficos. Además, se identificaron las partes del cuerpo como la mano derecha, la parte baja/media de la espalda, los ojos, la muñeca derecha y la zona de glúteos, que probablemente necesiten tratamiento médico de acuerdo con la frecuencia e intensidad manifestada. Se detectó que el 22% de los conductores presentaban carga mental alta, el 67% media y el 11% baja, donde la exigencia temporal y física son las fuentes más relevantes de carga mental. También todos los conductores de la muestra presentan alguna molestia de diferente intensidad y frecuencia en alguna parte de su cuerpo y algún nivel de carga mental de trabajo. Por lo que es necesario más estudios en esta profesión vulnerable por su impacto en la seguridad de los pasajeros, de terceros y de ello mismos.

Palabras clave. Carga Mental de Trabajo, Operadores de Transporte Público, Molestias Musculoesqueléticas.

Relevancia para la ergonomía: Esta investigación contribuye a la caracterización de los conductores de transporte público referente al nivel de carga mental percibida, así como de las molestias musculoesqueléticas provocadas por su actividad laboral, ya que en ellos recae responsabilidad de garantizar su seguridad y la de los pasajeros.

Abstract: In Ciudad Juarez, Mexico, public transportation service lacks of safe and ergonomic conditions, attributed to the state of the roads, buses, and drivers' performance. Other stressors present in drivers are long working hours, rotating shifts, vehicular traffic, and those related to their state of health. This research aims to determine the sources of drivers' mental workload, as well as the most frequent musculoskeletal discomforts and experimented aggressions during work. The methodology has 6 phases. In the first phases, a bibliographic search was carried out as well as the evidence of drivers' performance, health status, violence at work, unit conditions, and the number of users. In the fourth phase, the Marley and Kumar and NASA TLX methods were implemented. In the final phases, the main sources and level of mental workload and musculoskeletal discomfort were determined. As a result, the sample of 27 drivers was characterized based on sociodemographic indicators. In addition, the main musculoskeletal discomfort was identified where the right hand, lower/middle back, eyes, right wrist, and buttocks, were the body parts probably requiring medical treatment according to the frequency and intensity manifested. Additionally, 22% of the drivers presented a high mental workload, 67% medium, and 11% low, where temporal and physical demands are the most relevant mental workload sources. Also, all drivers present some discomfort of different intensity and frequency in their bodies and some level of mental workload. Therefore, more studies are needed in this vulnerable profession due to its impact on the safety of passengers, third parties, and themselves.

Keywords. Mental Workload, Public Transport Operators, Musculoskeletal Discomfort.

Relevance to Ergonomics: This research contributes to the characterization of public transport drivers regarding the level of perceived mental workload, as well as musculoskeletal discomfort caused by their work activity since they are responsible for ensuring their safety and that of their passengers.

1. INTRODUCTION

In Ciudad Juarez, a city with about 1.5 million inhabitants, 14% (more than 200 thousand users) of the population uses public transportation services. Several problems are faced in the public transportation sector where 80% of the units that offer the service in the last 16 years have not been renewed. Even though the Transportation Law of the State of Chihuahua only allows ten years of age. Therefore, it is evident that it is still a challenge for public administrations to provide quality and efficient service in this city and there are 1,200 collective transportation concessions (Miranda, 2020). This same author informs that young people are the ones who usually use the transportation, since at least 50 percent of the users are from the student community, while 30 percent are adults between 28 and 50 years old and the remaining 20 percent are older adults, so it is possible that students are the ones who carry out this type of acts against transportation. Another aspect that contributes to the problem is the organization of this service is considered informal labor-wise since drivers do not have any type of social protection or well-established work schedules, as these can vary between 14 and 17 hours a day and salary income depending on the number of passengers they manage to transport ("En el infierno del transporte público," 2014). In addition, in February 2022, there were 12 crashes, one hit-and-run with injuries and another with death, also a passenger injured by a fall, and a rollover with at least 12 injuries (Tovar, 2022).Given these situations, there is another relevant perspective regarding the quality of life at work for drivers, since there is evidence of musculoskeletal disorders (MSDs) and stress conditions that make it even more complex to solve not only in this city but also in Latin America (Morales et al., 2021). In the case of mental workload, there is evidence that it is one of the main factors leading to mental fatigue (MacDonald, 2003), which can lead to periods of time in which situations can present a danger to drivers and passengers. That is why this research presents an analysis of mental workload and musculoskeletal discomfort in public transport operators in Ciudad Juarez Chihuahua, Mexico.

2. OBJECTIVES

The general objective is to identify the sources of mental workload of public transport drivers in Ciudad Juarez, as well as the most frequent musculoskeletal complaints.

1. To develop the field study in a sample of drivers by convenience.
2. To analyze and process and characterize the data of the sample.
3. Develop the mental workload analysis using the NASA TLX method.
4. Develop musculoskeletal discomfort analysis using Marley and Kumar's method.

3. DELIMITATION

As delimitation, a sample by convenience of public transportation drivers in Ciudad Juarez will be studied on a single route line or city route.

4. METHODOLOGY

This is a cross-sectional, non-experimental study with a convenience sample who signed an informed consent form and voluntarily participated in the study. A methodology consisting of 6 stages is proposed as shown in Figure 1.

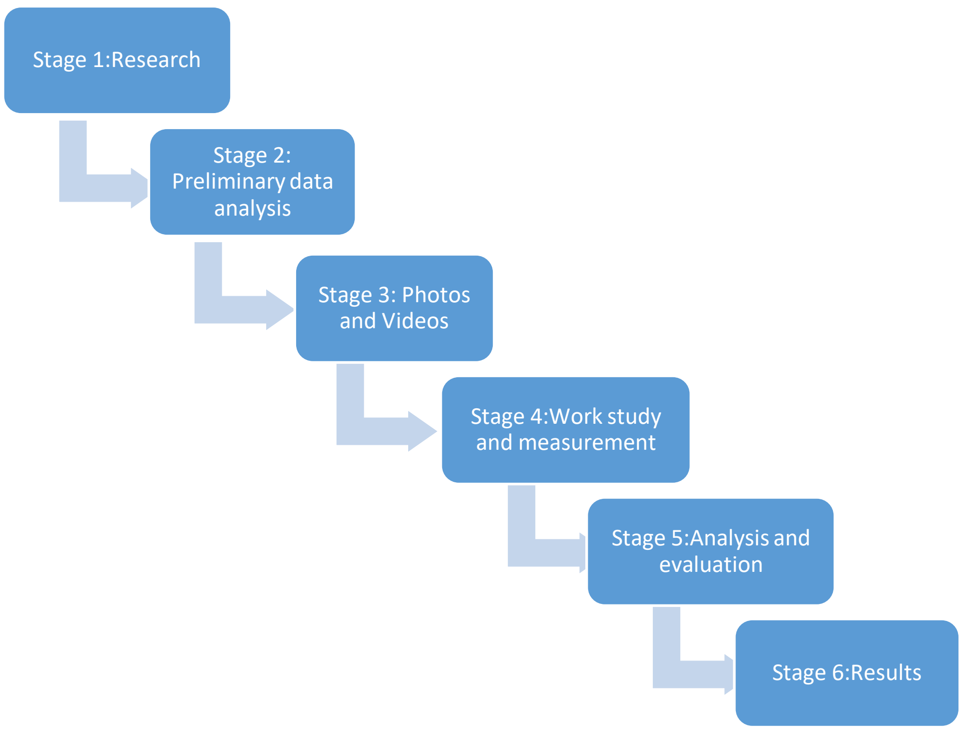

Figure 1. Stages of the Methodology

In the first stages, a bibliographic search was conducted, and a preliminary survey was applied to determine evidence of poor operator performance, unit conditions, accidents throughout the year, and the number of users, in addition to the health status of the operators, to study the sources of mental workload and find out if they have previous musculoskeletal complaints.

The photo and video stage comprises gathering evidence from the drivers' performance and drivers' unit conditions, the drivers' environment was captured both outside and inside the unit. In the fourth stage, two instruments were applied to the participants, one belonging to the NASA TLX Methodology (Hart & Staveland, 1988) and the second provided by the Marley and Kumar Method (Marley & Kumar, 1996). For this purpose, face-to-face interviews were conducted with the different participants during the working day, with the first author recording the answers with the different instruments. In the final stages, the data were analyzed, and the main sources and level of mental workload present in the operators were determined. In addition, musculoskeletal discomfort was determined considering its frequency and intensity, as well as the level of action required.

5. RESULTS

The sample for this study included 27 participants, all males. The age distribution of the participants is shown in Figure 2. The participants work more than 12 hours a day, their weekly salary is in the range of 2,300 to 2,500 pesos, 14 of the participants have 1 or 2 children. Only 6 participants have some type of insurance from a family member. Nearly 90% of the participants have been victims of violence such as assaults, fights, and verbal aggression.

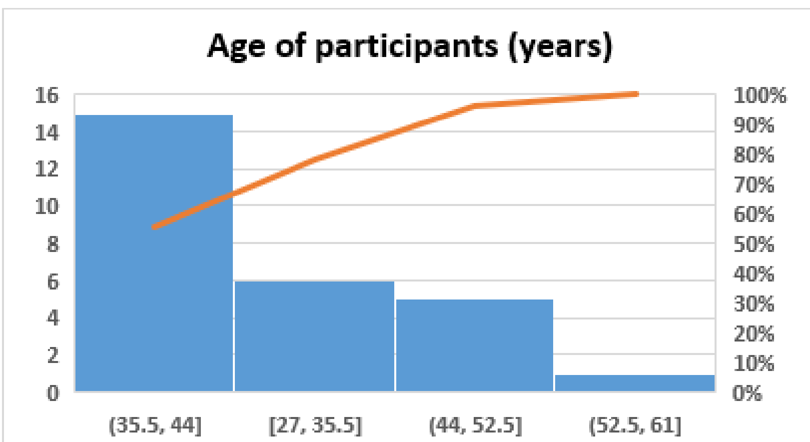

Figure 2. Age of the participants (years)

During the photos and videos evidence stage, the poor condition of the units was documented, as shown in Figures 3 and 4. In addition, Figure 5 shows the percentages of aggressions suffered by the participants while driving the units.

Figure 3. Unit conditions

Figure 4. Unit conditions

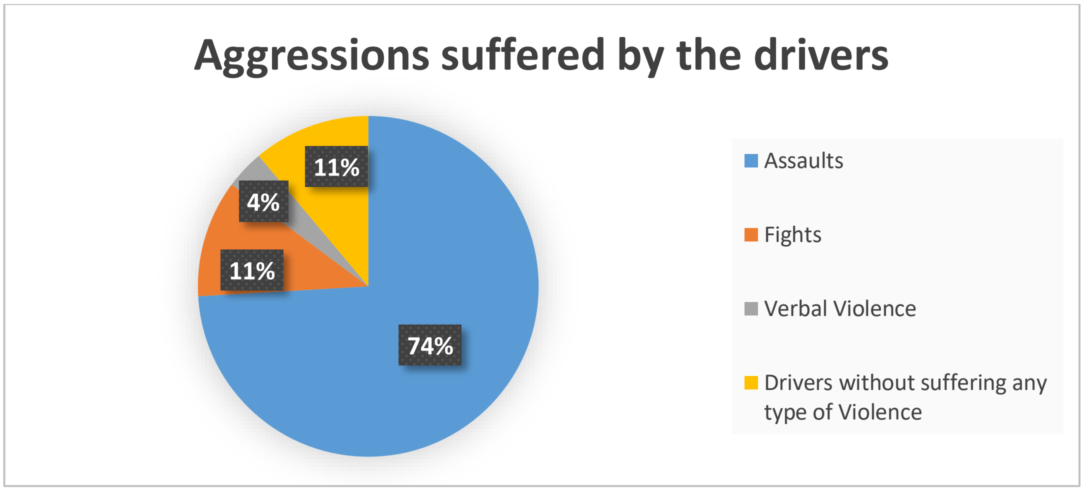

Figure 5. Aggressions suffered by the drivers.

Ten of the drivers (37.07%) had previous musculoskeletal injuries, 5 had additional problems in addition to the old injuries, and 2 had symptoms of injury progression. Figure 6, shows the number of drivers requiring treatment or therapy according to frequency and intensity of discomfort (Marley & Kumar, 1996). Yellow color represents "Somewhat likely to seek treatment" and red color "Very likely to seek treatment", while green color is "Not likely to seek treatment".

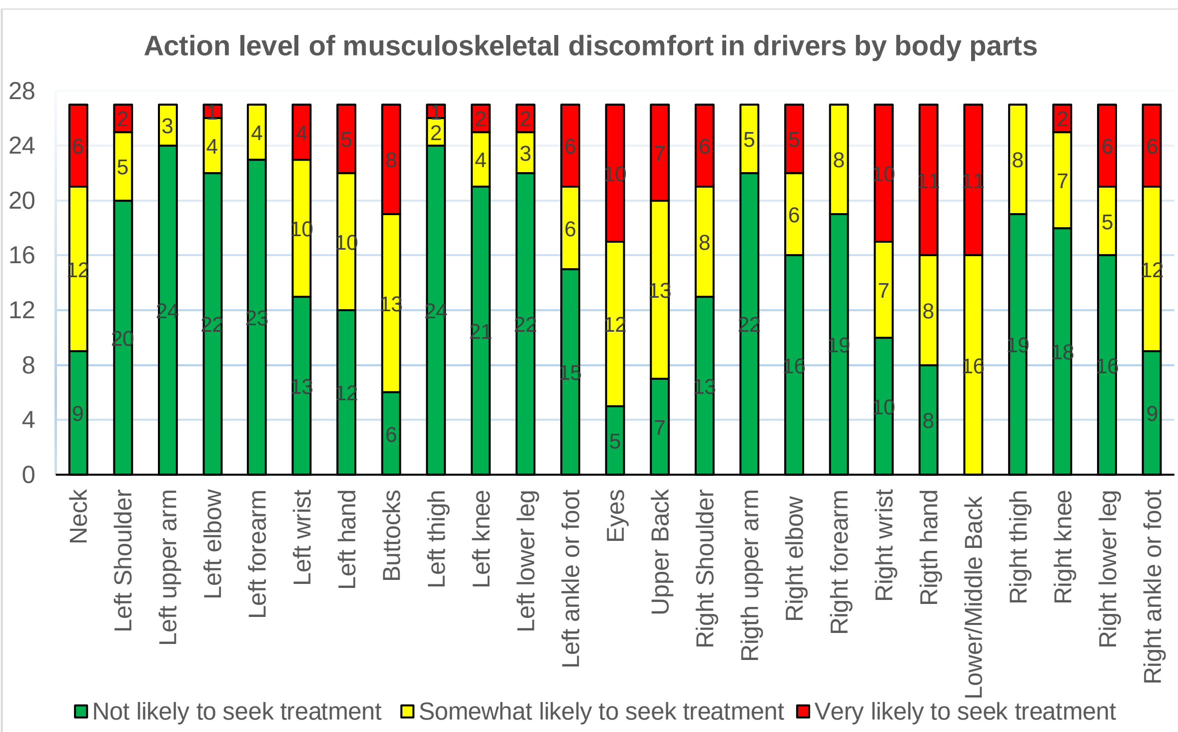

Figure 6. Action level of musculoskeletal discomfort in drivers by body parts

On the other hand, Table 1 shows the main musculoskeletal complaints presented by the participants that are less likely to need some kind of medical attention, while Table 2 shows the main complaints that would be likely to need some kind of medical attention. All these parts of the body are less used while driving the bus, compared to the right side of the body.

Table 1. Main musculoskeletal discomforts, which are not likely need some kind of medical attention.

Body part	Qty. of participants
Left Arm	24
Left Thigh	24
Left Forearm	23
Left Elbow	22
Lower Left Leg	22

Table 2. Main musculoskeletal discomforts, that somewhat likely to need some kind of medical attention.

Body part	Qty. of participants
Lower/Middle Back	16
Gluteus	13
Upper back	13
Ankle/right foot	12
Eyes	12
Neck	12

The main musculoskeletal complaints and the number of drivers suffering from them are shown in Table 3. The most frequent are: the right hand, the lower/middle back, the eyes, the right wrist, and, the buttocks which probably need some kind of medical attention or treatment according to the frequency and intensity manifested among the participants.

Table 3. Main musculoskeletal discomforts, which probably need some kind of medical attention.

Body part	Qty. of participants
Right Hand	11
Lower/Middle Back	11
Eyes	10
Right Wrist	10
Buttocks	8

Overall, all drivers reported some discomfort of varying intensity and frequency in some parts of their body; however, not all of them require treatment or medical attention.

Regarding mental workload, the drivers presented different levels of NASA TLX weighted rate, as shown in Figure 7, with the highest frequency of medium mental workload conditions with ratings values in a range of 51.3 to 69.3.

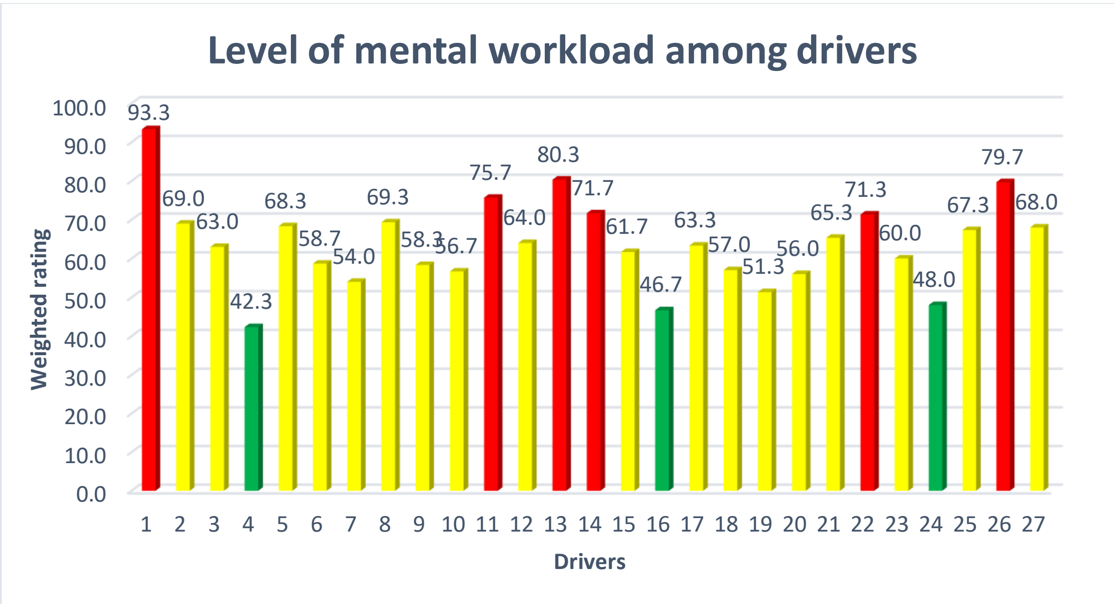

Figure 7. Level of mental workload among drivers

The number of participants suffering from mental workload is shown in Table 4, identifying that 22% of the drivers present a high mental workload. In the case of these six drivers, the dimension that contributes the most to their level of workload is frustration, where three of them considering it as the most relevant, while temporal demands with two, followed by the effort dimension with one.

Table 4. Levels of mental workload

Level of mental workload	Quantity of participants	Total (%)
High	6	22
Medium	18	67
Low	3	11

Overall, 100% of drivers have some level of mental workload. Where 89% of the sample have medium and high levels of mental workload. The main dimensions contributing to the mental workload of all drivers are temporal and physical demands. Figure 8 shows the contributions of all dimensions.

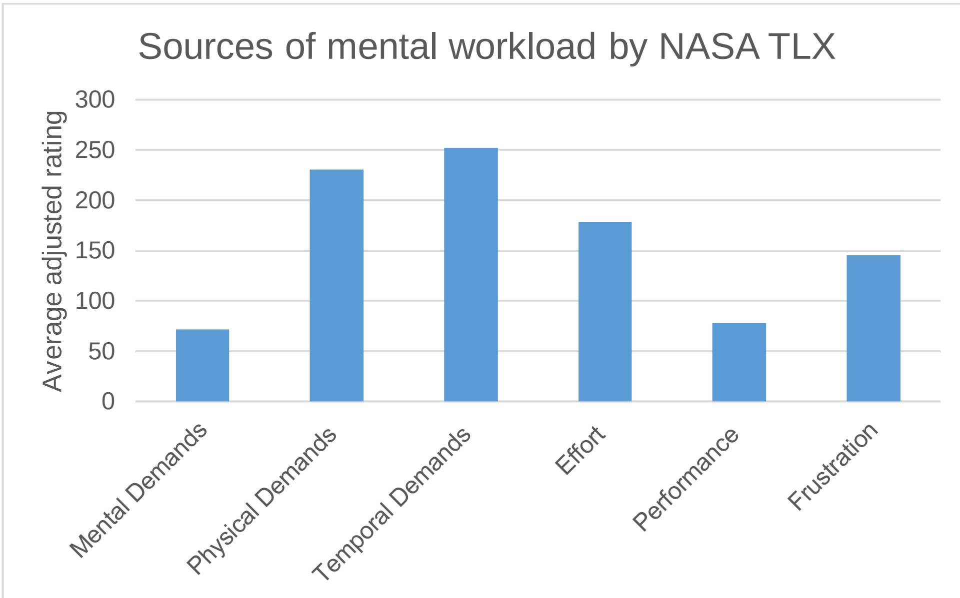

Figure 8. Sources of mental workload by NASA TLX

According to these results, the temporal demand may be related to the pressure to meet the travel times between each station, so each delay generates an increase in the drivers' mental workload perception. While the physical demand can be attributed to the fatigue of this activity related to long workdays of more than 12 hours, without rest periods, the high frequency of movements of body parts, the age of the driver, and the state of health. The drivers are prone to suffer from cardiovascular diseases, heart attacks, obesity, hypertension, and diabetes mellitus, due to poor diet and sitting all day long.

6. CONCLUSIONS

As conclusions, it’s important to determine the ergonomic risk factors to which public transportation drivers’ are exposed since it is through their identification that controls can be established to reduce or eliminate them, avoiding illnesses and even work accidents which leads to conduct improvements in working conditions, health of drivers and customer satisfaction. In this research we have determined the most frequent evidences of violence at work, the most relevant sources of mental workload and frequent musculoskeletal discomfort in public transportation drivers in Ciudad Juarez, thus the general objective was fulfilled. In the case of the four specific objectives, these were accomplished since a study in the field was carried out on a sample of drivers, the information collected was analyzed by a descriptive study of the data. In addition, the analysis of mental workload using the NASA TLX method and the musculoskeletal disorders were analyzed using the Marley and Kumar method.

In this research, two hypotheses were put forward, the first related to the presence of mental workload and the second related to the presence of musculoskeletal discomfort in some part of the body of public transport drivers. Both hypotheses were confirmed since all of the drivers in the sample present some level of mental workload and musculoskeletal discomfort in some part of their body. Therefore, more studies are needed in this vulnerable profession due to its impact on the safety of passengers, third parties, and themselves.

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STUDY OF PSYCHOSOCIAL FACTORS AND MENTAL LOAD ASSOCIATED WITH THE PACKING PROCESS IN AN AGRICULTURAL COMPANY

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Resumen En México, la evaluación de riesgos psicosociales ha sido considerada en la Norma Oficial Mexicana 035 de la Secretaría del Trabajo y Previsión Social, recién publicada en Diario Oficial de la Federación, así como también en el Reglamento Federal de Seguridad y Salud en el Trabajo. El tener un ambiente psicosocial agradable para el trabajador fomenta un mayor rendimiento y desarrollo personal es por ello la importancia de la atención oportuna a dichos riesgos, por lo cual en este proyecto se hace el estudio donde se permita evaluar a los involucrados en el proceso de empaque de semilla de maíz, mediante la aplicación de la norma antes referida. El resultado hace una clara referencia a los aspectos psicosociales que deben de cuidar las empresas del giro mencionado así mismo esta es aplicada en base al resultado que se obtenga de aplicar Método NASA TLX, el cual permite dictaminar la carga mental de los trabajadores con el fin de abordar, atacar, evitar y prevenir problemas que pongan en riesgo al trabajador, encontrando las causas potenciales que desatan el nivel de carga, de esta forma el estudio permitirá a la empresa bajo estudio tomar decisiones de impacto en el desempeño del trabajador.

Palabras clave: Carga, Trabajo, Factores, Psicosociales.

Relevancia para la ergonomía: Identificar de manera puntual y oportuna relacionada a la presencia de carga mental y factores psicosociales permitiendo con ello emprender acciones enfocadas a su disminución y/o eliminación.

Abstract In Mexico, the evaluation of psychosocial risks has been considered in the Mexican Official Standard 035 of the Ministry of Labor and Social Welfare, recently published in the Official Gazette of the Federation, as well as in the Federal Regulation of Safety and Health at Work. Having a pleasant psychosocial environment for the worker encourages greater performance and personal development, which is why the importance of timely attention to these risks is why in this project the study is made where it is possible to evaluate those involved in the process of corn seed packaging, through the application of the aforementioned standard. The result makes a clear reference to the psychosocial aspects that the

companies of the aforementioned line of business must take care of, as well as this is applied based on the result obtained from applying the NASA TLX Method, which allows to determine the mental load of the workers with the purpose to address, attack, avoid and prevent problems that put the worker at risk, finding the potential causes that unleash the load level, in this way the study will allow the company under study to make decisions that impact the worker's performance.

Keywords : Burden, Work, Factors, Psychosocial.

Relevance for ergonomics : Identify in a timely and timely manner related to the presence of mental workload and psychosocial factors, thereby allowing actions focused on its reduction and/or elimination to be undertaken.

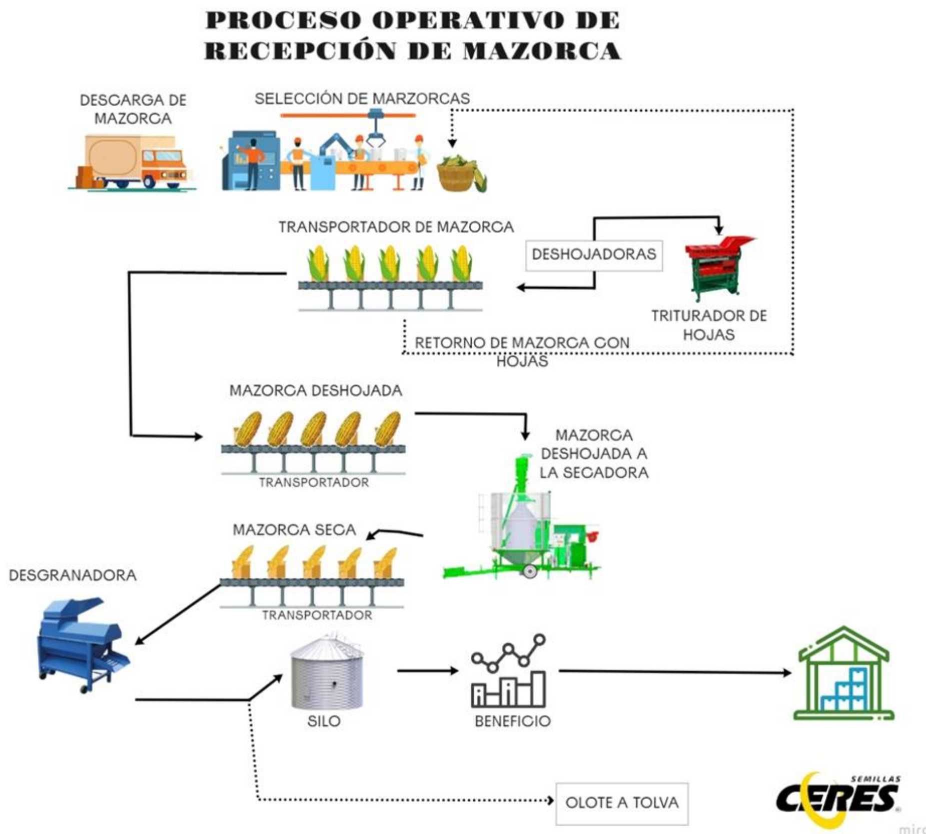
1.INTRODUCTION _

Mexico is characterized by its richness in resources, culture and nature, standing out for its great development in the management of architecture, language, mathematics, and its lands. The use of the land and the employment of labor becomes present as the activities of the inhabitants were perfected, thus agriculture emerging as a key part in the care of the land and the first crops (Martínez, 1983).

Over the years, policies and governments have been changing, and in turn evolving, creating more and more laws, committees, organizations, unions and treaties, to mention the most important such as: Law of Agricultural Associations, Union of Tomato harvesters, Law for the Promotion of Agricultural Associations of the State of Sinaloa (Aguilar and Romero, 2010).

The State of Sinaloa manages to be a key point for the cultivation of corn, making this practice the need to undertake, update and adapt to the changes that the world presented (Norzagaray , García, Llanes , Troyo and Muñoz , 2010). In this context, the company under study arises, which is located in Los Mochis, Sinaloa. Being this organization one of the promoters for agricultural development and born due to the needs of farmers in the main agricultural markets of Mexico (Grupo Ceres, 2021). It currently offers products and services with cutting-edge technology, the general process is shown below.

Figure 1. Production process



In the previous figure, seed packaging stands out since it is, according to management personnel, a key part of the company's success. When exploring this process, possible activities were identified that may be the cause of a factor of psychosocial damage and/or high mental workload, since its execution requires handling excessive loads of seeds.

In Mexico, the Official Mexican Standard NOM-035-STPS-2018, Psychosocial risk factors at work, was recently published. Identification, analysis and prevention, which is created with the intention of avoiding psychosocial risks that workers may present, with such a rule the worker and the company are protected. (Official Gazette of the Federation, 2018).

This is how today every organization is obliged to carry out an organizational study to identify psychosocial factors that can affect the worker's performance, as well as it is essential to take the necessary measures derived from it.

2.OBJECTIVE

Identify the psychosocial factors and mental load associated with the packaging process in an agricultural company.

3. METHODOLOGY

The object under study is made up of the workers who make up the packaging line of the company under study.

The materials that were used to carry out the study were: Record format, necessary to obtain information from the workers regarding the dimensions of mental workload, and; Spreadsheets, for capturing, managing and interpreting information;

The Procedure was based on the NASA TLX method and consisted in the development of the following steps:

1. Characterize the sampling subjects: In this section, the employees involved in the process under study are selected and the main characteristics are described, such as: sex, seniority, marital status, age or other.
2. Obtain information: To obtain the information, a survey was applied in physical format, but not before giving a brief explanation about its completion. As a next step, the surveys are captured as part of the results processing (scores and weights).
3. Interpret results: Here a kind of opinion is issued regarding the level of mental workload that occurred in each worker based on: from 0 to 50, Low; 51 to 69, Medium; and 70 to 100 High.
4. Once the mental load results are available, an interview was applied to the number of workers suggested by NOM-035-STPS-2018 in relation to the number of workers in total (see table 2).

Table 1. Determination of the number of workers to survey.

Total number of workers	Number of workers to interview
1-15	1
16-50	2
51-105	3
More than 105	1 for every 15 workers

Generate recommendations: Finally, recommendations are generated based on the interpretation of the data, which must attack the problem, giving the company options that really work and reduce the problem that arises.

4. RESULTS

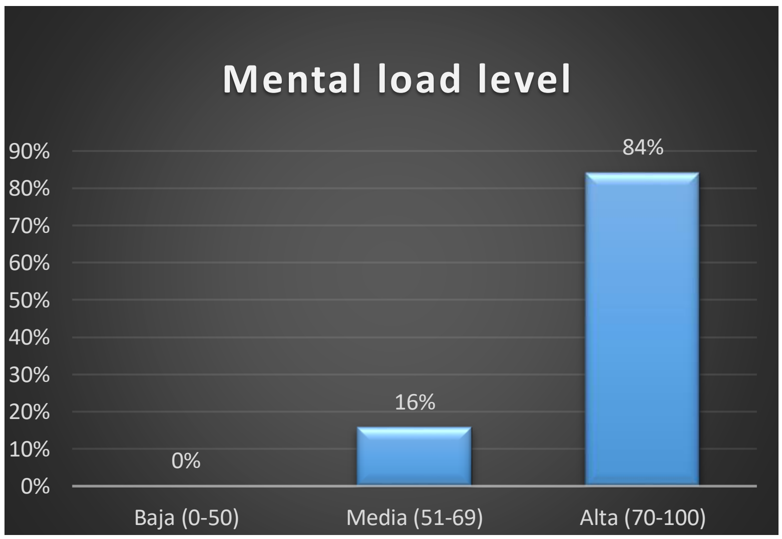
After learning about the process, the first phase of the project began, in which the employees involved in the packaging process were selected and whose characteristics are described below:

- In total there are: 19 employees.
- 10% are female and 90% male.
- The seniority of the employees is on average 10 years.

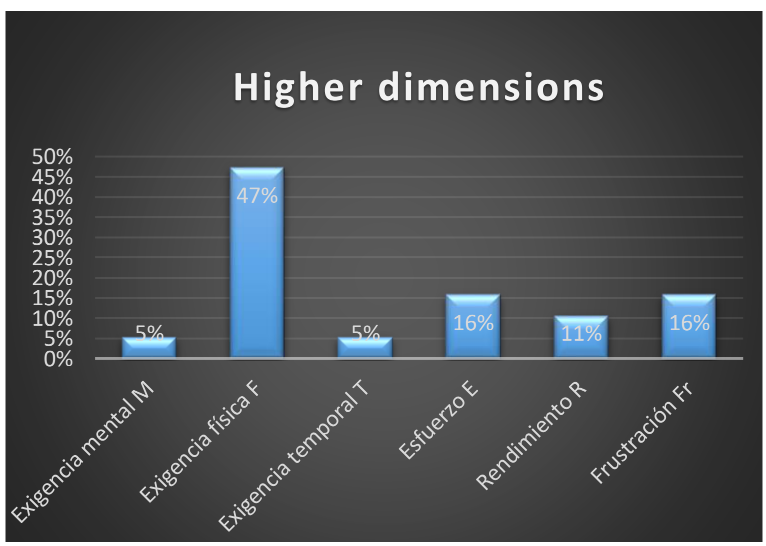
- Marital status is 100% married or in free union.
- The average age is 34 years.
- 60% are father or mother of a family.

As a next step, the NASA TLX method was applied, the results of which are shown below:

Figure 2. Result of the mental load evaluation



a) Level of mental workload in employees



b) Dimensions with greater presence

It can be seen in the figure above that: a) 84% of the employees are at a High mental load level (Alta), 16% are Medium (Media), and none of the total number of employees has a Low mental load (Baja); b) Regarding the dimensions, Physical

Demand is the one with the greatest presence with 47% followed by Effort and Frustration with 16%, Performance , Mental Demand and Time Demand present values less than 5%.

The next step consisted of applying to two of the employees identified with high mental workload the questionnaire suggested by the: Official Mexican Standard NOM-035-STPS-2018 in order to detect any possible severe traumatic event and whose results in both cases, based on in the responses issued in each category, it was null and does not require clinical assessment in aspects related to: I. Severe traumatic events, II. Persistent memories about traumatic events suffered during the last month, III. Effort they have made to avoid similar circumstances or circumstances associated with the event during the last month and IV. Affectation.

With this, it can be asserted that there is no indication that any psychosocial factor is causing the High mental load, so the recommendations and/or actions to be undertaken should be to counteract the dimensions with the greatest presence,

5. CONCLUSIONS

It was possible to identify the psychosocial factors and mental load associated with the packaging process in the agricultural business. It was found that 84% of employees suffer from high mental workload and there is no evidence that it is caused by psychosocial factors. Thanks to this information, it was possible to generate strategies focused on reducing the mental load and improving aspects associated with infrastructure, machinery, and work areas.

The following are recommendations:

- Hiring support staff: this measure will allow the reduction of physical demands through a better balance of activities.
- Adaptation of machines: it will help speed up the movement of the packaging, avoiding fatigue and contributing to less effort.
- Creation of mixed schedules: this option consists of the employees being in schedule rotation with the intention of getting out of the monotony and routine.
- Creation of rest intervals: here it is suggested that a minimum rest of 15 min be assigned for every two hours of work, with the intention that the operator can regain energy and rest mentally.
- Readjust the work program and/or deliveries in such a way that there are no sudden changes, which will allow better performance.
- Generate spaces for dialogue where the worker can express everything that prevents an adequate operation.

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IMPROVEMENT IN HANDLING TOOLBOX FOR LATHE

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Resumen: El caso práctico se realizó en el laboratorio de Maquinas herramientas que da servicio a 350 alumnos, durante la semana, la mayoría de las actividades tiene que ver con los tornos.

Los problemas principales se detectaron al inicio y final de cada clase de laboratorio. Ya que se debían pedir, entregar y transportar material, en lo cual registraban malas posturas y problemas en el manejo de las cajas de herramientas, además de que se busca disminuir el contacto entre los alumnos y los auxiliares de laboratorio por posibles contagios por pandemia.

Se hizo un análisis de estudio de riesgos ergonómicos, riesgos físicos y se aplicaron las normas mexicanas de la Secretaria del Trabajo y Previsión Social (STPS) adecuadas al proyecto.

Se trataron recomendaciones de la Organización Internacional del Trabajo (OIT), así como los métodos Quick Exposure Check (QEC), Manual Handling Assessment chart (MAC), El Instituto Nacional para la Salud y Seguridad Ocupacional (NIOSH) para mejoras ergonómicas, y herramientas de mejora industrial y un simulador de proceso para validar mejoras.

Se mejoraron eficiencia de trabajo en torno en un 33% y el manejo en Almacén en un 100%, así como mejoras sustanciales en manejo de herramientas en torno conforme investigación aplicada en diseño de estaciones para torno y un mejor resguardo de los riesgos COVID

Palabras clave: Método MAC, Método QEC, OIT COVID

Relevancia para la ergonomía: Los esquemas de diagramas con simulación de procesos permiten análisis de riesgos ergonómicos en el manejo de materiales a la par con el cumplimiento de los requerimientos de riegos COVID

Abstract: The case study was carried out in the Machine Tools laboratory that serves 350 students, during the week, most of the activities have to do with lathes.
The main problems were detected at the beginning and end of each laboratory class. Since they had to order, deliver and transport material, in which they registered bad postures and problems in the handling of the toolboxes, in addition to the fact that it seeks to reduce contact between students and laboratory assistants due to possible infections due to pandemic.

An analysis of the study of ergonomic risks, physical risks was made and the Mexican standards of the Ministry of Labor and Social Welfare (STPS) appropriate to the project were applied.

Recommendations of the International Labour Organization (ILO) were discussed, as well as the Quick Exposure Check (QEC), Manual Handling Assessment chart (MAC) methods, The National Institute for Occupational Safety and Health (NIOSH) for ergonomic improvements, and industrial improvement tools and a process simulator to validate improvements.

Work efficiency was improved by around 33% and warehouse handling by 100%, as well as substantial improvements in the handling of tools around according to applied research in the design of lathe stations and better protection from COVID risks.

Keywords.MAC Method, QEC Method, COVID ILO

Relevance to Ergonomics: Diagram schemes with process simulation allow ergonomic risk analysis in material handling at the same time as compliance with COVID irrigation requirements

1. INTRODUCTION

The practical case was carried out in the laboratory of Machine Tools that serves Mechanical, Industrial, Mechatronics, Aerospace, Bioengineering and renewable energies in its spaces is responsible for serving up to 70 students daily to 7 groups in periods of 2 hours each, only in this laboratory 350 students are served, during the week, most of the activities have to do with the lathes.

The main problems were detected at the beginning and end of each laboratory class, since material had to be ordered, delivered and transported, in which they registered bad postures and problems in the handling of toolboxes, in addition to the fact that it seeks to reduce contact between students and laboratory assistants due to possible contagion due to pandemic.

The redesign of the process was reconsidered when manipulating the toolboxes for lathes, that bad postures were reduced when taking them and left in storage and on the lathe, reducing in the auxiliaries the probability of suffering injuries due to manifest discomfort in the Nordico questionnaire of Kuorinka.
An improvement in the application of Mexican ergonomics and standards is required, so a study analysis of ergonomic risks, physical risks was made and the Mexican

standards of the Ministry of Labor and Social Welfare (STPS) appropriate to the project were applied.

Recommendations from the International Labor Organization (ILO) were discussed, as well as Quick Exposure Check (QEC), Manual Handling Assessment chart (MAC), The National Institute for Occupational Health and Safety (NIOSH) for ergonomic improvements, and industrial improvement tools and a process simulator to validate improvements.

Work efficiency was improved by around 33% and warehouse handling by 100%, as well as substantial improvements in the handling of tools around according to applied research in the design of lathe stations and better protection from COVID risks.

2. OBJECTIVES

Redesign the toolbox management process for lathes through work evaluation applying validations of Mexican standards, ergonomic risk analysis, process simulation and ILO COVID recommendations, through proposing a station that allows ergonomic postures and that complies with safety standards to avoid possible injuries to the worker when handling tools.

3. METHODOLOGY

1. Mexican Standards for Lathe Machine Tools, Material Handling, Temperature, Humidity and Lighting Conditions in the Workplace to confirm that the values are within the values of comfort in accordance with the environment in your workplace.
2. ILO for recommendations and follow-up in COVID-related areas
3. QEC, MAC (NOM 036 STPS), NIOSH methods for support in ergonomic analysis
4. Process diagrams and simulation to determine impact of ergonomic improvement on process efficiency

4. RESULTS

4.1. Mexican standards for validating physical conditions of the workstation

a) NOM 011 STPS(DOF, 2002), permissible values of decibels 80 dB in station. As can be seen in Figure 1 the lowest decibels were glued to the walls where there was no metal. Noise does not affect the study process (3M 2022)

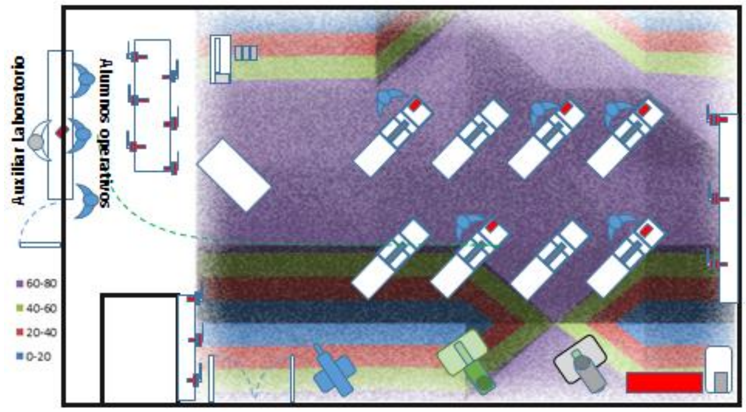

Figure 1.Values of decibels (dB) in station

b) NOM 015 STPS 2011(DOF, 2002), temperature in classes inside the laboratory has been 40 °C with humidity of 60% in this summer output, is outside permissible parameters, however inside storage the temperature is controlled at 22 °C.

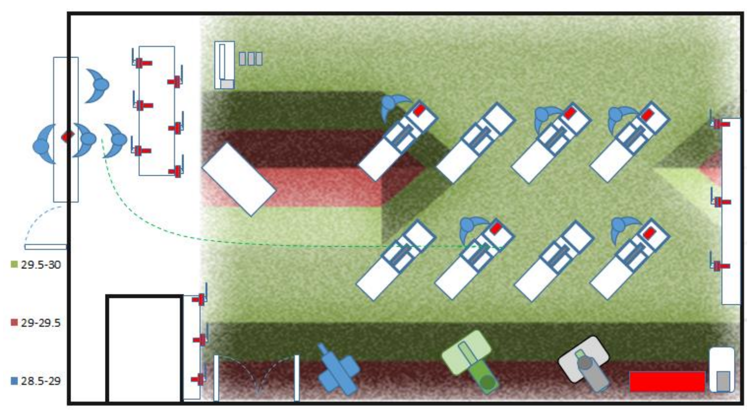

Figure 2. Temperature values in °C, with 2 cooling systems in the machine tool shop.

It was required to use 2 cooling systems for low temperatures during summer season being the highest temperatures shown in Figure 2, which ranged between 29 and 30 °C, and outside were at 45 °C.

c) NOM 025 STPS (DOF, 2008), Lighting between Lathes is within the necessary 300 lux. As shown in Figure 3, Lighting oscillated between the values of 300 db, there are places with better lighting since they are next to windows

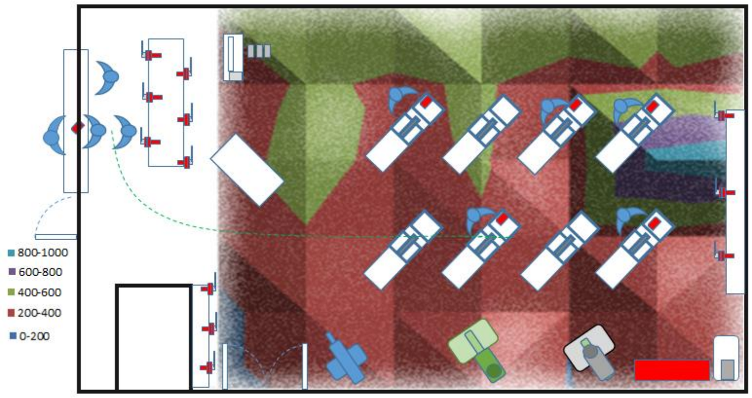

Figure 3. The values in Lux of lighting are shown in Machine Tools Workshop

d) NOM 036 STPS (DOF, 2018), Risk level was Medium-Possible, points were 6 and 10, short-term actions were required.

Table1. Shows the results of applying NOM 036 STPS (MAC) to operational students and Laboratory Assistants

Factor de riesgo	Puntuación antes de mejora							
	Alumnos operativos				Auxiliares Laboratorio			
	Levanta		Traslada		Levanta		Traslada	
Peso/frecuencia	Verde	0	Verde	0	Verde	0	Verde	0
Distancia horizontal	Verde	0	Naranja	3	Rojo	6	Verde	0
Región vertical	Verde	0	Rojo	2	Naranja	1	Verde	0
Torsión y flexión	Verde	0			Rojo	2		
Restricción postural	Verde	0	Naranja	1	Naranja	1	Verde	0
Acopla mano-carga	Naranja	1	Naranja	1	Naranja	1	Verde	0
Superficie trabajo	Verde	0	Verde	0	Verde	0	Verde	0
Otro factor ambiente	Naranja	1	Verde	0	Verde	0	Verde	0
Distancia transporte			Naranja				Verde	0
Obstáculo ruta			Verde	0			Verde	0
Puntuación	2		7		11		0	
Nivel de Riesgo	Bajo -Aceptable		Medio- Posible		Medio- Posible		Bajo -Aceptable	

We applied the Standard 036 STPS (MAC) since auxiliaries reported when applying Kuorinka Nordic Questionnaire having discomfort in shoulders, arms and back when handling the toolboxes of lathes, the results of the analysis are shown in Table 1.

4.2 Regarding ILO recommendations.

Figure 4 shows the results of the evaluation to the area corresponding to the machine tool workshop, obtaining a decrease of 14.46%, of which a 16.67% decrease in the handling of work utensils. For laboratory assistants, the results evaluated in the corresponding areas shown in Figure 5 decreased 20.08% and by

25% in the handling of work utensils.

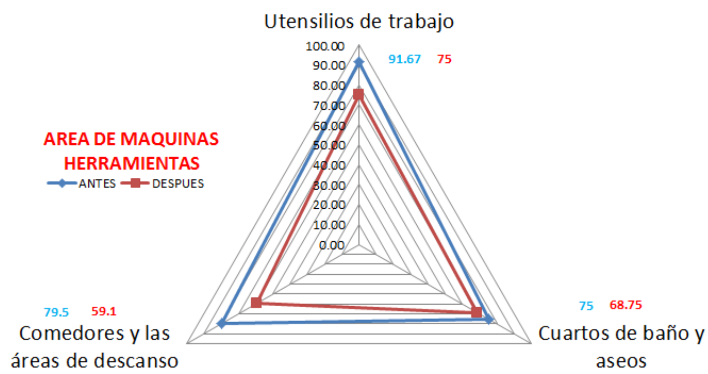

Figure 4. Behavior of ILO COVID recommendations before and after decreases applied in operational student areas

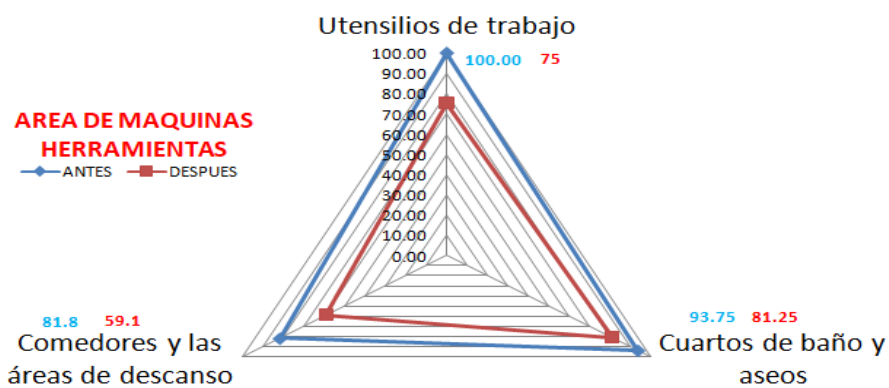

Figure 5. Behavior of ILO COVID recommendations before and after decreases applied in areas of Laboratory Assistants

4.3 Ergonomic analysis and evaluation in lathes and tool warehouse (Melo, 2009) (Cañas, 2011).

a. Material handling was validated by means of the Sue Rodgers ergonomic risk assessment method, obtaining the low results for having a Low Risk Score for being between a score of 1 to 4 in its score that are observed in Table 2

Table 2. Valuation of tool box handling by Sue Rodgers method

Factor de riesgo	Puntuación antes de mejora			
	Alumnos operativos		Auxiliares Laboratorio	
	Levanta	Traslada	Levanta	Traslada
Cuello	3	1	3	3
Hombro derecho	4	1	1	1
Espalda	1	1	4	1
Brazo y codo derecho	1	3	4	4
Muñeca Mano dedo derecho	4	4	4	4
Piernas /Rodilla	1	1	4	1
Tobillos/Pie	1	1	3	1

b. The packaging station was validated by means of the ERGONOMIC RISK ASSESSMENT METHOD WERA (Workplace Ergonomic Risks Assessment), obtaining the results shown in Table 3.

Table 3. Toolbox handling assessment by WERA method

Factor de riesgo	Puntuación antes de mejora			
	Alumnos operativos		Auxiliares Laboratorio	
	Levanta	Traslada	Levanta	Traslada
Hombro	3	2	3	3
Muñecas	3	3	3	3
Espalda	2	2	4	3
Cuello	2	2	4	3
Piernas	3	3	5	4
Fuerzas	2	2	4	3
Vibración	3	3	3	3
Estrés contacto	4	4	4	4
Duración tarea	2	2	3	3
TOTAL	24	23	33	29
Observación	Tarea aceptable	Tarea aceptable	Necesita más investigación y requiere cambios	Necesita más investigación y requiere cambios

b. The packaging station was validated by means of the QEC ergonomic risk assessment method, obtaining the results shown in Table 4

4.4 Process diagrams and process simulation

Process diagrams and process simulation allowed a better analysis of tool handling to eliminate or decrease what did not add value.

The Path Diagrams of figure 6, allow us to identify what type of ergonomic tool we could apply, since if material is handled, the NOM 036 STPS or the MAC, RAPP, NIOSH Tools can be applied, even based on the weight of the load, effort applied, postures adopted, and frequency of handling.

Table 4. Valuation of toolbox handling by QEC method

Factor de riesgo	Puntuación antes de mejora			
	Alumnos operativos		Auxiliares Laboratorio	
	Levanta	Traslada	Levanta	Traslada
Espalda	BAJO	BAJO	MEDIO	BAJO
Hombro/ Brazo	BAJO	BAJO	BAJO	BAJO
Muñeca/ Mano	BAJO	BAJO	BAJO	BAJO
Cuello	BAJO	BAJO	MEDIO	BAJO
Conducción	BAJO	BAJO	BAJO	BAJO
Vibración	BAJO	BAJO	BAJO	BAJO
Ritmo de Trabajo	BAJO	BAJO	MEDIO	MEDIO
Estrés	BAJO	BAJO	MEDIO	MEDIO

In operations or material handling we could also discuss it with Sue Rodgers, WERA, QEC, RULA, OCRA among others.

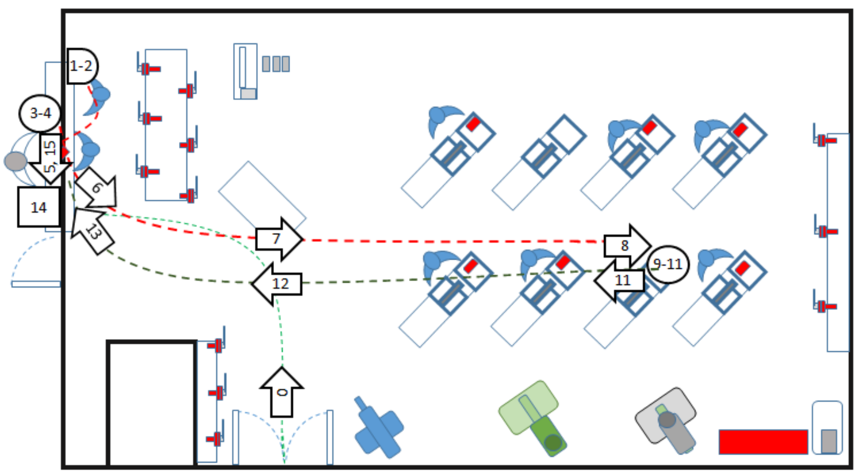

Figure 6. Shows the Tour Diagram before improvement

Figure 7 shows through the PROMODEL simulator the modeling of the process of handling toolboxes for lathes as well as the operation of the same, this allowed in turn similar improvements through estimating what would happen if we eliminate the transport and handling of the tool boxes by permanently placing them in the around where they correspond. This allowed to substantially improve the process giving more operating time for the class and roughing operations on the lathes.

The final route diagram can be seen in Figure 8, where you can see that the boxes will be permanently on the lathes with which 40 minutes are eliminated and added to the class before laboratories of 1 hour and 11 minutes were taught to classes of 1 hour and 50 minutes

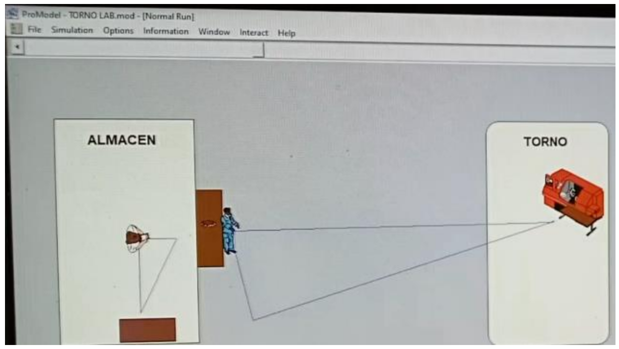

Figure 7. Route diagram with PROMODEL for handling tool boxes on lathes

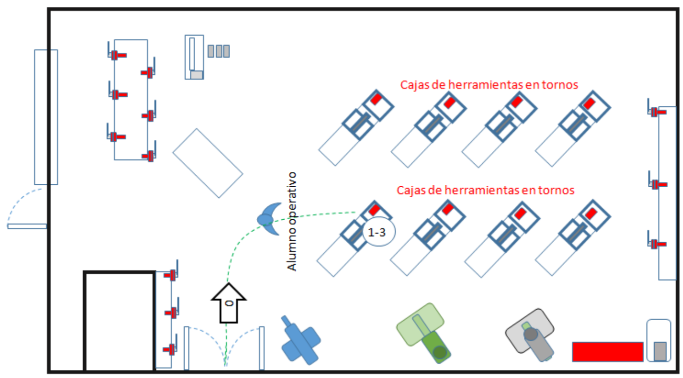

Figure 8. Shows Final route diagram, with tool boxes on lathes

5. DISCUSSION/CONCLUSIONS

5.1 The Mexican Standards NOM 15 STPS are a matter of controversy to acquire air conditioning equipment, NOM 036 could be met in Low Acceptable when transports disappeared and taken from tools in warehouse.

It was perceived that the ambient factor affected, as well as the postural restrictions and couplings when handling the toolboxes, but all this disappeared when leaving each of the toolboxes in each of the corresponding lathes.

It was justified documentarily with the application of this work to rent two industrial chillers in the area of machine tools.

In addition, it was necessary to meet the needs expressed in the questionnaire that comes at the end of the standard, which served to choose the ergonomic validation tool that could check the changes that were required in the material handling procedure, which is no longer applied.

5.2 ILO recommendations to reduce COVID risks were met. The distance between the students who accumulated waiting to receive a tool and between the laboratory assistant and the student who requested the tool box was observed.

5.3 The ergonomic analysis and evaluation in lathes and warehouse showed the need to reduce or eliminate unsafe conditions and acts. The ergonomic evaluations coincided with the discomfort manifested by the assistants and some students who expressed how annoying the handling of the toolbox was. The evaluations allowed to justify the fact that the boxes with tools are not in storage, but in the lathe where they are required.

5.4 The process simulation and the schematization of processes allowed to evidence the change requirements.

The Process Route Diagrams and the simulation of the travel time allowed to identify where the areas of opportunity for improvement could be had and where to justify to the authorities the requirement to move the toolboxes of the warehouse, to have them available to the students in the turnstiles where most of the time they spend in their classes would be required.

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INCLUSION IN RECREATIONAL AND LEISURE ACTIVITIES OUTSIDE THE HOME, FROM THE PERSPECTIVE OF ERGONOMICS IN WHEELCHAIR USERS WITH PARAPLEGIA OF LEGAL AGE

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Resumen: México para 2020 en cifras del INEGI, el 4.9% de las personas vive con alguna discapacidad. El 38.8% de ese porcentaje son personas en silla de ruedas, lo cual la convierte en la discapacidad más latente en nuestro País. Una persona con paraplejía debe aprender a vivir con una limitación permanente. Por ello la importancia de analizar la problemática desde la perspectiva de la ergonomía como herramienta en inclusión de la silla en el entorno físico, accesibilidad y el desarrollo de habilidades para realizar ARO.

Las actividades recreativas y de Ocio (ARO), forman parte esencial en el desarrollo de una sociedad y son fundamentales para mejorar la calidad de vida humana. Las ARO son todas aquellas que se realizan de manera voluntaria de participación gozosa, de felicidad.

El presente documento parte de las principales ARO fuera de casa y las limitaciones a las que se enfrentan los usuarios de silla de ruedas al realizarlas de manera independiente. Para obtener los resultados de este trabajo se dividieron las principales ARO fuera de casa en 4 grupos: actividades deportivo-recreativas, actividades de asistencia a espectáculos, actividades de visita a espacios y actividades socio-familiares.

Se aplicó un test de 21 preguntas a 19 usuarios de silla de ruedas, donde se evaluaron las actividades que realizaban y aquellas que estaban interesados en realizar; así como, las limitaciones y problemáticas a las que se enfrentaba en los espacios físicos y entorno general de la actividad. El resultado arrojo que las actividades de visita a espacios eran las de mayor interés para el 84% de los usuarios, siendo las visitas a centros comerciales y centros nocturnos las principales con 15 respuestas a favor, además de señalar que son actividades importantes de realizar.

Con la investigación se pretende concientizar la necesidad de conocer el trabajo de la ergonomía, la importancia que tiene su aplicación y el compromiso al que nos enfrentamos al crear entornos inclusivos en los que las comodidades de unos no sean las carencias de otros.

Palabras clave: Ergonomía, ARO, Calidad de vida, Paraplejia

Relevancia para la Ergonomía: Demostrar que la discapacidad no es una situación que se pueda elegir, pero el cómo vivirla sí. Es necesario crear y trabajar en entornos inclusivos. El incluir este tipo de problemáticas en el área de la ergonomía resulta muy importante para contribuir en su crecimiento como disciplina y ayudar a evidenciar su lugar en la concepción de escenarios más adecuados para todo tipo de población, sin importar sus características. En este sentido el enfoque sobre actividades poco analizadas, como las ARO fuera de casa representa una oportunidad y un terreno fértil que puede traer nuevos caminos para la ergonomía.

Abstract: According to INEGI figures for 2020, 4.9% of Mexico's population lives with a disability. Of that percentage, 38.8% are people in wheelchairs, which makes it the most prevalent disability in our country. A person with paraplegia must learn to live with a permanent limitation. Therefore the importance of analyzing the problem from the perspective of ergonomics as a tool in the inclusion of the chair in the physical environment, accessibility and the development of skills to perform ARO.

Recreational and Leisure Activities (ARO) are an essential part of the development of a society and are fundamental to improve the quality of human life. The ARO are all those that are carried out voluntarily of joyful participation, of happiness.

This paper is based on the main AROs outside the home and the limitations faced by wheelchair users when performing them independently. To obtain the results of this work, the main AROs outside the home were divided into 4 groups: sports-recreational activities, activities for attending shows, activities for visiting places and socio-family activities.

A 21-question test was applied to 19 wheelchair users, where the activities they performed and those they were interested in performing were evaluated, as well as the limitations and problems they faced in the physical spaces and general environment of the activity. The result showed that the activities of visiting spaces were the most interesting for 84% of the users, being the visits to shopping malls and nightclubs the main ones with 15 responses in favor, in addition to indicating that they are important activities to perform.

The research aims to raise awareness of the need to know the work of ergonomics, the importance of its application and the commitment we face in creating inclusive environments in which the comforts of some are not the shortcomings of others.

Keywords: Ergonomics, ARO, Quality of life, Paraplegia

Relevance to Ergonomics: To demonstrate that disability is not a situation that can be chosen, but how to live it is. It is necessary to create and work in inclusive environments. The inclusion of this type of problems in the area of ergonomics is very important to contribute to its growth as a discipline and help to show its place in the conception of more appropriate scenarios for all types of population, regardless of their characteristics. In this sense, the focus on little analyzed activities, such as AROs outside the home, represents an opportunity and a fertile ground that can bring new paths for ergonomics.

1 INTRODUCTION

According to United Nations statistics, there are 650 million people in the world who have some type of disability (Ladinez Garces, 2020). While in Mexico for 2020, according to INEGI figures, 4.9% of people live with a disability; that is, more than 6 million. Of this percentage, 38.8% are people in wheelchairs, which makes it the most latent disability in our country, with adult men being the most affected. The number of people with paraplegia is increasing year by year and its main cause is trauma associated with traffic accidents, firearm injuries, stab wounds, falls from height, shallow water immersions, sports accidents and accidents at work (Henao & Parra, 2010).

An injury such as paraplegia has serious consequences in all areas of the patient's life and involves adapting to constant changes and limitations inherent to the situation and facing experiences of loss and threats to health (Bickenbach, et al, 2014). Huete (2012) defines paraplegia as the lack of lower motor control, trunk and pelvic organs; either, total or partial regardless of the degree of injury. Paraplegia is not only traumatic in the medical sense; it destroys an entire way of life and divides the person's history into two parts: before and after. A person with paraplegia will have to learn to live with a lifelong limitation; therefore, the environment, accessibility, skill development, participation and opportunities for recreational and leisure activities are key concepts in adapting to a new life (Selva Marroquí, 2013).

According to the International Classification of Functioning (ICF), the social participation of people with disabilities depends on the accessibility of the environment. Thus, accessibility becomes important as a condition that enables people to move, arrive, enter, leave and make use of the spaces and services available to the community in general. (Hurtado Floyd, Et al, 2012).

For people with paraplegia, the wheelchair becomes their means of movement. Therefore, it is important to identify the lack of inclusively designed environments where the wheelchair is not an impossibility for the optimal execution of activities that could be within their faculties, but due to the lack of inclusive spaces are not (Castillo, et al, 2020). The study focuses on the main AROs outside the home, which are divided into four groups: sports-recreational activities, activities for attending shows, activities for visiting spaces and socio-family activities (Mateo Sánchez, 2014).

AROs are of essential importance for the development of every individual, since, in addition to being a pleasurable activity, they contribute to the improvement of quality of life (QOL). The ARO are all those activities that the user performs voluntarily, of joyful participation and happiness without expecting any retribution for its realization. They can be spontaneous or organized, performed individually or collectively (Mateo Sánchez, 2014). In addition to representing the occupation given to free time, AROs are a link that exists between people and are a fundamental part of the functioning of a society. Currently, the impact that AROs have on each member of society is extremely relevant, influencing the positive development of their CV. This is also a human right that every citizen has.

The concept of QOL is aimed at the way in which the individual perceives the place he/she occupies in the cultural environment and in the system in which he/she lives, as well as in relation to his/her objectives, expectations, criteria and concerns. QOL is conceived as a state of general satisfaction, derived from the realization of the person's potentialities. It is a subjective feeling of physical, psychological and social well-being, it includes aspects that go beyond the satisfaction of basic needs in which independence plays an important role (Henao Díaz, 2022). "Quality of life seems to be related to the level of independence of people with paraplegia" (Angle, et al, 2019)., so it is necessary to work on the design of more inclusive scenarios that allow these and other populations, to perform their activities autonomously.

The conditions of the environment can affect or facilitate the realization of ARO outside the home; for people with paraplegia, it is learning to live in a new condition, which becomes a permanent challenge, since the activities that were considered "simple" now carry a different challenge depending on the environment (Moreno & Amaya, 2009). The person with a disability must work daily in a hostile social environment, in adverse circumstances, generally based on indifference and contempt (Duboy, 2011). Places of social recreation such as squares, shopping malls, parks, soccer stadiums, etc., should consider, like any other space, the participation of people with diverse characteristics. This requires environments and services that allow raising the quality of what is offered to the user, regardless of whether he or she depends on a wheelchair to move around or not.

2 OBJECTIVES

To evaluate how the characteristics of the context (system) influence the inclusion of AROs in the independence of people with paraplegia.

1.1 Identify which types of AROs are most important for adults with paraplegia.

1.2 Identify which AROs are the most limiting to independence in adults with paraplegia.

1.3 To diagnose the aspects of the context that represent a limitation for the performance of ARO in persons with paraplegia.

1.4 To determine which aspects influence social inclusion when performing ARO.

3 METHODOLOGY

The research focuses exclusively on AROs performed outside the home, in wheelchair users with paraplegia of legal age who perform and are interested in performing AROs and in places in the metropolitan area of Guadalajara. For the same reason, AROs such as: going on a trip, going to the beach and any that represent leaving the city were discarded.

3.1 Participants:

Nineteen wheelchair users with paraplegia participated, 13 men and 6 women between 23 and 55 years of age, who perform and are interested in performing ARO outside the home, increasing their independence and quality of life.

Users with limitations other than or attached to those of lower limb movement, unable to move outside the home for health reasons, with health and/or cognitive problems were excluded.

3.2 Materials and equipment:

The google forms platform, pencil and paper (for notes), computer with Word and Excel for coding results, smartphone, tablet or some device that could access the platform and connect to the internet were used.

3.3 Measurement instruments:

Using the google forms platform and based on the article by Mateo-Sánchez, J.L. (2014) "Recreational activities: their characteristics, classification and benefits", using the main AROs outside the home, a questionnaire with 3 sections and 21 questions (open, Likert scales and multiple choice) was conducted.

The invitation to answer the questionnaire was sent through social networks: Twitter, Facebook groups and Whatsapp, where the email was requested to send the form, which consisted of a welcome, information about the project, informed consent, personal data and was asked to have 15 minutes to answer it completely.

The first part of the questionnaire inquired about the interest in performing the main AROs outside the home, the level of importance and the main activities performed. The second part focuses on the barriers she faces, the activities she would like to perform and wheelchair information.

4 RESULTS

Of the 7 participants who live in Guadalajara, 5 are men and 2 are women between 25 and 40 years of age; 5 of them use a manual wheelchair, 1 uses an electric wheelchair and 1 uses both. 75% of the participants carry out ARO outside the home accompanied by friends and family members. This group of participants are single and working; some have their own business, are students and employees, and state that the main difficulties they face are: short and inclined ramps, space clearance and inaccessible distributions.

In the first part of the questionnaire about the main ARO that you do or would like to do, the activity that obtained the highest rate of positive responses was visiting places: visiting shopping malls with 83% of responses in favor and nightclubs with 63%, in second place the activities of attending shows: going to the movies with 58% of responses in favor and attending festivals: such as the FIL (international book fair), with 44%, in third place socio-family activities: going to family events and celebrations with 35% of responses in favor and visiting relatives with 33%, finally sports-recreational activities: going to sports festivals with 18% of responses in favor and doing recreational sports with 12%. Fifteen of the 19 participants (10 men and 5 women) expressed interest in going to shopping malls, followed by 11 (6 men and 5 women) who indicated that they were interested in going to nightclubs, all of whom rated these activities as "Very important" and "Important".

In the second part of the questionnaire, 9 of the 19 participants (5 men and 4 women) expressed an interest in going on trips and going to nightclubs, the latter being the one most related to nightclubs, adding that they cannot attend due to the lack of infrastructure, attention and characteristics of the space for their optimal development in the activity and the space.

5 CONCLUSIONS

One of the situations that stands out is the importance of recreational and leisure activities for the participants, particularly for the female population. They reported a high interest that AROs outside the home should not be an option for a few, but that we can all be part of these activities that have a direct impact on the quality of life.

When analyzing the results of the most important activities in comparison with the one they do most, the one they would most like to do and the main limitations, it can be concluded:

They all agree that performing ARO (whatever it is) considerably increases their quality of life, but at the same time it is to face the limitations that most physical spaces and some services have, limiting being able to perform those ARO independently; for example, they mention that if there is elevator the buttons are high and if they are low they are narrow spaces or that if there are bathrooms with space for wheelchairs, the doors are very tight and the hand washers are high, to mention some situations.

From the above arises the need to show in greater depth the shortcomings and limitations of the systems in relation to essential concepts such as inclusion and the need to work in inclusive spaces and services in accordance with the characteristics and expectations of the entire population.

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REDESIGN OF A TOOL TO FACILITATE THE MAINTENANCE OF WASHING MACHINES IN A WHITE LINE REPAIR SHOP

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Resumen. En una tienda de reparación de línea blanca encargada de dar mantenimiento a lavadoras, se han detectado problemas consecuentes a las posturas y el agarre que poseen los trabajadores al efectuar su labor.
Se procedió a realizar un análisis de riesgos dentro de la tienda, por ende, se realizaron estudios de antropometría a los trabajadores y poder cumplir con el objetivo.

Se rediseñó una herramienta (llave) utilizada para abrir el interior de las lavadoras, la cual generaba un impacto negativo sobre la salud de los empleados, generando así mismo un impacto en la productividad del proceso.
La antropometría de los trabajadores debe ser considerada en todo momento cuando hablamos del diseño de herramientas.

Palabras clave: Rediseño, posturas, análisis, integridad.

Relevancia para la ergonomía: Permite desarrollar metodologías que contribuyan al desarrollo de diferentes actividades, en este caso, al rediseño de una herramienta de trabajo. Permite tener mayor control sobre los riesgos ergonómicos, eliminando así las posibilidades de adquirir diversas afectaciones a largo plazo. También, permite eliminar la fatiga del operador.

Este informe aporta diversidad de datos que contribuyen al correcto manejo de herramientas, permitiendo mantener una postura idónea al realizar diversas actividades.

Abstract. In a white line repair shop which give maintenance to washing machines, has been detected different problems due to the postures and the way that employees handle a tool.

We make a risk analysis into the repair store, so we applied anthropometric studies to be able to achieve the objective.

It was redesigned a tool used to opening the washing machines, which was generating a negative impact up employee's health and this also generated a negative impact up the productivity of the company.

Keywords. Redesign, postures, analysis, integrity.

Relevance to Ergonomics: It allows to develop different methodologies that contribute to the way on different activities are developed, on this case, the redesign of a work tool. Allows greater control over ergonomic risks, this eliminating the possibility of acquiring various long-term affectations. It also eliminates operator fatigue**.**

This article provides a huge data diversity that contribute to the correct tool usage, allowing to keep a right posture while is doing a task.

1. INTRODUCTION

The postures in the work area have a great relevance, since they insure the integrity of the employee, the efficiency, the care of the products and avoid fatigue that can mean substantial losses for the companies. That is why we decided to analyze a work area to find a way to facilitate the maintenance of washing machines.

A micro-company dedicated to the sale, repair and maintenance of white goods in Guasave, Sinaloa, Mexico, stated when the employee gives maintenance to washing machines they hit and hurt their limbs due to the type of tool used and the way in which they did the action with it; in addition, they have often damaged the inside of the washing machines by using the hammer in an inadequate way.

2. OBJETIVES.

Redesign a tool that allow to employees to do the washing machines maintenance task in a secure an efficient way.

3. JUSTIFICATION.

This Project is been elaborated to benefit to the employee health and owner company economic. With the improvement or redesign of this tool, we are looking for the decline of repetitive strain injuries and other work risk.

4. METHODOLOGY.

To make the redesign the best possible, we decided to use the twelve ergonomic principles, where we detected the main problems at the moment the employee handled the tool.

First, we applied a kind of survey to all the twenty employees; it it pretty important to remind that only work men in the company, because of the kind of work that is. This survey just gave us information about of comfortable was using the tool (without redesign), how the employee feels, how secure the employee was, also we asked if their bodies were feeling right after make the action.
After that, we elaborated graphs to show in a better way the results we obtained.

Figure 1 shows us that 80% of the employees do not feel comfortable when they use the tool.

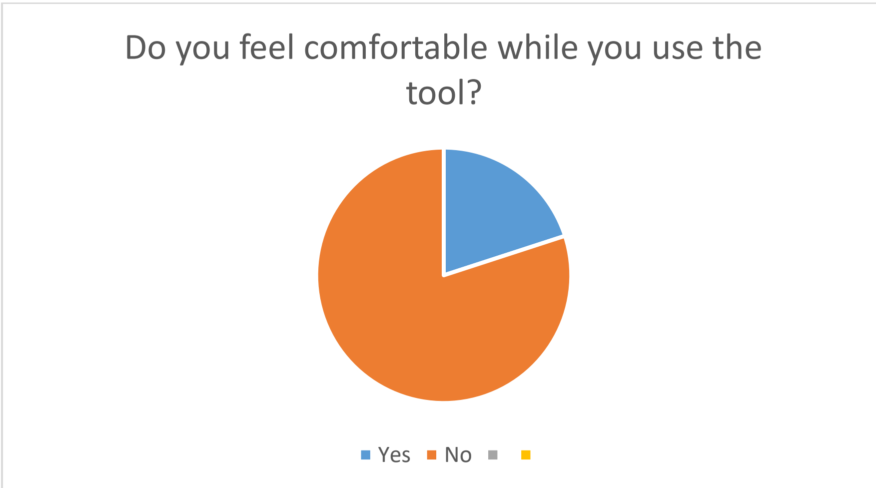

Figure 1. Results from question one.

Figure 2 shows that only 20% feel okay after they use the tool.

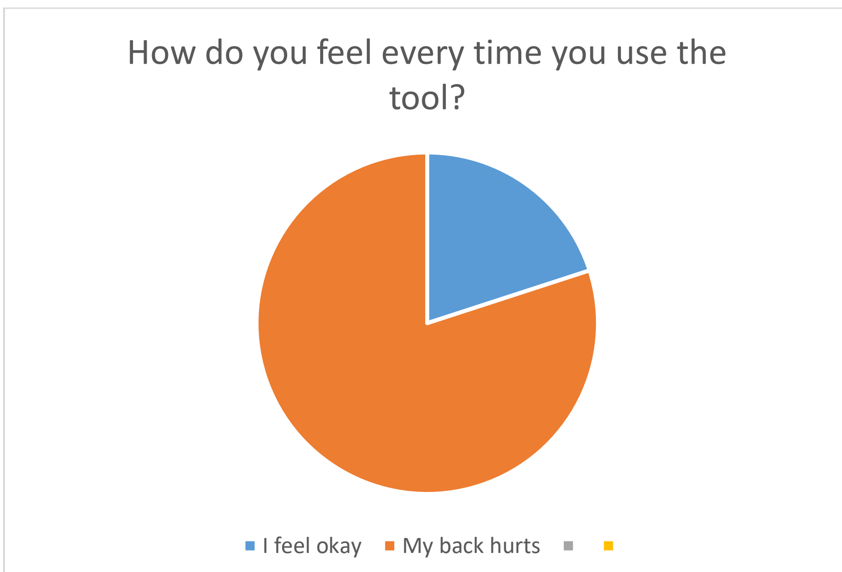

Figure 2. Results from question two.

Figure 3 shows that up the 50% (80%) think the tool it is not secure.

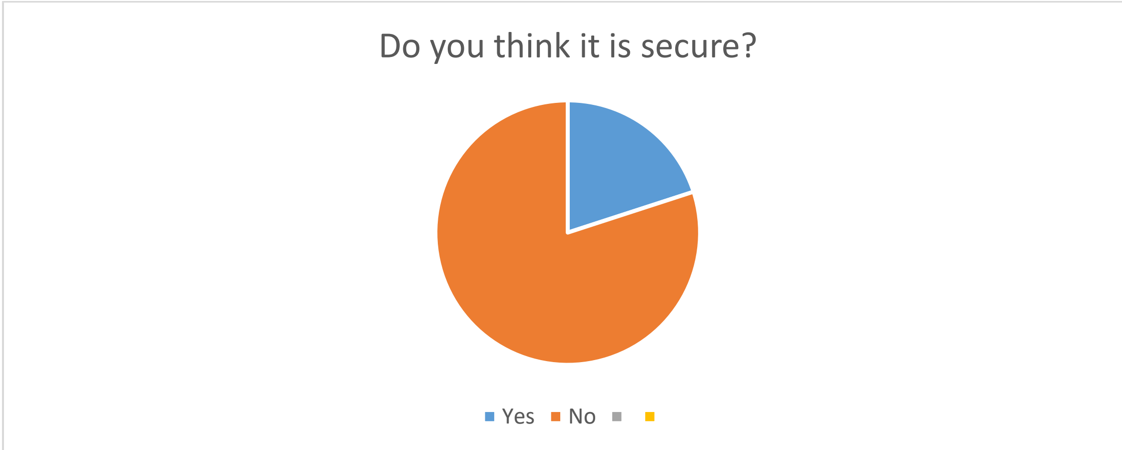

Figure 3. Results from question three.

And at the last, figure 4 shows that 80% feel their body not okay after make an effort.

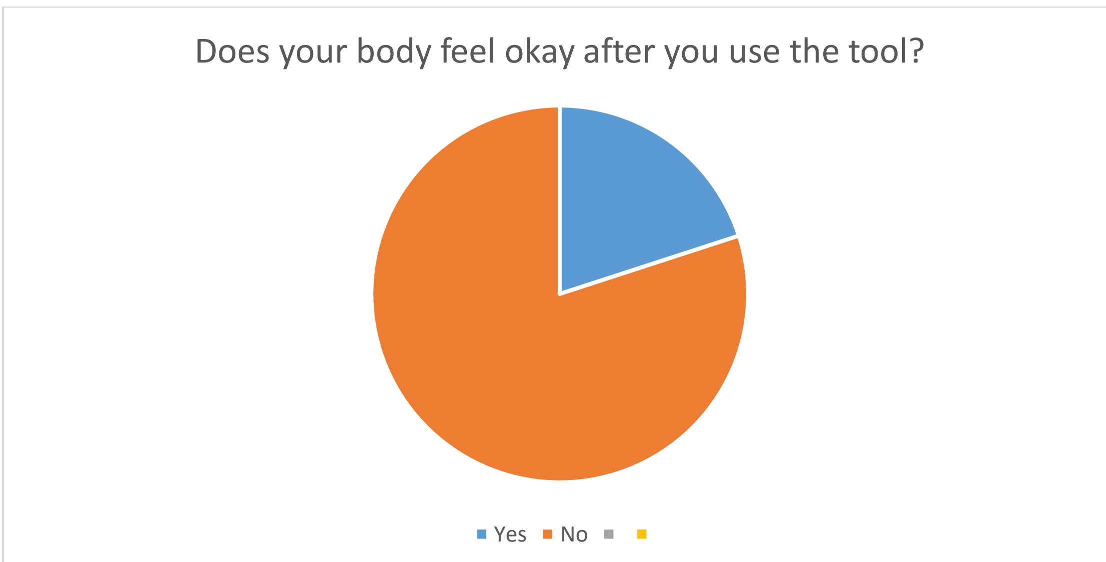

Figure 4. Results from question four.

The next step was analyzing the postures and the way the employees were doing the tasks, here, we were able to notice what they were doing bad. Figure 5 and figure 6 show this.

Figure 5. An employee doing the task.

Figure 6. An employee doing the task.

Applying a survey, we realized that is not enough information to start whit the redesign, so it was necessary to get an anthropometric sample, taking care in the parts of the body with the most risk. The men who work in this company are between 19 and 37 years old, which was very important to the sample. In figure 5 we present the results from the sample.

Código de muestra	MUESTRA																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
949	98	100	96	105	104	111	96	102	104	103	102	101	97	103	105	110	106	111	110	108
420	7	9	8	8	9	9	7	10	9	8	8	9	7	8	7	7	7	10	9	8
656	19	19	18	20	19	20	18	17.6	20	19.5	20	19	17	20	18	18	17	20	19	18
411	10	10	10	10	10	10	10	8.6	10	9	10	10	10	9	9	9	9	10	10	9

Figure 7. Results from the anthropometric sample based in ITH's anthropometric chart.

We also appealed to calculate the percentiles. We found that the diameter of 4.97 centimeters is the most suitable for the grip of the new tool. That's why we based on a 5th percentile.

				Percentiles		
mínimo	máximo	Media	DE	5	50	95
60	100.5	77.9	11.48	60.0	77.9	100.03
7	10	8	1.01	7.0	8	10.00
17	20	19	1.04	17.0	19	20.00
8.6	10	10	0.52	9.0	10	10.00

Figure 8. Percentil results.

Once we got the results, we started to think on the material the tool would be fabricated. It was opted to use iron because of it is an easy-going metal. Iron is a transition metal that belongs to group 8 or VIIIB of the periodic table and is represented by the chemical symbol Fe. It is a grayish, ductile, malleable and tenacity metal, used in numerous applications of great utility for man and society. Iron has been processed for millennia. However, it is difficult to find iron objects of such ancient ages because of their susceptibility to corroding, which causes their destruction. The oldest known iron objects were made with the one found inside meteorites. Such is the case of a species of beads made in 3500 BC, found in Gerzah, Egypt, and a dagger found in the tomb of Tutankhamun. Iron meteorites are characterized by a high nickel content, so it was possible to identify their origin in these objects.

Even when this material is susceptible to corroding, is an economic one, so that was another point to consider when the choosing.

5. RESULTS.

Now, there are the prototype images of our new tool (redesigned tool) made in SolidWorks; they are shown in different perspectives:

In figure 9 you can see the redesigned tool where we added a “body” with two bars to handle from.

Figure 9. Redesigned tool result in SolidWorks.

Next in figure 10 you can see the new tool from the front; this time, we represented the employee hands as the correct way to grip.

Figure 10. Redesigned tool in SolidWorks representing the way to handle correctly.

Then you can see the tool from another perspective in figure 11. The employee hands are still there because of you can discover another point of view.

Figure 11. Redesigned tool from a different perspective.

When the design was printed in SolidWorks, it was manufactured the tool obtaining the follow result (look at figure 12).

Figure 12. Redesigned tool.

Finally, in figure 13 you can see the way this tool must be collocated for a good work.

Figure 13. How the tool is collocated in the washing machines.

Figure 14 shows the graph of the data collected from the different diameters in 20 people based on a 5th percentile.

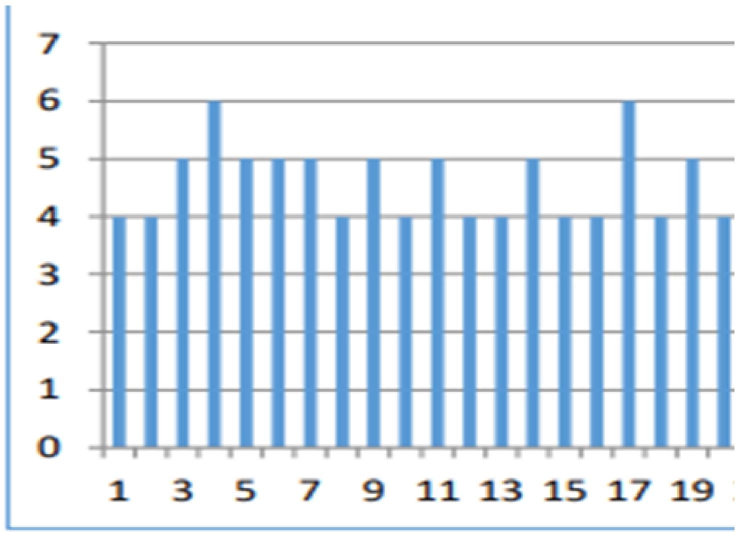

Figure 14. Grip diameter.

It was confirmed that this new tool makes the work a better one, improving the postures in employees, allowing them have more comfort and avoid risks and injures at work. This is captured in the next two images taken to one of the employees.

Figure 15. Correctly posture. to use the redesigned tool

Figure 16 Correctly grip to use the redesigned tool.

6. CONCLUSIONS.

With the obtained results we conclude that the redesign of different tools allows us to facilitate the work for companies' employees and at the same time, we are saving money while we are avoiding injures and incapacitations caused for these injures. In the redesign of this tool specifically, we confirmed that the problem raised at the beginning can be solved. Therefore, we have innovated in something we never thought.

It was stopped for a while and started to imagine how great could be the fact of start a company in charge of producing our new tool; it is a possibility to us for earning some money and for other people for have a job. Jobs opportunities with these ideas would be exceptional.

Also, we think ergonomics studies (anthropometric sample in this time) are really useful when we are interested on redesigned tools or a work area, when we are looking for the employee health and many other situations.

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COMPARATIVE ANALYSIS, FROM DESIGN AND ERGONOMICS PERSPECTIVE OF TWO MODELS OF WHEELCHAIRS USED BY WOMEN

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Resumen: Muchas personas con discapacidad motriz PCD dependen de una silla de ruedas para moverse con libertad en su entorno. Por lo tanto, es importante destacar que necesitan del apoyo de otra persona que las auxilie, especialmente, cuando deben desplazarse a sitios donde se precisa el uso de algún medio de transporte. Poca atención se ha prestado al personal de apoyo, en particular, a las molestias y lesiones que pueden sufrir derivadas de los movimientos rápidos e inesperados, así como las posturas forzadas que deben realizar bajo la presión de factores externos cuando realizan las maniobras para mover con rapidez y seguridad a la PCD de la silla de ruedas al interior del automóvil. Y sobre todo levantar la silla de ruedas para acomodarla en el interior de la cajuela del automóvil.

En este artículo se presenta de manera sucinta, un estudio de caso en el cual se desarrolla la descripción, análisis ergonómico y de diseño de dos modelos de sillas de ruedas. Sobre todo, se pretende enfocar la atención en la persona que auxilia para conocer con detalle la relación que se establece entre las partes móviles de la silla de ruedas con las que interactúa y que pueden ocasionar algunas lesiones o daño en las manos, en las extremidades superiores y espalda.

Palabras clave: Ergonomía, diseño, sillas de ruedas, personas de apoyo.

Relevancia para la Ergonomía: Esta investigación puede servir como guía para describir y analizar, desde el punto de vista de la ergonomía y del diseño, dos modelos de sillas de ruedas utilizados por personas con discapacidad motriz. Destacar que en este estudio se centra la atención en usuarios del sexo femenino,

Este ejercicio de análisis puede aportar datos a través de la observación centrada en el usuario del sexo femenino, para quienes estén interesados en este enfoque. Con la publicación de este trabajo se desea difundir los resultados de esta primera etapa y recibir, si fuera posible, algunos comentarios sobre el tema.

Abstract: Many people with motor disabilities rely on wheelchairs to move. Therefore, it is important to stand out they trust and rely on another person to help them, particularly when they must travel and need a car. Little attention has been

paid to caregivers, specially, to the discomfort and injuries they may suffer from quick and unexpected movements, as well as awkward postures due to reactions in circumstances beyond their control as they must help the other person to get into the car safely from the wheelchair and lift the wheelchair and place it in the trunk of the car.

This article concisely presents a case study in which the description, ergonomic analysis and design of two models of wheelchairs are carried out. Above all, it is intended to pay attention on the female caregiver in order to know about the interaction between the mobile parts of the wheelchair that may cause injuries or hurt her hands, upper limbs and back.

Key words: Ergonomics, design, wheelchairs, female caregivers.

Relevance to ergonomics: This research may be useful as a guide to describe and analyze, as both ergonomic and design approach, two models of wheel chairs used by people with motor disabilities. It should be noted that this study focuses on female users. This analytical exercise can provide data through observation focused on the female user. With the publication of this paper, we wish to spread the results of this first stage and receive, if possible, some comments on the subject at the next congress.

1. INTRODUCTION

Nowadays it is common to find people who need wheelchairs, due to various causes: health problems and/or aging, which implies a decrease in mobility of the lower limbs. It is important to attend this group of population identified as persons with motor disabilities. PWD

PWD may require assistance from another person within the home to carry out some activities. However, when they require total support is to move from one place to another since they need to use a means of transportation such as a car.

The interest in learning more about this issue arises from observing that the population in some places in Mexico City CDMX is increasingly composed of older adults, which is more evident when visiting hospitals and clinics. It has also been observed that women accompany the PWD, in any of the groups of different age ranges to which these people belong.

The intention of this study is to focus on the situation in which two women are present: the PWD and the attendant.

To study the issue, two existing models on the market were selected:
Transfer chair and heavy-duty chair. To help to decide, some data were compared with information published in Panero and Zelnik, on the traditional chair with a 58 cm (22") rim and a support ring to move with hands and arms. (Figure 1).

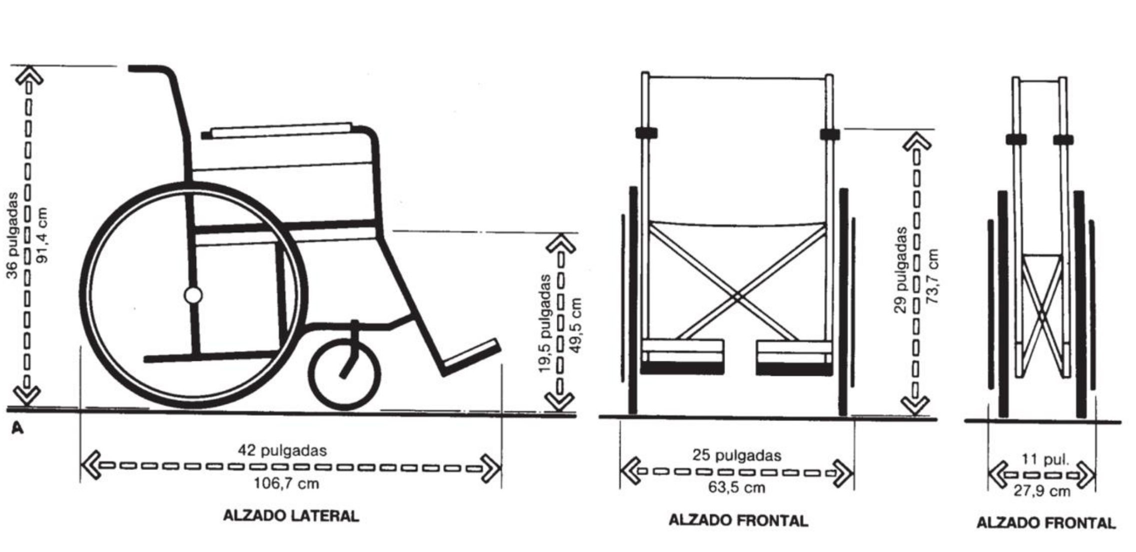


Figure 1.
Traditional wheelchair. 22” diameter
Panero & Zelnik (1998)

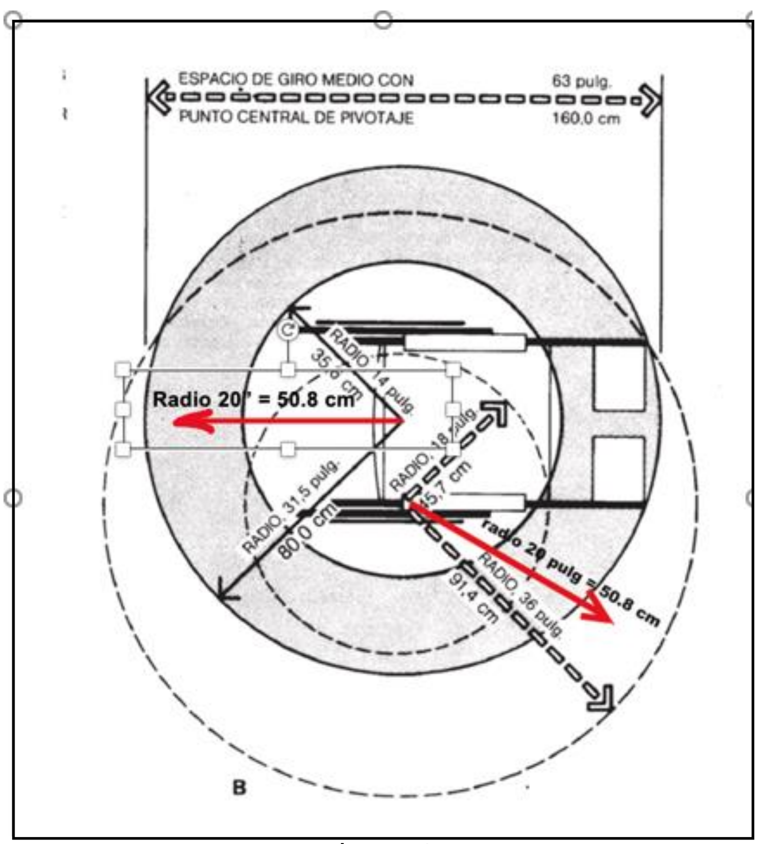


Figure 2
Comparative wheelchair turning-radius
Panero & Zelnik (1998)

Wheelchairs not only enable mobility, they must also support the trunk and the legs, allow the seated person to manipulate objects in front and at the sides, be stable, be lockable in place, and facilitate sitting down and getting out of the chair.

Specific design features of seat span, backrest, armrest, or leg support can meet the need to provide stable yet relaxed body support, at the same time avoiding pressure points and resulting sores.

Kroemer (2006).

The main considerations when choosing the transfer chair are that it is more appropriate for the interior, due to its dimensions, foldability and lightness; when it comes to going up and down stairs; this type of chair is more easily adapted to small spaces since it avoids having to modify the space. Accommodating it in the trunk of the car or in similar situations is easier.

On the other hand, the heavy-duty chair is more suitable for outdoor use and for traveling over uneven floors.

This paper compares the two models based on design and applied ergonomics.

Considering that design as a profession solves problems through objects and that Ergonomics is a discipline that provides scientific knowledge to better understanding the users in order to achieve the most appropriate solution to the identified problem. This article is focused on the contributions and common points of both disciplines.

To better understand the problem, some methods recommend dividing it into three units: **User Object Environment**.

> "Industrial Design is a strategic problem-solving process that drives innovation, builds business success, and leads to a better quality of life through innovative **products**, systems, services, and experiences."
>
> World Design Organization

In their publications, Avila and Prado (2006) mention that the object of study of Ergonomics is the man-object-environment system, as a complex structure of relationships and functions.

These relationships must be considered as a whole. However, in order to facilitate the research procedure, each one is analyzed, without forgetting the intrinsic relationship established between the object and the user through the activity.

Each object has a function, in this case sitting, which is highlighted even by the name with which it is identified and serves as the basis for its definition.

Table 2

Definitions: **chair:** *noun*

A chair is a piece of furniture for one person to sit in, with a support for the person's back.

Wheelchair: *noun*

A chair mounted on wheels for use by persons who cannot walk because they are temporarily or permanently disabled.

A special chair mounted on large wheels, for use by invalids or others for whom walking is impossible or temporarily inadvisable.

Therefore, we proceed to present the content of the research.

2. OBJECTIVES

From design scope emphasizing on ergonomics, describe, analyze and compare two different wheelchair models to get information about ergonomic risk factors caused by using each.

Consider women in each circumstance.
Develop didactic material and tools convenient to design students.
Engage students in understanding the user – object – environment relationship.
Include only two models of wheelchairs: transport and heavy-duty chair.

3. METHODOLOGY

This research is based on qualitative and quantitative methodology. Especially the case study technique. Case study supported by various design methods that complement each other in order to gain a deeper understanding of the particular problem.

- Description and analysis of two chairs.
- User centered design UX
- Research focused on female users
- Documentary research on ergonomic issues
- Analysis and description of tasks and activities that may cause injuries while using each wheelchair
- Consult anthropometric charts
- Obtain data with digital grip strength tester
- Provide evidence through photography and video

3.1 Description and analysis of two chairs.

3.1.1 Transport chair. Technical specifications
Manual wheelchair

Aluminum tube frame
Diameter: 3.2 cm (1 ¼ “)
Blue enamel paint
Weight capacity: **135 kg**
Product weight: **10 kg**
Seat width: 48.26 cm
Breathable nylon upholstery,
Comfortable, “restaurant-style” arms – (so you can pull up to tables and eat comfortably).
Compact foldable: the back folds down
Foldable seat
Easy storage and transport

Total height = 97 cm
Length = 85 cm without footrest
Width between casters, front view 50.8 cm (20”). (Figure 3)

Tasks:
Folding backrest with lever.
Gripping: Press with thumbs and other fingers with force to release and fold the backrest down. **Be Careful!**

3.1.2 Comparative Chart Transit Wheelchair

Table 3

Number	**Image**	**Description**	**Action**
1		Side view transit wheelchair Two female users: PWD and caregiver PWD: weight = 55 kg Height: 1.60 m Caregiver: Height: 1.50 m Weight: 55 kg Chair Height of handles: 80 cm	Caregiver pushes by leaning on two handles at 80 cm height, placed on the right and left sides. Caregiver **Awkward Pushing Position**

<table>
<tr><td>2</td><td>
</td><td>Chair with 4 wheels of 20 cm

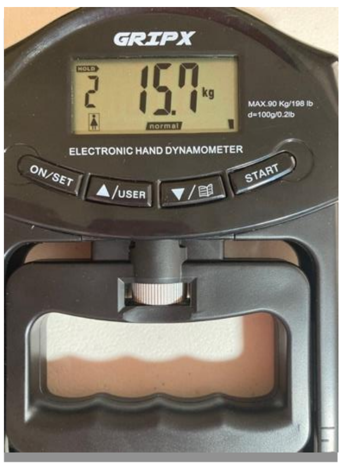
Two fixed back casters
Front wheels turn

Removable footrests for PWD</td><td></td></tr>
<tr><td>3</td><td></td><td>Small footrests to help the caregiver push up the chair</td><td>Caregiver must bend down to apply the brake, with each hand: Left and right

She must make sure the chair does not move.

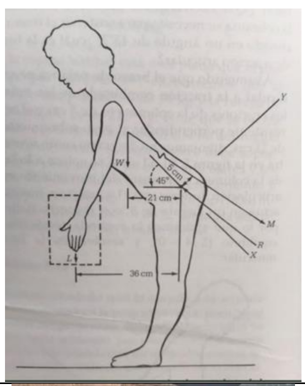
She cannot do it quickly.</td></tr>
<tr><td>4</td><td>
</td><td>Brake mechanism det</td><td></td></tr>
<tr><td>5</td><td>
</td><td>
</td><td>Measurements folded:
73 x 57 x 57 x 25 cm

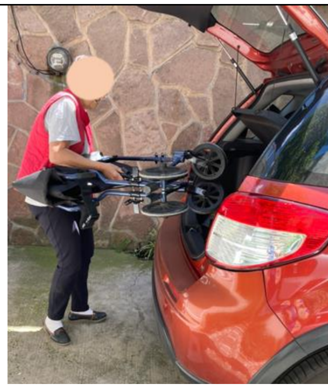
Detachable armrests</td></tr>
</table>

6			Folding backrest with lever. Gripping: Press tightly with thumbs and other fingers to release and fold the backrest down. **Caution.**
		Grip force measurement meter. Automatic capture. Hand grip power 198 lb / 90 kg. Accurate and easy to use. Sensitive sensor handheld dynamometer with accurate 0.2 lb / 100g increments, measuring range from 0.02 lb to 198 lb (100 grams to 90 kg), Highly sensitive touch switch units for easy access and display of measurements in one second. Robust memory Stores up to 19 independent cases where you can recall your grip force data anytime you want.	**Grip force Data:** The grip force measurement data is important because it refers to the effort that the user can apply on the wheelchair level to fold backrest. Caregiver: 60 years old Right hand: 24.7 kg Left hand: 18.0 kg **Left Hand** length: 170 mm width: 75 mm Right hand Length: 170 mm Width: 80 mm Female user 70 yrs old Right hand: 22.0 kg Left hand: 18.0 kg Length: 160 mm Width: 80 mm

3.1.3 Wheelchair transportation by car

Table 4

Number	Image	Description	Action
1		Loading the folded wheelchair into the trunk of the car. Product weight: 10 kg	The person bends down to raise the chair with both hands
2			Forces acting on the lower back when a person lifts a given weight. Forward flexion of the trunk
3			The person is lifting the chair into the luggage compartment **H = 80 cm**

4			The female user is lifting the chair into the luggage compartment **H = 80 cm**
5		The image shows different BODY tilt angles	The female user puts the chair into the luggage compartment. **H = 80 cm**

3.1.4 Heavy-Duty Wheelchair. Technical specifications

Transport chair. Technical specifications

Manual wheelchair
Aluminum tube frame
Diameter: 3.9 cm (1 ½’’)
Natural
Weight capacity: **135 kg**
Product weight: **15 kg**
Seat width: 48.26 cm
Breathable nylon upholstery,

Compact foldable: the back folds down
Foldable seat
Easy storage and transport

Total height = 90 cm
Length = 95 cm without footrest
Width between casters, front view 50.8 cm (20”). (Figure 3)

Tasks:
Folding backrest with lever.

Gripping: Press with thumbs and other fingers with force to release and fold the backrest down. **Be Careful!**

Table 5

Number	Image	Description	Action
1		H 89 cm Seat height 46 cm Width 59 cm D 30 cm back wheels casters D 20 cm front wheels	Folding back rest and seat Similar mechanisms to fold backrest Removable footrests
2		This image shows the assistant in relation to the heavy-duty chair. The position of the arm in relation to the handle.	The casters or w
3			The whip brake -cable is underneath the handle, which allows the caregiver to control the chair with both hands, easily and with no risks; without neglecting the PWD. (Person with disability). .
			Placement and adjustment of

4			removable footrests Each footrest weighs 700 g

4. RESULTS

4.1 The transfer wheelchair

The transfer wheelchair is very suitable for use inside rooms or small spaces, because as mentioned at the beginning, the turning radius is small and allows maneuverability. The PWD has no possibility of support because the rear tires are very small (10 cm) and cannot be used to move around. According to personal observations, it has been noted that the PCD lean on furniture, bars and other elements around, they can use the wheelchair to help themselves carry out their daily activities with a certain degree of independence. What is described is possible if the PWD can exert force with the arms to move at will. On the other, If it were difficult, then he/she is more dependent on other.

This wheelchair is very suitable to move to other places where the PWD can chat with relatives and friends, also easily approach the dining table or change to other armchairs or seats.

It is easy for a female person to get in and out of the chair at home. She can also load it into the trunk of a small car, with enough time to carry out the maneuver. The caregiver, who may also be the one driving the car, should take enough time and avoid sudden and forced movements.

In this situation it is important to note that the mechanism for folding the seat is important to avoid bruised fingers, as it has a lever that must be pressed and release the backrest to fold it and reduce the dimensions in height.

Previously, both footrests must be disassembled and placed independently to fit inside the trunk. Both footrests weigh about 1.5 kg.

The importance of the brake is emphasized, since the person assisting must bend down to operate it, either to apply or to release it. Therefore, he/she loses control over the PWD for a few moments, especially if he/she needs to apply it suddenly.

This small lever, even if it is at the back, can be reached by the user to prevent the chair from moving, with a slight movement, with either arm and hand can be achieved.

The chair analyzed is not suitable for use on sidewalks because the small, hard tires do not minimize the uneven floor.

Summarizing, it is a chair that is recommended for indoor use. It is suggested, if possible, to acquire another one to move the PWD to enjoy outside strides. Above all, it is important to transport the PWD to attend medical appointments and other important commitments.

4.2 The heavy-duty wheelchair

The heavy-duty wheelchair, on the other hand, is more appropriate for outdoor use because the tires are usually softer and larger in diameter. PWD tend to feel more comfortable and safer.

The heavy-duty wheelchair, on the other hand, is more suitable for outdoor use because the tires are usually softer and larger in diameter. PWD usually feel more comfortable and safer during transfers. Especially, because the attendant can control the chair and any movement, as she does not have to bend down to trigger the brake. In the same way, she can release it easily.

This wheelchair is recommended for going up or down ramps, of different slopes, as the large wheels are appropriate because it is easier to push. The position of the brake, which can be activated at any time, provides greater safety. In the same way, it can be applied gradually and the chair can be better controlled when moving down a steep slope.

The footrests can be easily folded or removed to reduce the overall dimensions of the wheelchair.

Experience has shown that it is more difficult to fit in the trunks of compact and subcompact cars, especially if a female user has to lift it in a hurry. (Weight: 15 kg).

5. CONCLUSIONS

This paper presents not he conclusions of preliminary research on the subject. As the findings developed, it grew more interesting, so we were committed to continue. It is only the beginning. We are aware of the importance of the depth and scope of this topic, due to the importance of attending special users, especially women.

Some instruments, such as goniometers and dynamometers were bought, with the purpose of organizing an experimental ergonomics laboratory, in order to continue and achieve experience to improve results to education and design.

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ERGONOMIC WORKSTATION DESING IN THE FISH CLEANING PROCESS

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Resumen: El estudio ergonómico de los puestos de trabajo en las industrias permite evaluar y dar soluciones oportunas a las lesiones y enfermedades que se hacen presentes en las áreas de trabajo. Si bien, la ergonomía aplicada a la industria puede contribuir siendo de gran ayuda para aumentar la productividad a través de mejorar las capacidades físicas del trabajador adaptando su espacio de trabajo a las necesidades que este requiere. El estudio que se presenta se realizó en un espacio de trabajo dedicado específicamente en la limpieza de pescado, el objetivo general es evaluar su área de trabajo a fin de proponer un rediseño de la misma buscando que esta cumpla y se adapte a condiciones óptimas para que los trabajadores aumenten su desempeño y disminuya el riesgo laboral.

Palabras clave: Estación de trabajo, proceso, diseño, pesca.

Relevancia para la ergonomía: Diseñar e implementar las condiciones adecuadas en los puestos de trabajo dentro de los sistemas productivos permiten a estos un aumento de productividad. La participación de la ergonomía en que esto se pueda lograr está en que buscara de alguna manera la mejor distribución y optimización en de los recursos. Logrando la creación de nuevos o renovados sistemas productivos con eficientes puestos de trabajo procurando la seguridad del trabajador.

Abstract: The ergonomic study of workstations in industries allows to evaluate and provide timely solutions to injuries and diseases that are present in the work areas. However, ergonomics applied to the industry can contribute being of great help to increase productivity through improving the physical capabilities of the worker by adapting the workspace to the needs required. The study presented here was conducted in a workspace specifically dedicated to fish cleaning, the overall objective is to evaluate the work area in order to propose a redesign of the same looking for it to meet and adapt to optimal conditions for workers to increase their performance and reduce occupational risk.

Keywords. Workstation, process, design, fishing.

Relevance to Ergonomics: Designing and implementing the appropriate conditions in the workstations within the productive systems allows them to increase productivity. The participation of ergonomics in that this can be achieved is that it seeks in some way the best distribution and optimization of resources. Achieving the creation of new or renewed productive systems with efficient workplaces, ensuring the worker's safety.

1. INTRODUCTION

In industry, workers perform very special tasks and, in most cases, it is necessary to adopt inadequate postures in order to carry them out. To avoid these injuries, which not only harm the worker but also the company, as they are the cause of absenteeism and reduced performance, it is necessary to design the workstations considering an additional variable: the human factor.

The human factor is the most important component in any work system; its safety and comfort are aspects that must be taken into account to obtain optimum performance. Therefore, the design of the workstation must be such that it allows to achieve a relationship between the user and his task so that he is not disturbed by the equipment he uses, but on the contrary, he finds it useful and facilitates his work.

In this project an analysis of the primary activity (fishing) was carried out, specifically in the part of the fish cleaning system. It was possible to identify a series of failures in the process, specifically in the equipment and workstation design, in order to subsequently propose the necessary changes for a correct design of the equipment and work area, taking care of the integrity of the operators.

2. OBJETIVOS

2.1 General objectives

Design a workplace that meets optimal conditions for operators to increase their performance and reduce occupational risk.

2.2 Specific objectives

- Identify ergonomic conditions in the work area.
- Decrease process time.
- Maintain a cleaner work area.
- Reduce the risk of long-term injuries.
- Propose a new design of the work area.

3. METHODOLOGY

1. Conduct a current diagnosis of the work area in fish cleaning.
2. Analyze and identify if the equipment and conditions of the area in which the process is carried out comply with ergonomic principles.
3. Propose a redesign of the work equipment applying ergonomic principles in accordance with the needs and characteristics of the workers.

4. RESULTS

4.1 Current analysis of work area and its operations

The fish cleaning process is composed of 6 activities, scale removal, gutting, filleting, and finally, packaging and weighing for previous freezing. Figure 1 shows a diagram of the process:

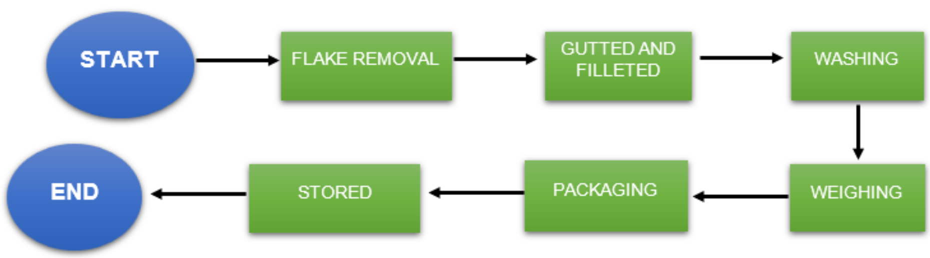
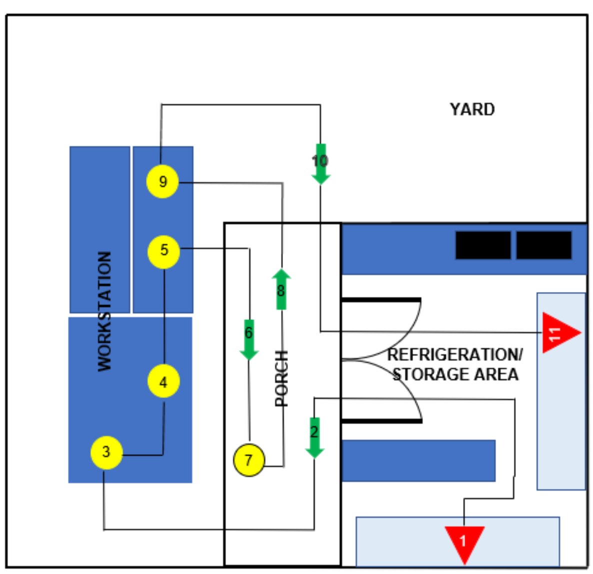


Figure 1. Production process diagram.

An analysis and follow-up of the production process was carried out to identify operations, transports and storage, creating a route diagram shown in Figure 2:



CODE	DESCRPTION
1	Remove the fish from the freezer from the refrigeration area.
2	Transport it to the workstation
3	Removal of scales
4	Gutting the fish
5	Clean the remains of blood with water
6	Transport it to the place where it is going to be weighed
7	Weighing fish
8	Transport it back to the workstation
9	Pack it
10	Transport it to the refrigeration area
11	Store it

Figure 2. Process flow diagram.

4.2 Identification of the ergonomic principles in the work environment

The operators during the fish cleaning process are exposed to long working hours where they perform repetitive movements that directly affect their health and therefore their productivity. After analyzing the work area and the activities performed in it, it was possible to identify the ergonomic principles that were not being complied with in the work area, Table 1 shows the results:

Figure 2. Work areas.

Table 1. identification of the ergonomic principles of the work environment.

Ergonomic principles	Workstations					
	1	2	3	4	5	6
1. keep everithing within reach			x	x		
2.Use elbow height as a reference	x	x				
3.The grip shape reduces effort	x	x		x		
4.Find the correct position for each task	x	x		x	x	
5.Reduce excessive repetitions	x			x		
6.Minimize fatigue	x	x	x	x		
7.Minimize direct pressure						

8.Adjust and change posture	x	x	x	x	x	
9.Provide space and access				x		
10.Maintain a comfortable enviorement	x	x		x		x
11.Highlight clearly to improve comprehesion						
12.Improve work organization	x	x		x		

4.3 Proposals and redesign of the work area.

The good design of a workstation is essential to achieve a favorable production flow, for this reason we proposed a redesign of the work area, seeking within our possibilities the appropriate way to comply with ergonomic principles and thus facilitate the work of the operators.
Our main task has been to propose strategies for a new distribution and design of the work area, as shown in figure 3 below:

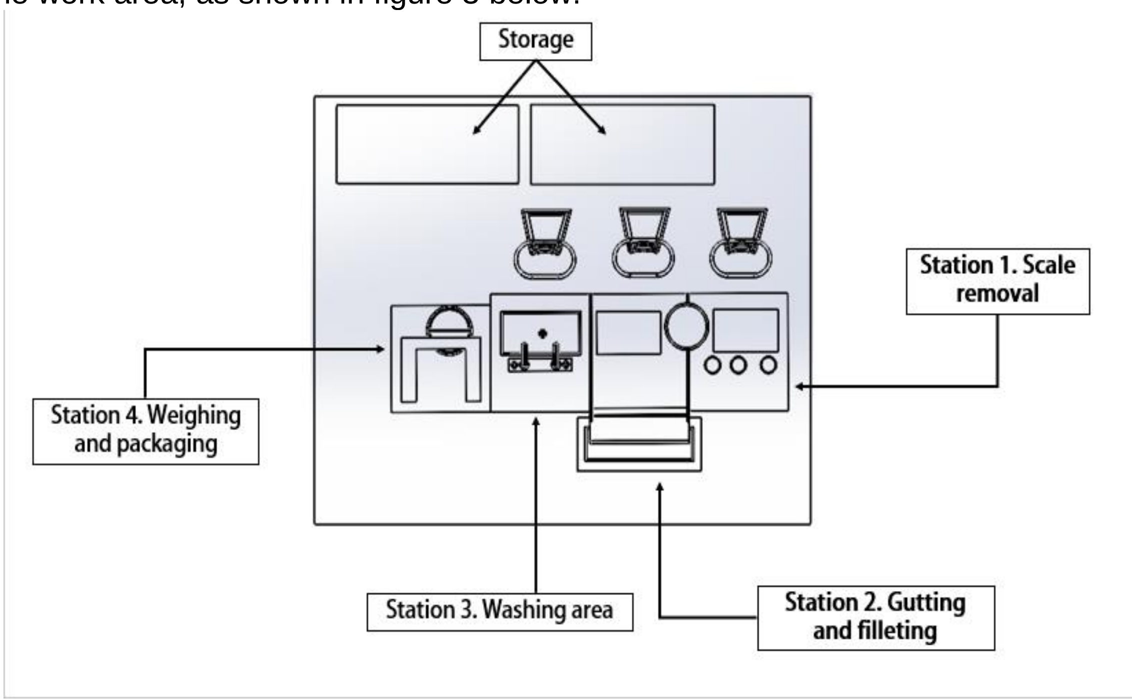


Figure 3. New distribution of the work area.

The redesign of the stations allows us to facilitate the work performance of the operators and to look for the necessary improvements to make their work more comfortable and to perform it in adequate health conditions, therefore, we decided to make a distribution on the table according to the work being done.

In the first part of the process, containers were placed for the tools and utensils used to remove the scales from the fish to keep everything within reach and in an orderly manner.

In the evisceration process, the work station was redesigned and a slide was added so that the raw material waste can slide into a container and then be discarded.

A sink was also designed for proper cleaning of the fish fillets.

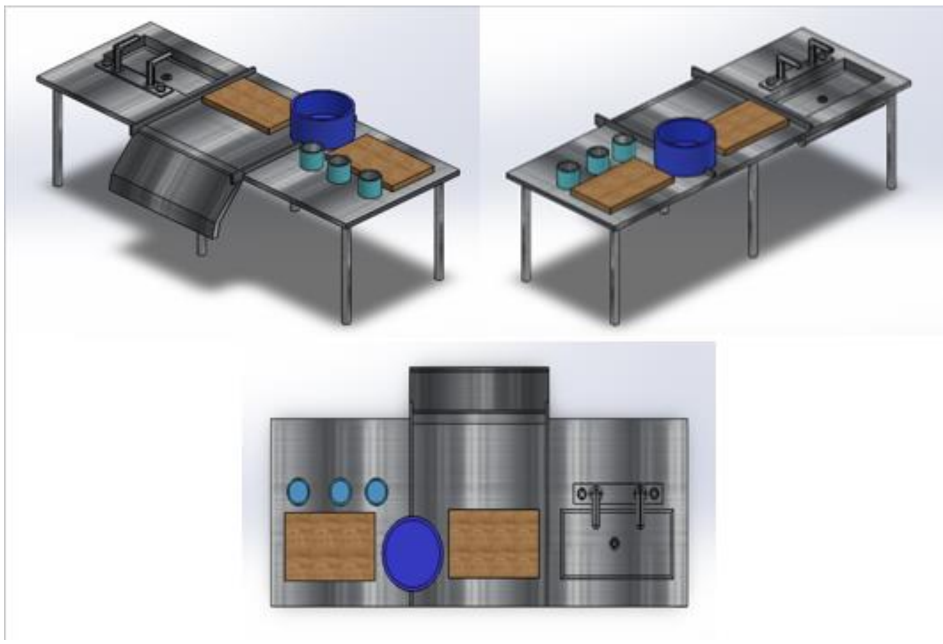


Figure 4. Workbench design

Finally, we have the weighing and packaging station, where a hanging scale positioned on a metal structure was adjusted in order to reduce delays in the process, since in the previous distribution the operator had to move to another area to weigh the product.

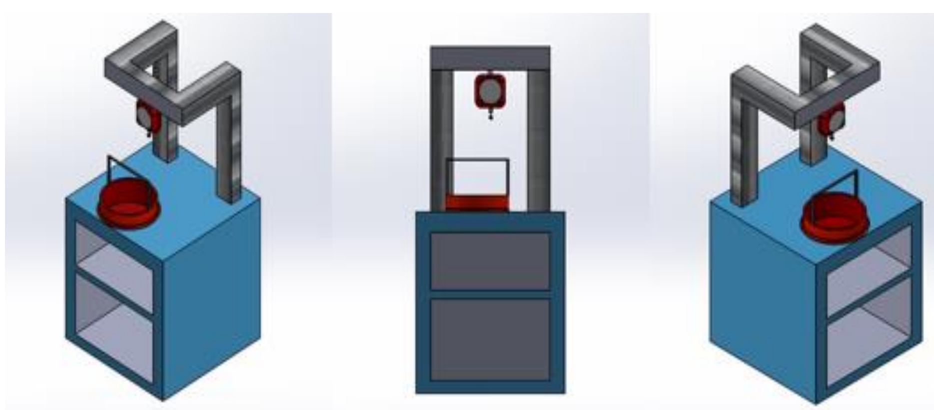


Figure 5. Weighing and packaging area.

On the other hand, as previously mentioned, operators face long hours of work where they are used to stand during this time, those who perform this process claim that it is very difficult to perform this work sitting down, because the position does not allow them to do it, however, we believe that this is due to the conditions in which their work material is not adequate.

In view of this need, we have designed an anti-fatigue bench, where the operator can use it when necessary, considering that alternating between sitting on the bench and doing his work standing up for different periods of time will allow him to reduce the fatigue caused by his activities.

Figure 6. Anti-fatigue seat design

Once the needs had been identified and the proposals applied, the general design of the work area was drawn up, where all the ideas and improvements considered were applied.

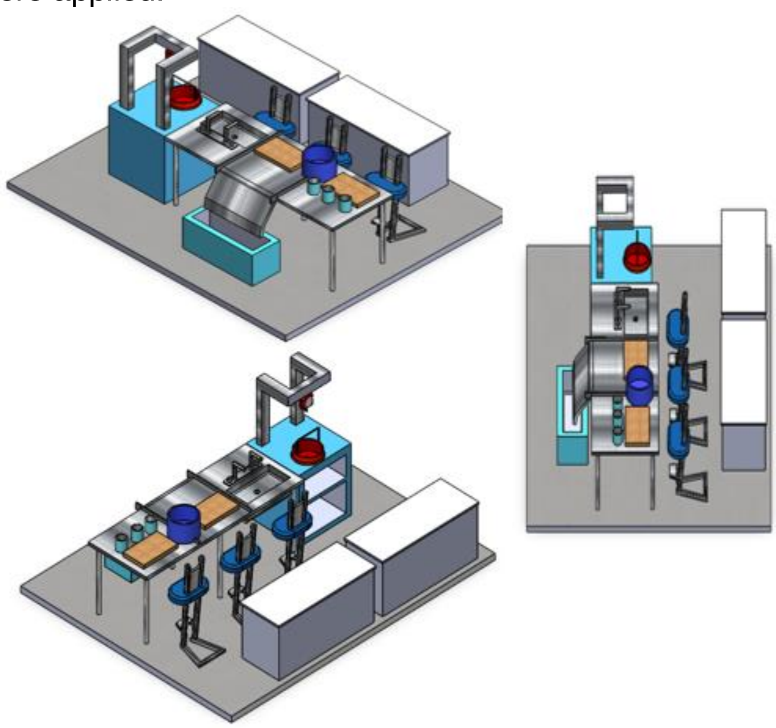


Figure 7. Design and general layout of the work area

5. DISCUSSION/CONCLUSION

When carrying out the analysis and collecting data about the fish cleaning production process, it was concluded that ergonomics plays an important role in achieving the proposed objectives, since maintaining the work area with the right tools and equipment for the activities being performed reduces the incidents that could occur if they were not correct.

Adapting the work area of the operators who perform the activities, provides comfort and maximum physical performance to carry out the production process and thus meet the needs that arise.

With this research we were able to identify the importance of identifying the ergonomic needs of a process such as fishing, providing the operator with the necessary tools and conditioning their workplace to improve their effectiveness in their activities and processes.

In the original design the distribution was not the most adequate, taking into account that the distribution of work was poorly organized and poorly structured, the work tools were not adequate to the operators, but rather the operator is the one who had to adapt to these work tools which of course causes fatigue, tiredness or even work stress.

With this new design we want the operator to feel comfortable and safe to perform his work, being aware that the instruments and tools are suitable for him, organized so that he does not have to move from one place to another because the design of our work table is a continuous flow of the process, starting from the removal of the fish scales to packaging and storage, causing a decrease in delays and increasing the productivity and effectiveness of the work.

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STUDY OF ENVIRONMENTAL CONDITIONS IN A BOOTS AND SADDLERY FACTORY IN MOCTEZUMA, SONORA

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Resumen: Se presenta un estudio de Ergonomía Ambiental en una fábrica de botas y talabartería, donde se trabajan artículos de cuero. Se ha realizado a partir de analizar las condiciones de iluminación y ruido, en búsqueda de la protección de la salud de los trabajadores, basándose en métodos como LEST (Método del Laboratorio de Economía y Sociología del Trabajo), RULA (evaluación de la carga postural por Rapid Upper Limb Assessment), y entrevistas sobre la iluminación productiva, tomando en cuenta las normas mexicanas aplicables de la Secretaría del Trabajo y Previsión Social, así como del Instituto Nacional Ecología, obteniéndose resultados favorables de los factores ambientales, pero se requieren acciones con respecto a las posturas corporales de los trabajadores. Se propone un cambio en la distribución de planta, para mejorar más las condiciones del centro de trabajo considerando incluso la ventilación y se recomiendan también la toma de acciones inmediatas para mejorar las posturas y reducir la fatiga laboral además de las lesiones por trabajos repetitivos.

Palabras clave: ergonomía ambiental, iluminación, ruido, enfermedades de trabajo, posturas.

Relevancia para la ergonomía: Al ser éste un estudio de Ergonomía Ambiental, se demuestra la aplicación de las metodologías como RULA y LEST para espacios de trabajo manual que puede ser considerado hasta artesanal, como lo son las talabarterías, resaltando la mejora de las condiciones de trabajo y la reducción de riesgos físicos.

Abstract: An Environmental Ergonomics study is presented in a factory for boots and saddlery, where leather goods are worked. The lighting and noise conditions had been considered, in order to protect the workers' health, based on methods such as LEST (Method of the Laboratory of Labor Economics and Sociology), RULA (evaluation of postural load by Rapid Upper Limb Assessment), and interviews on productive lighting, taking into account the applicable regulations of the Mexican Ministry of Labor and Social Welfare, as well as the National Ecology Institute, obtaining favorable results from environmental factors, but regarding the workers postures, actions are required. For the layout, a change is proposed to further improve the working environment, even considering ventilation, and immediate actions are also recommended to improve postures and reduce work fatigue as well as repetitive work injuries.

Keywords: environmental ergonomics, lighting, noise, occupational diseases, postures.

Relevance for ergonomics: As this is an Environmental Ergonomics study, the application of methodologies such as RULA and LEST is confirmed for manual workspaces that can be considered artisanal, such as saddlery, highlighting the improvement of the conditions of work and the reduction of physical risks.

1. INTRODUCTION

This study is about the environmental conditions in a saddlery in Moctezuma, Sonora. Place where leather articles are worked, producing products related to horses, such as saddles and tackle, but also belts, purses, wallets, among others. This research seeks to protect the safety and health of workers based on lighting and noise; using as instruments a sound level meter and a lux meter generating benefits of higher performance, reduction of fatigue caused by poor posture and eye fatigue of the operator.

Two ergonomic evaluation methods were used, RULA, to obtain a certain posture and the level of action on acceptable postures and, if necessary, make changes; also, LEST to have a global and objective evaluation of the environmental physical conditions. Likewise, the standards NOM-025-STPS-2008, NOM-011-STPS-2001 and NOM-081-ECOL-1994 were considered for lighting and noise considerations.

A change was proposed for the work areas, which includes adding air extractors since the place does not have any and the number of windows is limited, as well as redistributing and changing the lighting in the work areas, which may reduce the effects produced by noise and improve the space for the worker's view.

2. OBJECTIVES

- Analyze the environmental conditions in the Factory of Boots and Saddlery in Moctezuma, Sonora, through the measurement of lighting and noise, contrasting with the appropriate measures, evaluating with the LEST method.
- Develop an efficient proposal to redistribute the layout of the Boot and Saddlery Factory according to the correct direction, angle, and importance of light, providing the best recommendations for the work environment.

3. METHODOLOGY

To know the current situation regarding the environmental conditions in the Boots and Saddlery Factory, lighting and noise studies were carried out. This was developed through visits to the Boots and Saddlery Factory during working hours, using the Luxmeter instruments to measure lux; Sound level meter, taking the decibel (dB) measurement.

Likewise, measurements were made at each workstation on the postures adopted by the operators in the performance of their work, collecting 19 measurements taken at each workstation according to the positions adopted, in two ways: standing and sitting (according to the requirements of the operation they perform), determining the severity of said positions using the RULA and LEST methods to evaluate the physical environment.

Subsequently, the productive lighting was determined, studying through a checklist, with 20 questions, applied with the support of management and through tours around the work areas.

The analysis of the approval units of lux and decibels (dB) was carried out for each space of the work area, according to the Mexican safety and ecology regulations, comparing the measurements with the instruments.

Finally, windows, doors, skylights, and air conductors were checked to determine the ventilation of the work area.

Based on the results of studies of lighting, sound, and postures, a proposal was developed to change the distribution of the production lines of the Boots and Saddlery Factory, generating a new Layout, taking lighting as the main factor, as well as noise. and ventilation, considering that it will help reduce work fatigue and work risks, as well as indirectly reworking the manufactured products and as a result increasing the quality of the product.

4. RESULTS

The facilities of the Boots and Saddlery Factory with its four production lines distributed to the demand for work, which with respect to production seem to be balanced, but with respect to safety, health and comfort for the workers, a rearrangement of the workstations with the machines that generate the most noise, also including an air extraction system to reduce the discomfort caused by inhalation of solvents and paints.

Analyzing the fatigue of the workers, because of the productive lighting instrument, in their 20 questions, the majority of the workers stated that they did not require actions to improve the lighting because they do have the necessary to carry out the work.

Table 1. Productive lighting results in an interview with workers.

PRODUCTIVE LIGHTING		YES	NO	TOTAL
1	The skylight or windows are used to take advantage of the daylight. Do you propose action?	4	11	15

2	The workstations are arranged so that work that requires bright light is done near windows or under skylights. Do you propose action?	5	10	15
3	The ceilings and walls are painted white or a light color. Do you propose action?	1	14	15
4	Multiple light sources are used at the workstations. Do you propose action?	4	11	15
5	Lamps, windows, and workstations are positioned to avoid glare. Do you propose action?	14	1	15
6	Lighting fixtures are placed in a high position or lampshades are provided to avoid direct glare. Do you propose action?	9	6	15
7	Shades, curtains, trees, and vines are used to prevent or lessen direct glare from the sun. Do you propose action?	3	12	15
8	Light sources, machines, or other objects that reflect light are relocated to avoid indirect glare. Do you propose action?	3	12	15
9	Local lamps are used to provide adequate light required for detailed work. Do you propose action?	2	13	15
10	Mobile local lamps with flexible arms are provided. Do you propose action?	1	14	15
11	The direction of the light sources is selected considering the type of task. Do you propose action?	13	2	15
12	General and local lighting are combined to provide the necessary light and avoid large contrasts in brightness. Do you propose action?	2	13	15
13	Avoid working in an isolated area with strong light surrounded by a poorly lit background. Do you propose actions?	1	14	15
14	Screens or curtains are used to avoid a complex background. Do you propose action?	0	15	15
15	Appropriate colors are used for the working backgrounds. Do you propose action?	1	14	15
16	Glossy surfaces are eliminated of the field of view of the worker. Do you propose any action?	0	15	15
17	Each lamp or each group of lamps has its own electrical switch. Do you propose actions?	1	14	15
18	Individual plugs and sockets are proposed at the workstations to reduce the use of extension cords. Do they propose action?	0	15	15
19	Lamps, skylights, windows, ceilings, walls, and partitions are periodically cleaned. Do you propose action?	14	1	15
20	Bulbs and tubes that have burned out or have reduced brightness are replaced. Do you propose action?	0	15	15

Regarding lighting, it was determined with respect to the average lux generated by the luminaires in the 19 workstations, obtaining standard results, which are below the limits that the regulations dictate, for work with machines, with moderate to light distinction, from 200 to 500 lux, however, it is important to clarify that there are places or workstations that generate figures with a little more luminosity than some others. These results can be seen in the following table.

Table 2. Measurement results with Luxmeter.

	LUXMETER									
	LINE 1		LINE 2		LINE 3		LINE 4			
WORKSTATION	1	86	1	133	1	93	1	135		
	2	78	2	72	2	66	2	1545 with light bulb	2	371 without light bulb
	3	415	3	113	3	105	3	57		
	4	82	4	112			4	154		
	5	60					5	104		
							6	110		
							7	78		

Neutral Place	192 Lux

Regarding noise, the dB is below the permissible regulated limits, which are below 90 dB, therefore, it is considered acceptable, having values from 6.70 dB to 11.40 dB. These results are shown below in Table 3.

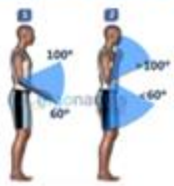
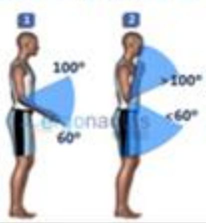
Table 3. Sound measurement results at workstations.

	SONOMETER							
	LINE 1		LINE 2		LINE 3		LINE 4	
WORKSTATION	1	8.7	1	8.63	1	8.4	1	7.69
	2	11.4	2	8.9	2	8.1	2	9.19
	3	6.7	3	7.98	3	7.79	3	8.45
	4	8.57	4	7.78			4	7.61
	5	8.53					5	8.27
							6	7.4
							7	7.45

Neutral Place	8.66 dB

When applying the RULA Method, an evaluation of 7 was obtained, indicating that it is necessary to immediately make changes in the design of the task and / or the job position. The results of this evaluation are shown below in Table 4, followed up with one operator at all workstations, including trunk and wrist score modification; legs, forearm, wrist, and neck scores.

Table 4. Posture evaluation results using RULA method.

WORKER POSTURE	RULA METHOD	RULA	DESCRIPTION
	RULA – Trunk score modification 	+1	His position: Trunk with lateral tilt
	RULA – Legs score 	+2	His position: The feet are not supported, or the weight is not symmetrically distributed
	RULA – Forearm score 	+1	His position: Flex between 60° and 100°
	RULA – Trunk score modification 	+1	His position: Trunk with lateral tilt
	RULA – Forearm score 	+2	His position: Flexion < 60° or > 100°
	RULA – Neck score 	+3	His position: Flexion > 20°

 	RULA – Wrist Score 	+3	His position: Flexion or extension >15°
	RULA – Modifying wrist Score 	+1	His position: Ulnar deviation
	RULA – Arm score 	+4	His position: Flexion >60°
	RULA – Modifying the trunk score 	+1	His position: Rotated trunk

Regarding the evaluation for the physical environment as a part of the LEST method, to evaluate the lighting and noise of the measurements taken in the Factory of Boots and Saddlery, in the case of noise, all were evaluated with 3, 4 and 5, which means weak discomfort, some improvement could bring a better comfort; and in the lighting measurements, the results obtained reflect a satisfactory situation with values between 1 and 2, as well as 3 and 4 points, referring to weak discomfort, therefore, some improvement could provide better comfort.

Table 5. Assessment of the LEST method.

Grade	Assessment
0, 1, 2	Satisfactory situation
3, 4, 5	Weak discomfort, some improvement could provide better comfort
6, 7	Medium discomfort, there is a risk of fatigue
8, 9	Strong discomfort, fatigue
10	Situación nociva

Taking the results into consideration, the current layout distribution, shown in Figure 1, of the Boots and Saddlery Factory is observed below and a new distribution is proposed (Figure 2) that considers better lighting and ventilation, including the production lines, doors, windows, skylights, air ducts and for the new layout it also incorporates the emergency exits and a nursing area and restroom near the production area to consider all the worker’s needs.

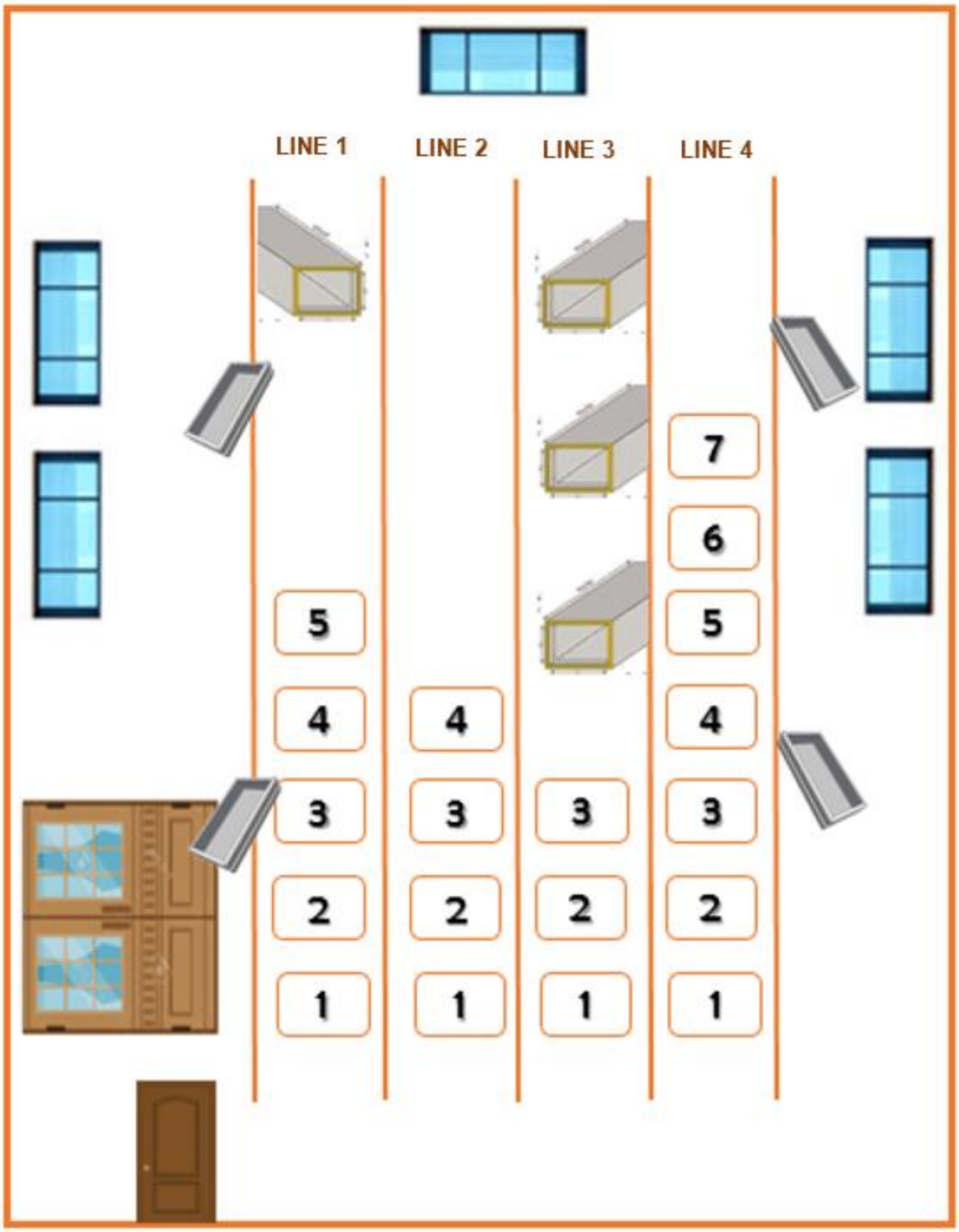


Figure 1. Current layout of the Factory of Boots and Saddlery, it has a large door, a small door, five windows and four skylights.

The layout proposal shows a balance between the production lines, for better use of the facilities, with respect to the environmental conditions, proposing that we continue to leave the air ducts, and increasing to six windows and six skylights, also placing a bathroom inside the production area and two emergency exits.

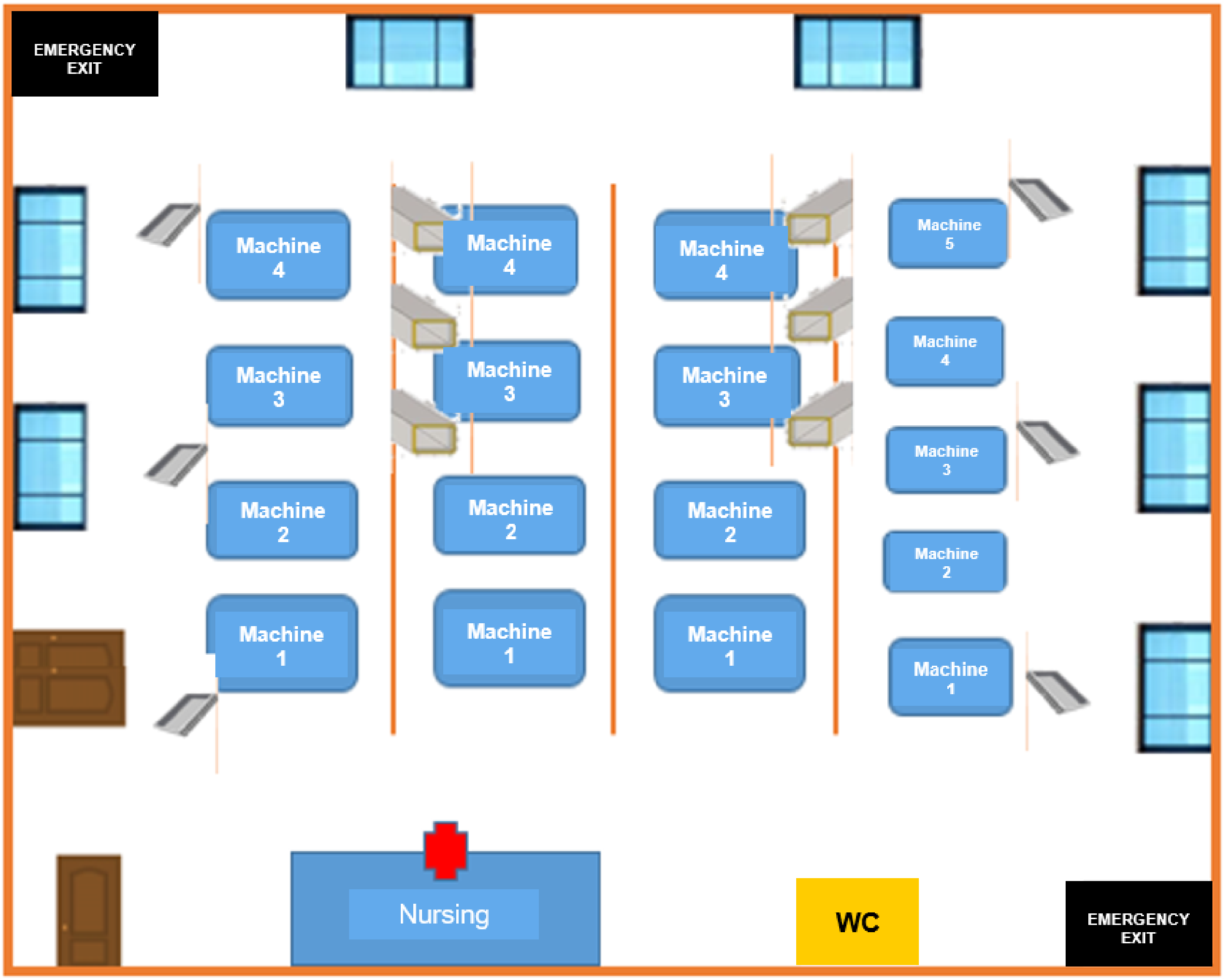


Figure 2. Layout proposal. It would have a large door, a small door, seven windows, six skylights, an infirmary, a bathroom, and two emergency exit routes.

5. CONCLUSIONS

When studying the environmental conditions of work in the Factory of Boots and Saddlery in Moctezuma, Sonora, the effectiveness of the ergonomic methods applicable to study environmental conditions is confirmed, of which RULA and LEST were used, where favorable factors were found for the case of lighting and noise, and when evaluating positions, it was observed that immediate improvements are required.

With the knowledge of productive lighting, it was possible to determine that the workers work in a suitable lighting environment for the development of their work activities.

With this study, proposals for improvement were formulated, for a rearrangement in the work area, of greater comfort when working, facilitating lighting, without the need for eye wear on the workers. In the same way, a decrease in noise is expected, although the values obtained are within what is allowed by the regulations, and finally, satisfaction can be obtained by improving ventilation by creating a comfortable and pleasant work environment.

A second stage of improvements is recommended by implementing not only the change and adjustments in the plant distribution but also to reduce fatigue and the cause for possible injuries due to the evident result of the evaluation with RULA, continuing with the study of the movements of workers to generate fixtures and support systems for their limbs, reducing bad posture.

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TECNOLOGÍA PARA LA GESTIÓN DE RUIDO EN HOTELES DE SOL Y PLAYA EN VARADERO, CUBA

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Resumen: Las instalaciones hoteleras cubanas, y en particular las ubicadas en destinos turísticos de sol y playa, no poseen un enfoque de gestión en el tratamiento de la contaminación por ruido. En consecuencia, se propone una tecnología para la gestión de ruido en hoteles de sol y playa que integre técnicas, procedimientos y metodologías para su oportuna identificación, evaluación, diagnóstico y control. Los principales resultados se centran en la creación de una tecnología para la gestión del ruido que incluye la valoración del confort acústico; el uso de los mapas de ruido como herramienta de diagnóstico, la selección, modificación y creación de métodos de control de ruido. El objeto de estudio fueron 4 hoteles de sol y playa en Varadero: Iberostar Varadero, Meliá Marina, Be Live Experience Tuxpan y Meliá Las Américas. Mediante la comparación de los Niveles de Presión Sonora antes-después de la implementación, modelación y/o estimación de un grupo de medidas primarias, secundarias y organizativas; en un total de 20 áreas afectadas de los 4 hoteles se demostró de forma general que se logró reducir los niveles de ruido a los que se exponen trabajadores y clientes con mejoras en los parámetros de confort acústico.

Palabras clave: tecnología, gestión, ruido, hoteles de sol y playa, Cuba

Relevancia para la ergonomía: Se muestra la concepción de una tecnología de gestión que integra herramientas de identificación, evaluación, diagnóstico y control del ruido en instalaciones hoteleras de sol y playa. Constituye un referente de buenas prácticas para la gestión de ruido en hoteles.

Abstract: Cuban hotel facilities, and in particular those located in sun and beach tourist destinations, do not have a management approach in the treatment of noise pollution. Consequently, a technology is proposed for noise management in sun and beach hotels that integrates techniques, procedures and methodologies for its timely identification, evaluation, diagnosis and control. The main results focus on the creation of a technology for noise management that includes the assessment of acoustic comfort; the use of noise maps as a diagnostic tool, the selection, modification and creation of noise control methods. The object of study was 4 sun and beach hotels in Varadero: Iberostar Varadero, Meliá Marina, Be Live Experience Tuxpan and Meliá Las Américas. Comparing the Sound Pressure Levels before-after the implementation, modeling and/or estimation of a group of primary, secondary and organizational measures; in a total of 20 affected areas of the 4 hotels was demonstrated in a general way that it was possible to reduce the noise levels to which workers and clients are exposed with improvements in acoustic comfort parameters.

Keywords: technology, management, noise, sun and beach hotels, Cuba

Relevance to Ergonomics: The conception of a management technology that integrates noise identification, evaluation, diagnosis and control tools in sun and beach hotel facilities is shown. It constitutes a benchmark of good practices for noise reduction in hotels.

1. INTRODUCCION

El ruido ha sido reconocido en la actualidad como el contaminante ambiental más difundido y con mayor influencia en la sociedad y en el desarrollo de las actividades de la vida diaria. (Arachchige et. al., 2019; Al-Taai, 2021).

La Organización Mundial de la Salud estima que al menos 432 millones de adultos presentan pérdida auditiva incapacitante en el mundo; que el 50% de las pérdidas auditivas podrían evitarse mediante prevención, un diagnóstico precoz y una gestión eficaz. (WHO, 2019)

El enfoque de gestión de ruido y la adopción del propio término son muy limitados a nivel global. Como definen Krūkle & Bendere (2017) la gestión del ruido es una actividad encaminada a mantener bajas exposiciones al ruido, de modo que no existan molestias o afectaciones a la salud. Países desarrollados como Australia y Nueva Zelanda proponen, a partir de bases normativas, el establecimiento de programas de gestión del ruido ocupacional (SA/SNZ, 2005; SWA, 2018).

En Cuba la gestión no constituye el núcleo de la prevención del riesgo de ruido. Específicamente en las instalaciones hoteleras cubanas, el ruido es analizado solamente como un indicador más de los sistemas de gestión medioambiental o de seguridad y salud en el trabajo. (Ochoa Avila & Leyva Driggs, 2021; Martínez Rodríguez et. al., 2021)

2. OBJETIVOS

Desarrollar una tecnología para la gestión de ruido en hoteles de sol y playa que integre técnicas, procedimientos y metodologías para su oportuna identificación, evaluación, diagnóstico y control.

Validar la tecnología en hoteles seleccionados en el destino turístico de Varadero, Cuba.

3. METODOLOGÍA

Se propone una tecnología (Ver Figura 1) que responde directamente al cumplimiento de parámetros de la gestión de la seguridad y salud en el trabajo y de la gestión medioambiental del hotel donde se pretenda aplicar.

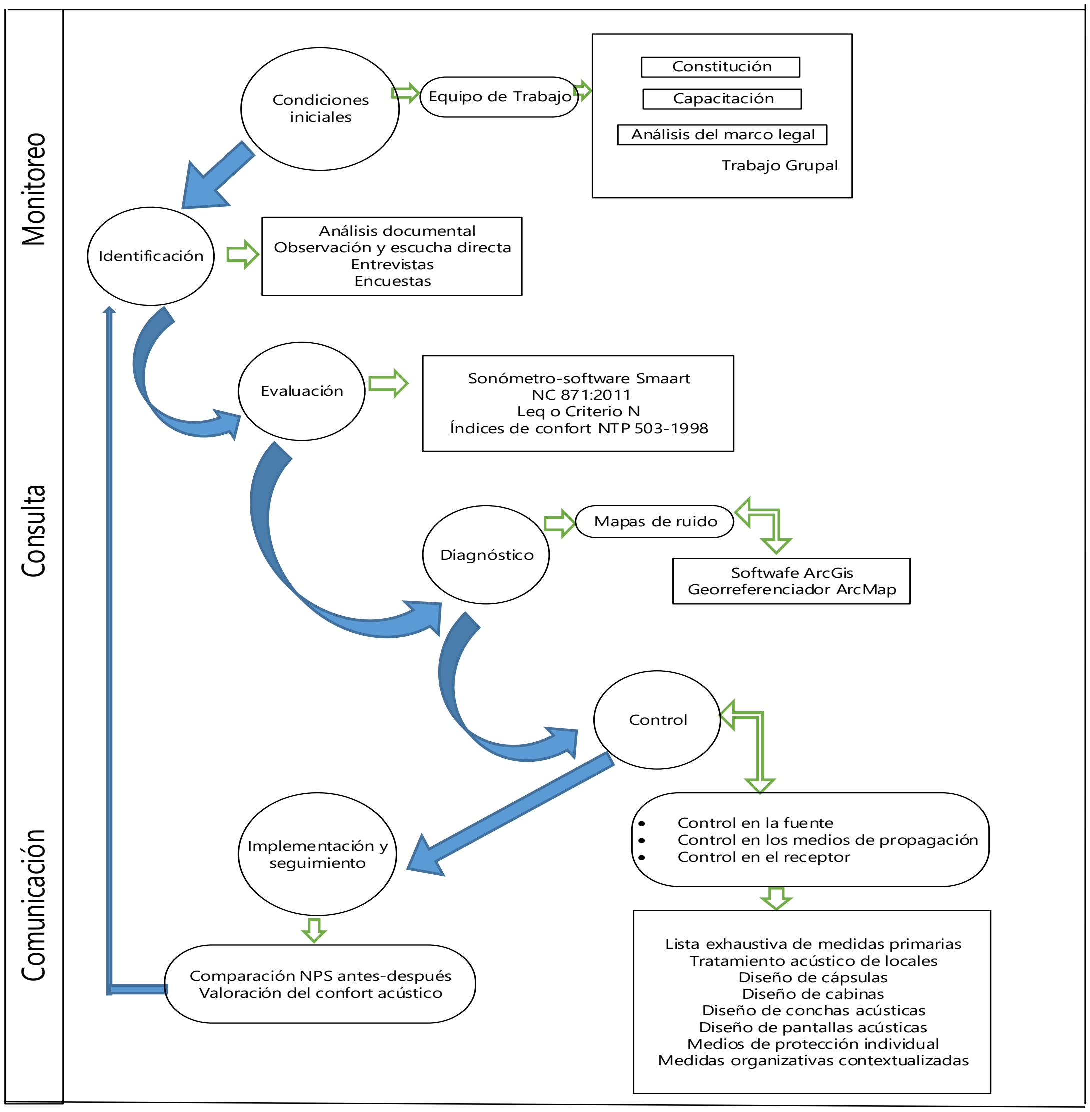


Figura 1: Tecnología para la gestión de ruido en hoteles de sol y playa.

Repercute también en la satisfacción del cliente externo y en el atractivo de la instalación. Se caracteriza por el enfoque de mejora, donde el empleo oportuno de medidas de control asume un carácter continuo a través del seguimiento y la retroalimentación.

Constituye una visión general donde se pueden apreciar los elementos que deben considerarse para la gestión del ruido en hoteles de sol y playa. En la misma se recogen las seis (6) etapas por las que se compone, a saber: preparación de condiciones iniciales, identificación, evaluación, diagnóstico, control, monitoreo y seguimiento. Cada etapa se sustenta en la aplicación de una serie de técnicas que deben ser aplicadas de forma lógica y ordenada. Su funcionamiento se basa en el principio de mejora continua y considera, la comunicación, consulta y monitoreo en todo momento, como elementos base para disminuir los niveles de ruido y obtener mejoras en parámetros de confort acústico.

Para el cumplimiento de la fase de control, las medidas primarias deben diseñarse en correspondencia con la propuesta de Rodríguez González et. al. (2007); las secundarias están reflejadas en el libro "Ruido, vibraciones y presiones anormales" de García Dihigo (2017) y las posibles medidas organizativas ajustadas a las características de estas instalaciones se pueden encontrar en Almeda Barrios et. al (2019). Siempre se debe cumplir el principio de jerarquía de control que proponen Viña Brito y Gregori Torada (1987).

4. RESULTADOS

4.1 Identificación y evaluación del ruido

Se seleccionaron 4 hoteles de sol y playa en Varadero donde fue aplicada la tecnología: Meliá Marina Varadero, Iberostar Varadero; Be live Experience Tuxpan y Meliá Las Américas. En los cuatro (4) hoteles propuestos existían evidencias en los inventarios de riesgos laborales, que se complementaban con la opinión de los especialistas de Seguridad y Salud en el Trabajo, de la presencia de ruidos molestos en determinadas áreas de la instalación.

Las mediciones se realizaron bajo los requisitos de medición que establece la NC ISO 1999:2011. Para ello se empleó el sonómetro vinculado al software Smaart 7. En cada área se determinaron los NPS en diferentes puntos de interés con desglose en el espectro de frecuencias.

Se compararon los NMA que establece la NC 871:2011 con los NPS existentes en todos los locales identificados. De igual forma, en las áreas frecuentadas por clientes, se contrastaron los criterios de confort de la NTP 503:1998 con los NPS existentes y se analizaron las opiniones de los clientes sobre las molestias ocasionadas por el ruido.

Para facilitar la comprensión del análisis realizado se construyó la Tabla 1, que muestra en cada área identificada de los cuatro (4) hoteles, los NPS existentes, los NMA, el criterio de confort y la valoración de si el ruido en dicha área es perjudicial o no.

Tabla 1. Comparación de los niveles de ruido en las áreas analizadas

Hotel	Área	NPS exist[1]	NMA (NC 871-2011)	Criterio de confort (NTP 503-1999)	Valoración
Iberostar Vardero	Lavandería Oficina ama de llaves Comedor de empleados Lobby Bar “Los Arcos”	80 NdB 71.1dBA 77.8 dBA 82.4 dBA	75 NdB 70 dBA 70 dBA 70 dBA	No aplica No aplica No aplica 50dBA	Perjudicial Perjudicial Perjudicial Perjudicial
Meliá Marina	Habitaciones del “the level” Oficina cajero central Buffet “El Pilar” Mini tintorería Lobby	73 NdB 75 NdB 85.4 dBA 87.6 dBA 88.8 dBA	65 NdB 65 NdB 70 dBA 80 dBA 65 dBA	35NdB No aplica 50dBA No aplica 50dBA	Perjudicial Perjudicial Perjudicial Perjudicial Perjudicial
Be Live Experience Tuxpan	Oficina personal de costo Oficinas servicios técnicos Mini tintorería Habitaciones 313,315,317,319 Área de show Restaurante buffet “Cristal”	80 NdB 75 NdB 87.6 dBA 68.5 dBA 89 dBA 87.3 dBA	65 NdB 65 NdB 80 dBA 70dBA 70 dBA 70 dBA	No aplica No aplica No aplica 40dBA 50dBA 50dBA	Perjudicial Perjudicial Perjudicial Perjudicial Perjudicial Perjudicial
Meliá Las Américas	Lavandería Oficina de mantenimiento Cocina Comedor de empleados Ranchón de la playa	80 NdB 70 NdB 80 NdB 83.1 dBA 91.1 dBA	75 NdB 65 NdB 75 NdB 70 dBA 70 dBA	No aplica No aplica No aplica No aplica 50 dBA	Perjudicial Perjudicial Perjudicial Perjudicial Perjudicial

Como resultado de la comparación todas las áreas analizadas registraron niveles de ruido por encima del criterio que establece la NC 871:2011 lo cual se correspondió con una valoración de perjudicial.

Es importante resaltar que, a partir de las valoraciones obtenidas, los criterios de confort establecidos para las áreas con presencia de clientes no se cumplen en

[1] De los ruidos constantes se mostró únicamente el valor de la menor frecuencia perjudicial.

ninguno de los casos y se observan amplias diferencias entre los niveles existentes y dichos criterios.

Con el fin de complementar la evaluación y obtener información relevante de las características acústicas de los locales evaluados se realizó el cálculo e interpretación del índice de confort acústico Tiempo de reverberación (Tr) en todas las áreas ruidosas. La tabla 2 muestra los resultados obtenidos.

Tabla 2. Resultado del cálculo del índice Tiempo de reverberación (Tr)

Hotel	**Áreas objeto de estudio**	**Tr(s)**
Iberostar Varadero	Lavandería	3.95
	Oficina Coordinación Ama de Llaves	0.39
	Comedor de empleados	0.85
	Lobby bar “Los Arcos”	3.42
Meliá Marina	Restaurante Buffet “El Pilar”	0.56
	Mini tintorería	0.47
	Habitaciones del “the level”	1.01
	Oficina cajero central	0.07
	Lobby	1.7
Be Live Experience Tuxpan	Mini-tintorería	0.10
	Oficinas del área de Servicios Técnicos	0.51
	Oficina de Costo	0.72
	Habitaciones 313, 315, 317 y 319	1.06
	Área de show (Bar Piscina)	0.28
	Restaurante buffet “Cristal”	0.34
Meliá Las Américas	Comedor de empleados	0.64
	Lavandería	1.74
	Oficina de mantenimiento	0.51
	Ranchón de la playa	0.18
	Cocina	2.31

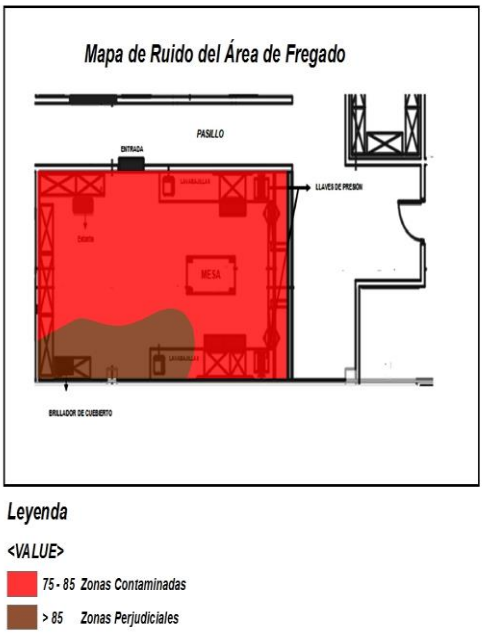
Según la NTP 503-1998 los tiempos de reverberación recomendados, para estos locales (edificio de tipo residencial) deben ser menores que uno (1), pero no todos los valores obtenidos cumplen con esta condición. En todas las instalaciones existen locales con superficies altamente reflectantes y con escasas propiedades acústicas, tal y como reflejan los Tr obtenidos.

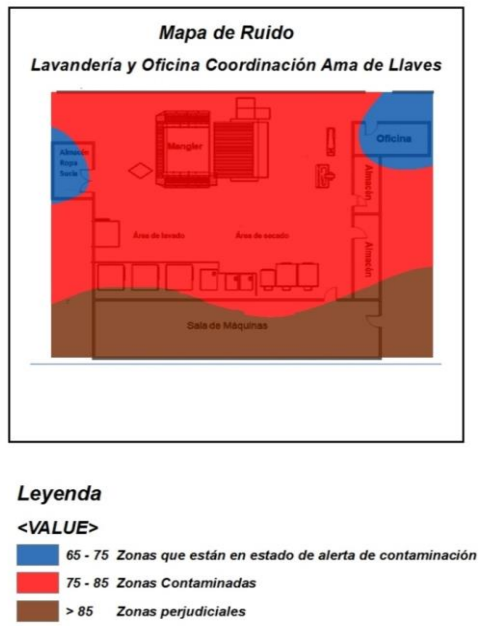
4.2 Diagnóstico de la contaminación sonora en los locales afectados: mapas de ruido

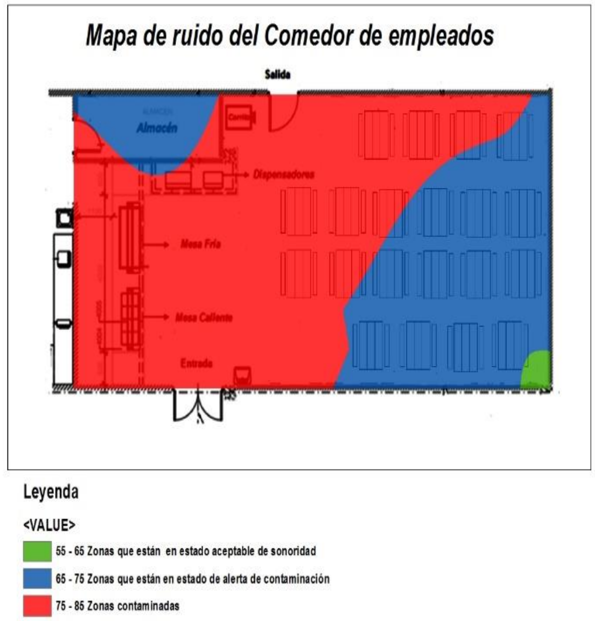
Se construyeron, empleando el software ArcGis versión 10.3, los mapas de ruido en las áreas afectadas, en la Figura 2 se ofrecen como ejemplo los mapas de ruido que ilustran el comportamiento sonoro en las áreas afectadas del Iberostar Varadero.

Como se observa en la figura, la mayor parte de los locales se encuentran en estado de contaminación sonora.

Se muestran aquellas áreas en el interior de los locales donde los niveles de ruido provocan mayores afectaciones, las cuales se corresponden con los colores rojo y marrón atendiendo a la escala empleada. Esta información constituye una importante variable de entrada para las decisiones de control que posteriormente se deben asumir.







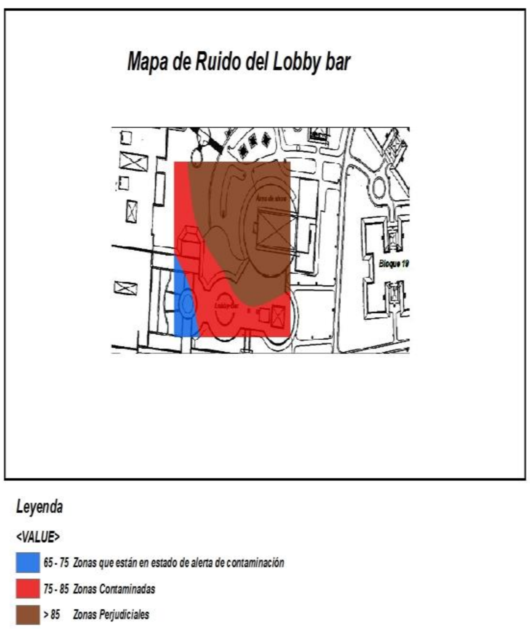


Figura 2. Mapas de ruido en áreas afectadas del Iberostar Varadero

4.3 Establecimiento de medidas de control de ruido

En todas las áreas ruidosas se comenzó por la valoración de la posible sustitución de equipos o procesos por otros más silenciosos. Ante la imposibilidad de efectuar este tipo de cambios se analizó la implementación de medidas primarias.

La medida primaria propuesta para disminuir el ruido estructural emitido por los equipos de secado en el Área de minitintorería-hotel Meliá Marina y el área de lavandería-hotel Meliá Las Américas fue la utilización de materiales con alto coeficiente de amortiguación para reducir la transmisión del ruido estructural a partir del empleo de calzos de neopreno para la suspensión de los equipos de secado.

Se diseñaron, a partir de las metodologías propuestas por García Dihigo (2017) un grupo de soluciones para limitar la transmisión del sonido en el aire en diferentes áreas de los hoteles analizados.

En el Restaurante buffet “Cristal” del hotel Be Live Experience Tuxpan se diseñó el tratamiento acústico del local. La Tabla 3 resume los principales resultados obtenidos de la aplicación de la metodología.

Tabla 3. Resultados de la aplicación del tratamiento acústico en el restaurante buffet “Cristal”

Pasos	Requisitos de cálculo	Valor obtenido
Paso 1- Tr antes	V= 1357.12 m^3	0.34 segundos
	Atot =631.72 sab	
	γ = 1.07 dB/100 m	
	M=$0{,}00247 m^{-1}$	
	$\bar{\alpha}$ =0.255 sab/m^2	
	Stot=2473.2 m^2	
Paso 2- Nr	Fmi= 2000 Hz	3 dB≤ 8 dB
	Lex=73 dB	
	Lrec=70 dB	
Paso 3- Material a utilizar	A_2= 1286.06 sab	Paneles fonoabsorbentes de espuma acústica (2,5 - 15 cm) $\alpha = 0.97\ sab/m^2$
	Aat=79.288 sab	
	St=792.88 m^2	
	αt=0.91 sab/m^2	
	Superficies a revestir= Techo y paredes	
Paso 4- AOR	αr =0.87 sab/m^2	739.12 m^2
	αat =0.1 sab/m^2	
Paso 5- TR después	Atot= 1274.76 sab	0.17 segundos
Paso 6- Disminución de TR	-	ΔRT =0.17 segundos

Es necesario revestir 739.12 m^2 de los 792.88 m^2 que poseen el techo y las paredes del buffet con paneles fonoabsorbentes de espuma acústica. Con la aplicación del revestimiento se logrará una reducción de 0.17 segundos en el tiempo de reverberación.

En las Habitaciones del “the level” en el hotel Meliá Marina el emplazamiento al aire libre y la ubicación cercana al mar de la instalación propicia que la corrosión actúe aceleradamente en la estructura de las enfriadoras ubicadas en el patio de servicio.

Por otra parte, un análisis individual de las fuentes de ruido demostró que existe la posibilidad tecnológica de aislar mediante encapsulamiento las enfriadoras. En este sentido, se propone el diseño de una cápsula. En la Tabla 4 se observan los resultados fundamentales obtenidos.

Tabla 4. Resultados de la aplicación de la metodología de diseño de cápsulas a las enfriadoras del hotel Meliá Marina

Pasos	Requisitos de cálculo	Valor obtenido
Paso 1- Evaluación	Fmi= 250 Hz	Afectaciones en la frecuencia de 250 Hz
	NPS existente=73 dB	
	NPS recom=61 dB	
Paso 2- Nr	-	12 dB
Paso 3-D	Prefijado por NC: 775-9 (2010)	3 m
Paso 4- Superficie de la cápsula	Lc= 17 m	538.82 m^2
	Ac=13 m	
	Hc=5.30 m	
Paso 5 Atenuación sin orificios	Material a emplear= Paredes bloque de hormigón 20 cm espesor Puertas planchas de acero 1 mm espesor Techo de tejas de acero 1 mm espesor	17.4 dB
	R_1= 44 dB	
	$\Delta R = 20.40$ dB	
	$Rres$=23.6 dB	
	Aci=128.17 sab	
Paso 6: Atenuación con orificios	Cantidad de orificios: 6	12.69 dB
	Radio de 1 orificio=0,5 m	
	$Sup\ total\ orificios = 4.74$ m^2	
	ΔLo= 14.48 dB	

El diseño concebido permite el encapsulamiento de los 9 equipos mediante una estructura de paredes de bloque de hormigón de 20 cm con dos (2) puertas de planchas de acero de 1mm de espesor y dimensiones de 5 m de largo y 3 m de altura para el acceso del personal de mantenimiento y la introducción o extracción de partes y piezas. El techo es una estructura desmontable de tejas de acero de 1 mm de espesor que permite la sustitución o extracción de los equipos utilizando medios de izaje adecuados.

En el techo se proponen realizar seis (6) aberturas circulares de 1 m de diámetro para el escape de aire caliente emitido por las enfriadoras como parte de su funcionamiento, para garantizar la ventilación del local.

Como se puede apreciar, el enclaustramiento propuesto permite reducir 12.69 dB de los 12 dB que se necesitan atenuar en la frecuencia perjudicial de 250 Hz.

La figura 3 que se muestra a continuación permite observar el diseño propuesto

Figura 3. Diseño de la cápsula para las enfriadoras del hotel Meliá Marina

Se aplicó además la división parcial o total de locales para limitar la transmisión del ruido de un área a otra; para ello se propuso la reparación o colocación de puertas o ventanas divisorias entre ellas. La Tabla 5 detalla la información referente a las características de dichas divisiones.

Tabla 5. Dimensiones de los elementos para la división parcial de locales en diferentes áreas

Hotel	Área	Descripción	Dimensiones
Iberostar Varadero	Lavandería	Puerta divisoria con la sala de máquinas	$0{,}9 \times 2{,}1 = 1{,}89\ m^2$
	Oficina Coordinación Ama de Llaves	Puerta divisoria con la lavandería	$1.8 \times 2.1 = 3.78 m^2$
Meliá Marina	Oficina del cajero central	Ventanilla de pago	$1 \times 1.30 = 1.30\ m^2$
	Restaurante buffet “El Pilar”	Puerta divisoria con el área de fregado	$1.25 \times 2 = 2.50\ m^2$
Be Live Experience Tuxpan	Oficinas de servicios técnicos	Puerta divisoria con la sala de máquinas	$0.89 \times 1.90 = 1.69\ m^2$
Meliá Las Américas	Comedor de empleados	Ventana hacia el área de fregado	$1.05 \times 1.30 = 1.365\ m^2$
	Cocina	Puerta divisoria con el área de fregado	$1.00 \times 2.20 = 2.20\ m^2$
	Oficina de mantenimiento	Puerta divisoria	$0.80 \times 2.10 = 1.68\ m^2$

En el hotel Meliá Marina se propuso la creación de una concha acústica y un escenario al aire libre en las áreas exteriores de la instalación, en el área cercana a la piscina. Esta medida permitirá desplazar las actividades de animación que se realizan en el lobby bar, mejorando de forma considerable la calidad acústica de los espectáculos ofrecidos y eliminando a la vez las molestias generadas por ruido en el interior del hotel.

Para ello se aplicó el Método de Lyon. Se fijó una altura de 1.66 m sobre el piso del escenario, una profundidad de 3 m y una fuente con una altura de 1.5 m. El escenario, estará a 0.66 m sobre el suelo. El plano de audición, se dividió en diez 10 sectores, de 1,30 m de longitud cada uno.

Se realizaron dos (3) aproximaciones del método y finalmente se obtuvo una envolvente de altura 3.40 m. La altura de esta envolvente varió muy poco en relación a la altura de la anterior aproximación (13 cm), por lo tanto, fue la forma definitiva de la curva de la concha acústica.

A partir de la modelación, con el fin de validar el funcionamiento de la concha acústica diseñada, se construyeron dos (2) maquetas con escalas de 6:100 donde 6 cm representan un (1) metro y de 24:100 donde 24 cm representan un (1) metro respectivamente. En la figura 4 aparece una imagen de las mismas.

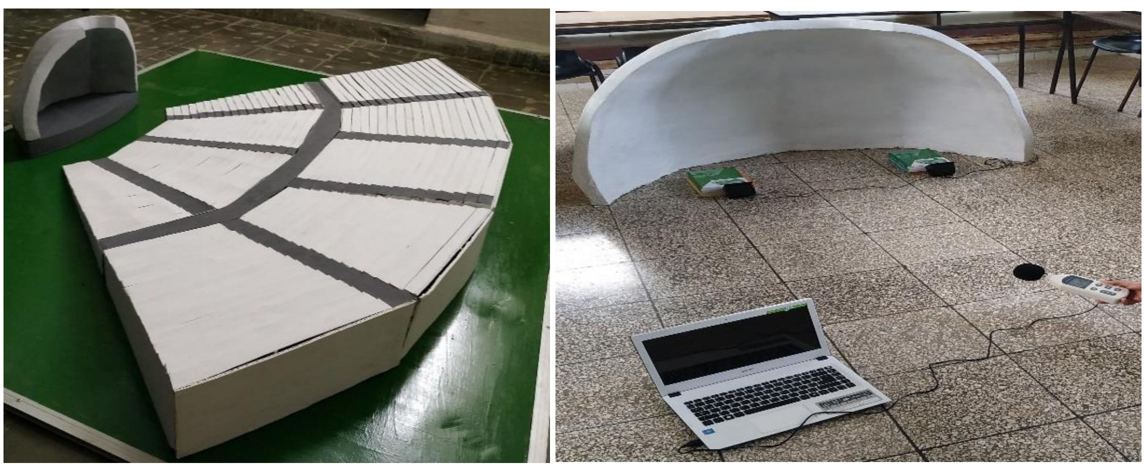


Figura 4. Disposición final de las maquetas

El desarrollo de un grupo de pruebas experimentales descritas por Almeda Barrios et. al. (2021) permitieron demostrar la efectividad del diseño propuesto dado que reflejaron la capacidad de la concha para lograr la equipotencialidad del sonido en las diferentes partes del escenario y la mejora de la calidad acústica de diferentes espectáculos.

Se propusieron una serie de medidas organizativas como complemento a otras medidas primarias y secundarias. De igual forma se plantearon en áreas afectadas donde no fue posible la aplicación del control en el foco o los medios de propagación. En la Tabla 6 se muestra, por cada hotel, las medidas correspondientes a las áreas con afectaciones analizadas.Tabla 6. Medidas organizativas propuestas en diversas áreas de los hoteles estudiados

Hotel	Área afectada	Medidas propuestas
Iberostar Varadero	Comedor de empleados	-Redistribuir las mesas de servicios que se encuentran cerca de los dispensadores y de los carritos para la cubertería de tal forma que no obstaculice el paso de los trabajadores.
	Lavandería	-Uso obligatorio de medios de protección auditiva para los trabajadores -Emplear señalética de elevados niveles de ruido en correspondencia con RD 286/2006
	Lobby bar “Los Arcos”	-Disminución del volumen de sonido de los amplificadores del audio, con la consideración de no afectar el show por deficiente escucha. -Ubicación de los bafles de sonido en un ángulo que evite la constante emisión de ruido hacia el lobby bar.
Meliá Marina	Mini-tintorería	-Uso obligatorio de medios de protección auditiva para el trabajador. -Emplear señalética de elevados niveles de ruido en correspondencia con RD 286/2006
Meliá Las Américas	Comedor de empleaos	-Sustituir el secador de manos del comedor de empleados por papel toalla. -Cerrar la ventana de fregado, y dejar solamente una apertura para introducir la bandeja.
	Lavandería	-Realizar el mantenimiento planificado a los equipos -Uso obligatorio de protectores auditivos para los trabajadores. -Emplear señalética de elevados niveles de ruido en correspondencia con RD 286/2006
	Ranchón playa	-Reducir el volumen de sonido de los amplificadores del audio. -Establecer niveles máximos de volumen en diferentes horarios del día. -Ubicación de los amplificadores de sonido en un ángulo adecuado, con dirección al mar.
Be Live Experience Tuxpan	Habitaciones 313, 315, 317 y 319	-Vender las habitaciones de domingo a viernes para evitar que existan clientes en el horario de la discoteca “La Bamba”. -Establecer estas habitaciones como: “Habitaciones de Cortesía”, utilizadas para clientes repitentes o grupo fam. -Establecer estas habitaciones para Guardia Administrativa.
	Buffet	-Redistribuir las mesas de servicios que se encuentran cerca de la puerta de la cocina hacia la otra sección del restaurante. -Aplicarles mantenimiento a los carritos auxiliares y sustituir las ruedas que se encuentran deterioradas.

Finalmente se valoró la efectividad de las medidas propuestas mediante su implementación, modelación y/o estimación. Se realizó la comparación de los valores de los NPS antes-después en todas las áreas afectadas. La Tabla 7 resume los resultados que se obtuvieron.Tabla 7. Análisis de la diferencia de los NPS antes-después de la implementación, modelación y/o estimación de las medidas de control

Hotel	Área	Medidas propuestas	Método de validación	NPS antes (dBA)	NPS después (dBA)
Iberostar Varadero	Lavandería	Medidas primarias/ medidas organizativas	Implementación/ estimación	80	80 65 con MPI
	Oficina Coordinación Ama de Llaves	Medidas Secundarias	Implementación	71.1	66.4
	Comedor de empleados	Medidas organizativas	Implementación	77.8	68.5
	Lobby bar “Los Arcos”	Medidas organizativas	Implementación	82.4	67.8
Meliá Marina	Restaurante Buffet “El Pilar”	Medidas organizativas	Implementación	85.4	69.2
	Mini tintorería	Medidas primarias/ medidas organizativas	Implementación/ estimación	87.6	85.3 70.3 con MPI
	Habitaciones del “the level”	Cápsula	Modelación	73	56.14
	Oficina cajero central	Medidas secundarias	Implementación parcial	75	65
	Lobby	Concha acústica	Modelación/ implementación	88.8	67.6
Be Live Experience Tuxpan	Mini-tintorería	Medidas primarias/ medidas organizativas	Implementación/ estimación	87.6	83.3 68.3 con MPI
	Oficinas del área de Servicios Técnicos	Medidas secundarias	Implementación	75	60
	Oficina de Costo	Pantalla acústica	Modelación	77.08	49.2
	Habitaciones 313, 315, 317 y 319	Medidas organizativas	Implementación	68.5	68.5
	Área de show (Bar Piscina)	Medidas organizativas	Implementación	89	68.9
	Restaurante Buffet “Cristal”	Tratamiento acústico	Modelación	73 Tr=0.34	70 Tr=0.17
Meliá Las Américas	Comedor de empleados	Medidas secundarias	Implementación	83.1	67.4
	Lavandería	Medidas primarias/ medidas organizativas	Implementación/ estimación	80	80 65 con MPI
	Oficina de mantenimiento	Medidas secundarias	Implementación	70	55
	Ranchón de la playa	Medidas organizativas	Implementación	91.1	66.6
	Cocina	Medidas organizativas	Implementación	80	70

Como se puede observar, con la implementación de las medidas propuestas se logra una disminución en los niveles de ruido en los locales afectados y mejoras en el cumplimiento de los parámetros de confort acústico.

Dando cumplimiento al principio de mejora continua que caracteriza a la tecnología, se debe aplicar anualmente, en correspondencia con la periodicidad establecida para los procedimientos de gestión de riesgos laborales en los hoteles de sol y playa en Cuba.

5. Conclusiones

Con la aplicación de la tecnología en 4 hoteles de Varadero, Cuba con afectaciones por ruido se realizó el diseño de métodos de control específicos ajustados a las características de los locales afectados. Su implementación, modelación y/o estimación permitió reducir los niveles de ruido a los que se exponen trabajadores y clientes en dichas instalaciones y obtener mejoras en los parámetros de confort acústico.

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SLEEP DURATION, PHYSICAL ACTIVITY, SEDENTARY BEHAVIOR, AND THEIR ASSOCIATION WITH COLLEGE STUDENT FATIGUE FEELING

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Resumen: Según la Asociación Americana de Salud Universitaria (ACHA), el 50% de los estudiantes universitarios perciben su salud como muy buena, y el 86% declararon sentirse agobiados (relacionados con la fatiga) en algún momento durante los últimos 12 meses. La escasa cantidad de horas delsueño, el comportamiento sedentario y la actividad física son factores que pueden relacionarse con la percepción de la fatiga por los estudiantes universitarios. Las relaciones entre la calidad del sueño, la actividad física, la conducta sedentaria y la sensación de fatiga percibida se han explorado de forma separada, sin embargo, no está clara la forma en que estos tres factores interactúan entre sí y con la sensación de fatiga percibida. Debido a la escasez de investigaciones en este sentido, se realizó un estudio longitudinal de quince semanas para determinar la asociación de las horas de sueño, el comportamiento sedentario, la actividad física y la fatiga percibida de 200 estudiantes universitarios. Se empleó un modelo de regresión logística con el propósito de determinar las asociaciones significativas entre los factores mencionados y la fatiga percibida. De acuerdo con los resultados de este estudio (α=0,05), la fatiga percibida y la cantidad de horas de sueño (4-5 horas) mostraron una fuerte asociación. Además, las categorías de Actividad física insuficiente (AFI)y la AF moderada (AFM) indican una asociación significativa con la fatiga percibida (AFI OR= 3,85., IC [1,57-8,98] y AFM OR=2,89, IC [1,24-5,84]). Además, para la variable género (femenino) se encontró una fuerte asociación con la fatiga percibida. El mismo comportamiento revelaron todas las categorías del índice de masa corporal (peso saludable, sobrepeso y obesidad). La edad y el comportamiento sedentario no mostraron asociaciones significativas. Los hallazgos de este estudio proporcionan información que puede guiar futuras investigaciones. Los resultados sugieren que el aumento de la actividad física y la promoción de las horas de sueño adecuadas pueden ayudar a reducir la fatiga percibida entre los estudiantes universitarios.

Palabras clave: Fatiga, estudiantes universitarios, actividad física, sueño, hábitos sedentarios.

Relevancia para la ergonomía: Esta investigación provee información sobre los hábitos de sedentarismo, actividad física, el sueño y su asociación con la fatiga, que puede dar pautas para realizar procesos de intervención para promover el bienestar físico y el desempeño académico de los estudiantes.

Abstract: According to the American College Health Association (ACHA), only 50% of college students perceived their health as very good, and 86% reported feeling overwhelmed (related to fatigue) at some point during the past 12 months. Poor sleeping duration, sedentary behavior, and physical activity are relevant factors in the feeling of fatigue of college student populations. No experimental studies assessed the relationship of sedentary behavior (SB) and the feeling of fatigue. The relationships between sleep quality, physical activity, sedentary behavior, and self-reported feelings of fatigue have been explored in a separate manner, however, the way in which these three factors interact with each other and with the self-reported feeling of fatigue is not clear. The college years may represent the last opportunity to address a large proportion of young adults' health issues comprehensively. Therefore, was performed a longitudinal study of fifteen weeks to determine the association of sleep, sedentary behavior, physical activity, and self-reported fatigue of 200 college students. Based on the outcomes of this study (α=0.05), fatigue score and hours of sleep (4-5 hr.) showed a strong association. Additionally, insufficient PA and moderate PA had a strong association (OR= 3.85., IC [1.57-8.98] and OR=2.89, IC [1.24-5.84]). Furthermore, gender (female) exhibited a strong association with fatigue. The same behavior revealed all categories of BMI (healthy weight, overweight, and obesity). Age and sedentary behavior showed no significant associations. The findings of this study provide information that may guide future research. The results suggest that increasing physical activity and promoting adequate sleep hours may help reduce self-perceived fatigue among college students.

Key words: Fatigue, college students, physical activity, sleep, sedentary behavior

Relevance for ergonomics: This research provides information on sedentary habits, physical activity and sleep and their association with fatigue, which can provide guidelines for intervention processes to promote physical well-being and academic performance of college students.

1. INTRODUCTION

According to the American College Health Association (ACHA), only 50% of college students perceived their health as very good, and 86% reported feeling overwhelmed (related to fatigue) at some point during the past 12 months (*Reports_ACHA-NCHAIIc*, n.d.). In addition to this, the ACHA indicates that the feelings of fatigue among college students can contribute to depression and anxiety. Some factors are associated with fatigue feeling which include sleep duration, sedentary behavior, and physical activity. Poor sleeping duration, sedentary behavior, and physical activity are relevant factors in the feeling of fatigue of college student populations. The World Health Organization (WHO) ranks physical inactivity as the fourth leading risk factor for global mortality, which not only negatively affects individual well-being, but also has an economic impact (Bull et al., 2020) . The WHO recommends as a strategy to reduce the negative effects of physical inactivity, to perform at least 150 minutes of moderate physical activity or 75 minutes of vigorous physical activity per week. In relation to physical activity, which includes activities such as walking, according to WHO, improvements in health occur when 3000 minutes per week of MET (Metabolic equivalent of task) are achieved (Kyu et al., 2016).

Sedentary behavior (SB) is another factor affecting individual health and well-being. Tremblay defines it as those activities with an energy expenditure below 1.5 METs, such as lying down or sitting, while physical inactivity implies that an insufficient amount of moderate to vigorous physical activity is performed (Sedentary Behaviour Research Network, 2012). According to Edelmann et al., (2022) sedentary lifestyles are prevalent in modern societies due to changes in physical activity, social and economic environments. Total sitting time is another factor associated with degenerative diseases.

The life of university students is characterized by sedentary activities, so the prevalence of sedentary behavior is higher among university students than among the general population. It is estimated that students spend an average of 7.29 hours per day in sedentary activity (Dunton, 2017). In addition, sedentary behavior increases as studies progress, which is also consistent with increased weight gain and body fat percentage in students (Castro et al., 2020).

The impact of sleep deprivation in fatigue feeling was examined by several where good quality of sleep was related to lower fatigue feeling. The relationship between the frequency of vigorous physical Activity and feelings of fatigue was found in other studies.

No experimental studies assessed the relationship of sedentary behavior (SB) and the feeling of fatigue. The relationships between sleep quality, physical activity, sedentary behavior, and self-reported feelings of fatigue have been explored in a separate manner, however, the way in which these three factors interact with each other and with the self-reported feeling of fatigue is not clear. The college years may represent the last opportunity to address a large proportion of young adults' health issues comprehensively. Therefore, was performed a longitudinal study of fifteen weeks to determine the association of sleep, sedentary behavior, physical activity, and self-reported fatigue of 200 college students.

2. Objetive

The aim of this study is to determine the association of sleep duration, physical activity, sedentary behavior, and self-perceived fatigue among college students. To identify potential health-related risk factors in regard to self-reported fatigue college students.

2.1 Delimitation

This study is limited to investigating the association of fatigue in students with risk factors such as physical inactivity, amount of sleep and sedentary habits.

3. Methodology

3.1 Participants

Two hundred college students from the city of Hermosillo, Sonora, Mexico were recruited for the development of this research. Students form Manufacturing industrial engineering program were invited to take part in the survey. All students received a link to the survey via the university mailing list. The demographic data of the sample considered in this study are as follows: Sex, age, weight, and body mass index. A convenience sample was used to perform the study.

3.2 Consent to participate

College students were asked to participate in this study, and 100% (N=200) of them stated that they agreed to do so. The study was approved by the Ethics Committee of the Universidad Estatal de Sonora. The researcher conducted a session to present the methodology and purpose of the study. Students were free to withdraw from the study at any time and those who chose to do so were provided with the results of the study. Pre-tests were conducted to examine question presentation, completion time and question comprehension, resulting in minor adaptations of the questionnaire. The survey was administered via online for 15 weeks and remainders were done during this period. All participants provided digital informed consent.

3.3 Measures

3.3.1 Fatigue

The Yoshitake's fatigue symptom checklist (YFSC) (Yoshitake, 1978) was used to measure self-reported fatigue. This tool was developed in Japan to measure fatigue in three categories: General symptoms of fatigue, intellectual fatigue, and physical fatigue. A composed fatigue index was calculated according these three categories. The fatigue index is calculated dividing the quantity of questions answered with "yes" by 30, then multiplied by 100. This checklist was administered every week at the final day activity. The instrument was available online for 15 weeks and requested to answer just one day by week (at the end day of activity).

3.3.2 Physical activity and sedentary behavior

The Spanish version long form of the International Physical Activity Questionnaire (IPAQ) was used to assess the self-reported PA level and sitting time

(Medina et al., 2022). The IPAQ is a reliable tool to assess the PA level among college students. In addition to the IPAQ, the self-reported sociodemographic variables gender, BMI, and age were assessed to identify inactive and sedentary lifestyle among college students.

3.3.3 Sleep duration

Sleep is still poorly understood (Abdali et al., 2019), and the amount of sleep a person requires can vary greatly depending on certain factors such as age, as well as entirely on an individual basis. A person who gets enough sleep should not experience daytime sleepiness or dysfunction. Researchers have discovered that getting 6-7 hours of sleep per night correlates with a few positive health outcomes. It was used an online tool (Sleep calculator, 2022), called the sleep length calculator to measure this parameter.

3.4 Data processing and statistical analyses

The fatigue index was calculated once a week according to Yoshitake procedure, the overall PA was expressed in MET-minutes/week, according to the guidelines for data processing and analysis of the IPAQ (Piercy et al., 2018). Questionnaires and surveys were considered invalid if any variable was missing. The collected data for PA was summarized as a continuous indicator and was expressed in MET-minutes per week. Therefore, the calculated minutes per week for each category (walking, moderate and vigorous activity) were computed by separately multiplying the minutes per day and the days per week, then the calculated minutes per week were multiplied by MET to weight each type of activity by its energy expenditure. Time spent in low-intensity activities, such walking, was multiplied by 3.3, time spent in moderate-intensity activities was multiplied by 4, and time spent in high-intensity activities were multiplied by 8. Students not meeting the minimal suggestions of at least 150 min of moderate PA, or 75 min of vigorous PA are classified as insufficiently active. Participants meeting of at least 300 min of moderate PA, or 150 min of vigorous PA were classified as highly active. A multivariate logistic regression model was used to determine the association between perceived fatigue and factors such as hours of sleep, physical activity, and sedentary behavior. A significance level of 0.05 was established.

Statistical analyses were performed using SPSS version 24 (IBM, Chicago, IL, USA)

4. RESULTS

4.1 Demographic and occupational characteristics of the students

A total of 234 students reviewed the online questionnaire and continued further. After a cleaning process the final sample consisted of 200 students from manufacturing industrial program at Universidad Estatal de Sonora in Hermosillo, Sonora, México. The sociodemographic characteristics of the students are shown in Table 1:

Table 1 Demographic characteristics of students

Characteristics	Variables	Value
Age (years)		
	Mean	18.36
	Range	18-21
	Standard deviation	.89
Sex (%)	Women	39 (19.5%)
	Men	161 (80.5%)
Body index mass	Mean	21.35
(kg/m^2)	Range	20.42-27.87
	Standard deviation	3.89

According to Table 2, the age of the students is in the range of 18 to 21 years (with a mean of 18.36 years and a deviation of 0.89 (years), 19.5% of the participants are women. The sample body mass index is in the range of 20.42 to 27.87 kg/m2.

4.2 Statistical analysis

This section presents a summary of the results of the statistical analysis, which will allow us to draw conclusions regarding the objective set. After processing data according to guidelines of IPAQ, a total of 200 participants were included.

4.2.1 Fatigue index

Overall fatigue index mean was 48.33%. The overall fatigue index mean (OFI) for women was 51.62% with a standard deviation (SD) of 24.72%. The OFI for men was 47.95% with a SD of 23.32%.

4.2.1 Physical Activity

According to IPAQ calculus, 46.5% of the sample were assigned as highly active, in contrasting 42.5% was insufficiently active. The mean value of PA was 2500 MET-minutes/week. Sample in overall, has a moderately activity. Results by gender are homogeneous. Table 3 summarizes the descriptive data.

Table 3 Means and standard deviations in PA

	Sample	PA MET-minutes/week		Insufficiently active	Moderately active	Highly active
	N	Mean	*Standard deviation*	N(%)	N(%)	N(%)
Total	200	2500.01	*1287.96*	85(42.5)	22(11)	93(46.5)
Gender						
Female	39	2963.25	*1217.54*	10(0.257)	19(49.1)	10(25.2)
Male	161	3965.45	*1978.87*	45(0.279)	78(48.7)	38(23.4)

4.2.2 Sedentary Behavior

The average sitting time of college students is 7h 29 min, with 46% of students sitting at least 5 hr. per weekday.

Table 4 Means and standard deviations in SB

	Sample	Sitting time (minutes/day)		Sitting time < 5 h	Sitting time>= 5 h
	N	Mean	Standard deviation	N(%)	N(%)
Total	200	437.40	*123.89*	114(57.0)	86(46.0)
Gender					
Female	39	432.89	*125.65*	20(51.2)	19(48.8)
Male	161	427.39	*1978.87*	85(0.279)	78(47.2)

4.2.3 Sleep duration

The average sleeping duration of college students is 6.89 h, with a standard deviation of 0.367 h per day. According to table 5, female students have more hours of sleep duration.

Table 5 Means and standard deviation of SD

	Sample	Sleep duration (hours/day)	
	N	Mean	Standard deviation
Total	200	6.89	*0.367*
Gender			
Female	39	7.25	*0.668*
Male	161	6.98	*0.358*

4.2.5 Multivariate logistic regression model

Based on the outcomes of this study (α=0.05), according to table 6, perceived fatigue score and hours of sleep (4-5 hr.) showed a strong association. Additionally, insufficient PA and moderate PA had a strong association with perceived fatigue (OR= 3.85., IC [1.57-8.98] and OR=2.89, IC [1.24-5.84]). Furthermore, gender (female) exhibited a strong association with fatigue. The same behavior revealed all categories of BMI (healthy weight, overweight, and obesity). Age and sedentary behavior showed no significant associations.

Table 5 Odd-Ratio and Confidence intervals

Variables		Fatigue
Sleep duration	4-5 h	**1.69(1.55-3.96)**
	6-7 h	0.89(0.67-0.98)
	8-9 h	0.35(0.45-0.69)
Physical Activity	Inssufficiently	**3.85(1.57-8.98)**
	Moderately	**2.89(1.24-5.84)**
	Highly	0.79(0.41-1.53)
Sedentary Behavior	Sitting < 5h	0.88(0.66-1.98)
	Sitting >=5 h	0.98(0.56-2.26)
BMI	Normal weight	**2.25(1.23-3.44)**
	Overweight	**3.69(1.45-2.45)**
	Obesity	**4.22(1.64-2.31)**
Gender	Male	1.40(0.81-2.42)
	Female	**2.23(1.23-3.43)**

Age	18-20	0.89(0.96-2.73)
	21-23	0.77(0.99-3.93)
	24-26	0.46(0.41-3.26)

p-value < 0.05 in bold, significance level a=0.05

5. CONCLUSIONS

Health promotion among college students is a key. Results demonstrate that sufficient sleep duration and physical activity may have a positive impact on perceived fatigue. No association was found between perceived fatigue and sedentary behavior. These findings provide information that may help guide future research, but findings suggest that increasing physical activity and promoting adequate sleep duration may help to reduce perceived fatigue among college students. The study has some limitations and strengths. The findings of this study provide information that may guide future research. The results suggest that increasing physical activity and promoting adequate sleep hours may help reduce self-perceived fatigue among college students. This study has some limitations and some strengths. Among them is the fact that the data were self-reported, therefore, we cannot rule out some overestimation of PA and underestimation of SB cannot be ignored for reasons of social desirability. Among the strengths of this study is its prospective design. In addition, the main variables were measured with validated instruments widely used in the literature. Finally, the logistic regression model was adjusted for confounding factors such as BMI, gender, and age.

Conflict of interest

None to report.

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FATIGUE AND TELEWORK IN LATIN AMERICA TEACHERS. AN URGENT NEED FOR STUDY

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Resumen El estudio de la fatiga en Latinoamérica es limitada al observar que el interés central de la disciplina del factor humano y ergonomía está enfocado en el estrés y posibles afectaciones (Benites, 2022; Naranjo y Terán, 2022), lo que motivó en hacer una revisión de la literatura científica sobre el impacto que arrojó el aumento del teletrabajo en el ámbito docente. Material y método: Es una revisión sistemática del periodo marzo 2019 a julio de 2022 en docentes de Latinoamérica que están expuestos al teletrabajo. Se utilizó el método PRISMA (Preferred Reporting Item for Systematic Review and Meta-Analyses: Moher et al. 2009) por ello, se contemplaron las tesis y artículos científicos en los idiomas inglés y español, con una descripción clara del procedimiento metodológico, y que en los resultados describieron detalladamente los factores de exposición, instrumentos utilizados y las consecuencias de la fatiga o cansancio. Conclusiones: Existe un área de oportunidad en la diversidad de evaluación en la población trabajadora que debe atenderse. Así también, es necesario contextualizar las condiciones de trabajo a las cuales están expuestos los trabajadores, en este caso la docencia. El estudio de la exposición de los docentes en una diversidad de espacios para efectuar el teletrabajo será un gran reto para los especialistas en Ergonomía y Estudios del Factor Humano para determinar las afectaciones inmediatas que dejará el teletrabajo si no se tiene un modelo transdisciplinario-basada en la evidencia que atienda este tipo de problemáticas no solo de la fatiga sino de la salud en general.

Palabras clave: fatiga, teletrabajo, docentes, ergonomía cognitiva, ergonomía organizacional.

Relevancia para la ergonomía: Se observa un área de oportunidad en la evaluación de la fatiga en distintos ambientes laborales. En este caso, se vislumbra la necesidad de fortalecer el desarrollo de modelos de evaluación por la exposición al teletrabajo y su interpretación del nivel de consecuencia que podría afectar a la población trabajadora.

Abstract: The study of fatigue in Latin America is limited by the fact that the main interest of the discipline of human factors and ergonomics is focused on stress and its possible effects (Benites, 2022; Naranjo and Terán, 2022), which motivated a review of the scientific literature on the impact of the increase in teleworking in the teaching field. Method: This is a systematic review of the period March 2019 to July 2022 in Latin American teachers who are exposed to telework. The PRISMA method (Preferred Reporting Item for Systematic Review and Meta-Analyses: Moher et al. 2009) was used, therefore, theses and scientific articles in the English and Spanish languages were contemplated, with a clear description of the methodological procedure, and which in the results described in detail the exposure factors, instruments used and the consequences of fatigue or tiredness. Conclusions: There is an area of opportunity in the diversity of assessment in the working population that needs to be addressed. It is also necessary to contextualize the working conditions to which workers, in this case teachers, are exposed. Studying the exposure of teachers in a variety of teleworking spaces will be a major challenge for specialists in Ergonomics and Human Factors Studies to determine the immediate impacts of teleworking without an evidence-based transdisciplinary model to address not only fatigue but health issues in general.

Keywords. fatigue, telwork, teachers, cognitive ergonomics, organizational ergonomics.

Relevance to Ergonomics: There is an area of opportunity in the assessment of fatigue in different work environments. In this case, there is a need to strengthen the development of assessment models for telework exposure and its interpretation of the level of consequence that could affect the working population.

1. INTRODUCTION

The contingency period of the COVID-19 pandemic generated changes in the different economic sectors, and in this sense, in education, teachers who were in front of the group had to respond immediately to build materials for face-to-face classes and not suspend academic activities (Cifuentes-Faura, 2020). Additionally, they had to attend to the rest of the responsibilities with the use of technology and digital tools from their homes (Martínez-Garcés & Garcés-Fuenmayor, 2020). These activities were a central theme in the study of occupational health and ergonomics to provide alternatives to reduce or avoid adverse consequences in the working population.

Therefore, it was observed that during the experience in the online classes there were limitations because there are differences in the type of network used at home, connectivity interruptions (Bravo & Quezada, 2021), difficulties in the use of Tics (Díaz, Ruiz & Egüez, 2021), work-family interference (Córdova & Quinga, 2022; Morales, 2022) due to sharing the same space between the members of the household and the extra-work hours dedicated to school commitments to attend to the actions generated in the different institutions (Cerda, Vázquez, Arredondo & Urdiales, n. f.).

The effects expressed in different studies revealed a series of factors that generate stress in teachers (Alcaraz, Sierra, Cupul & Vivas, year), socio-economic effects (Henríquez-Basurto, Bernardino-Castro, Bernardino-Castro, 2022), the presence of burnout (Soto & Soto, 2022) and a series of health problems and complications (Noroña, 2022), among others. A series of coexistence complications or difficulties faced by teachers at home that affected their work performance were also observed.

From the perspective of Ergonomics and the Human Factor, one of the concerns when studying workers is the long hours spent in front of a monitor and the consequences that this causes, mainly in terms of physical and mental fatigue, If there is no correction, this can turn into chronic fatigue, which will be reflected mainly in absenteeism, i.e., even if the worker is motivated to carry out his activities or is proud to collaborate in a company, he will be prevented by the irreversible symptomatology that excess work can bring.

2. OBJECTIVE

To identify the presence of fatigue and its consequences of telework exposure in teachers in Latin America during the period March 2019-July 2022.

3. METHODOLOGY

This is a systematic review of studies describing fatigue assessment instruments, telework exposure conditions and models with diagnoses during the period March 2019 to July 2022. The method used was PRISMA (Preferred Reporting Item for Systematic Review and Meta-Analyses: Moher et al. 2009) to discriminate those meeting the variables of interest. The search words were "distance work" OR "online work" AND "teachers" AND "fatigue" AND "Latin America" in Google Scholar. We eliminated those that did not specify the level of teaching, those that were not within the COVID-19 period, which corresponds to January to March 2019, studies that did not correspond to the geographical area of Latin America, those that did not reflect the effects of fatigue or tiredness in teachers, those that were memoirs, reports, bulletins, conference abstracts and dissemination publications that were not in the Spanish language. Only theses and scientific articles were included, with a clear description of the methodological procedure, and the results contained a detailed description of the consequences of fatigue or tiredness.

Procedure

1. Identification of publications on fatigue in Latin American teachers. A total 346 records were obtained in the google scholar search engine, which was the platform of choice as it was the most practical for finding publications in Spanish from the Latin American population. Repeated publications were eliminated.
2. Review of publications. The abstract was reviewed to see if they had data that explained the conditions where the activity was carried out, if they were studies that indicated the methodology and if the results included the affectations, consequences, or symptomatology representative of fatigue.
3. Study Eligibility. Once the publications of interest were discriminated and that they covered the inclusion criteria in 50 articles, the sections of the investigations carried out with teachers who gave virtual classes due to the COVID-19 pandemic and that already manifested the presence of fatigue. Of this, 33 publications that did not reflect the results of the presence of fatigue or its consequences were eliminated.
4. Data selection and analysis. For the analysis, 17 publications were used to make a list of the working conditions of teleworking and comparative representation to identify the way in which the study problem, the methodology, the results, and the conclusions were approached. For this reason, the information was classified into three important categories: the instruments used, the exposure factors and the consequences.

4. RESULTS

It reveals an absence of the use of specialized fatigue instruments and the urgency of a diagnostic and intervention protocol to address the repercussions of telework exposure, because most of the studies were constructed ad hoc, i.e., they have not passed the process of validation and reliability of what is assessed, and some are in the process of doing so (Table 1).

Table 1. Instruments used in studies on teacher telework and fatigue

Instrument	Dimensions	Autor, year
NASA-Task Load Index (NASA TLX)	Mental, physical, time, effort, performance, and frustration demand	Terán, Córdova, Muquinche, Gordón, 2021
Techno-stressors questionnaire	Scepticism, towards, the use of TIC, work fatigue, anxiety, and inefficiency	Carrión-Bósquez, Castelo-Rivas, Guerrero, Pachacama, Criollo-Sarco, Jaramillo-Verduga, 2022

Survey ad hoc, on the effects of teacher teleworking	Mental fatigue: difficulty in thinking and nervousness, self-perceived tiredness when talking, inability to focus attention and feeling of forgetfulness, lack of confidence and feeling anxious, self-perceived easy loss of concentration.	Solórzano, Delgado, Quimi & Bravo, 2021
Teleworking occupational risk questionnaire	Musculoskeletal risks, psychosocial risks, visual fatigue, and locative risks.	Reyes, Nuñez, León, Lezameta, Valderrama & Segundo (2021)
The Day After Survey: Impact of COVID 19 on teachers and their work in education	Socio-demographic profile, professional-occupational profile, risk behaviours, protection, self-efficacy and coping in teachers	Coppari, González, Bagnoli, Maidana, Ortiz, Recalde, 2021
Yoshitake Subjective Symptoms of Fatigue Test	Physical, mental, and mixed (physical and mental) requirements	Santos, 2021

The main sources of telework exposure are work overload (Rosales et al. 2022; Cabezas et al, 2022; Cerón et al, 2022; Oros et al, 2022; Toala et al. 2022; Parra et al, 2021; Cisternas, 2021), internet instability, connectivity problems due to the use of different digital tools to carry out virtual classes (Rosales et al, 2022; Cabezas et al, 2022; Zuñiga et al, 2022; Cerón, 2022; Santos, 2021; Toala, 2022; Lizondo et al, 2021; Russo, 2020), poor privacy settings or interruptions during class delivery (Cabezas et al, 2022; Cerón et al, 2022; Toala 2022). Also, a difference was found between gender and responsibilities, which could be inferred to be due to cultural overload in the case of women (Table 2)

Table 2. Sources of exposure from teleworking

Autor	Work overload	No direct communication	Complications of Access to tools (internet and device)	Digital skills deficiencies	Lack of adequate space for virtual classes	Saturation of students per group	Uncertainty about the duration of the pandemic	Ambiguity of roles functions	Work-family conflict
Rosales et al., 2022	x	x	x	x					
Cabezas et al, 2022	x		x		x	x			
Oros et al, 2020	x			x			x	x	

Zuñiga et al, 2022			x						
Cerón, 2021	x		x		x				
Santos, 2021			x						
Toala, 2022	x		x	x	x				
Lizondo, 2021			x						
Parra, 2021	x								
Cisternas, 2021	x								x
Russo, 2020		x	x						

Table 3 shows the physical and socio-emotional consequences (Rosales et al, 2022; Cabezas et al, 2022). Although it is conjectured that there must be mental effects because the workload is centred on the intellectual part, the studies do not show those related to this type of enquiries to confirm or emphasise the causes that generate the application of reasoning, analysis, information processing and decision-making, which are the main characteristics of the execution of activities in the teaching job, therefore, this limits to observe where the possible pathologies come from in this work sector or to determine which symptoms of fatigue are those that are linked to the generating factors of telework teaching, even so those that generated a generalised concern, confusion in the covid period were contemplated (Rosales et al., 2022; Cabezas et al.; Oros et al.; Cerón, 2021; Santos, 2021; Lizondo, 2021).

Tabla 3. Effects on teachers' health

Physical effects	Mentals effects	Socio-emotional effects
exhaustion (Rosales et al, 2022)	Icreased intelectual effort (Rosales et al, 2022)	Increased emotional effort (Rosales et al, 2022)
Loss of voice, body contractures, ulcers, and hypertension. (Cabezas et al, 2022)	Concern (Cabezas et al, 2022)	Psychological distress: anxiety, anger, tiredness, and stress, depersonalisation with their work. (Cabezas et al, 2022)

Headaches, apetite changes (Oros et al., 2020)	Bewilderment, constant concern (Oros et al., 2020)	Nervousness, fear (Oros et al., 2020)
exhaustion (Santos, 2021)	Mental health attrition (Cerón, 2021)	Anxiety, depression, and stress (Zuñiga et al, 2022)
Difficulty falling asleep (Santos, 2021)	Mental exaustion (Santos, 2021)	Family distancing (Toala, 2022)
exhaustion (Toala, 2022)	concern (Lizondo, 2021)	Nervousness, fear, sadness (Macías et al, 2022)
Muscle aches or contractures: back, neck, shoulder, headaches, and migraines (Parra, 2021)		Resilience (Cervantes, 2021)
Tiredness (Bahamóndez, 2020)		Anxiety (Russo, 2020)
Exhaustion, lack of sleep (Grasso, 2020)		Work-related stress (Criollo, 2021)

4. CONCLUSIONS

The exercise of the review of the scientific literature showed us that it is urgent to carry out studies that contextualize the different ways of working due to the change of the pandemic, because knowing the conditions of teleworking teachers would help in describing the work process and see the problems that exist in Latin America due to the scarcity of resources to develop virtual work from home, in addition to the fact that some institutions lack connectivity tools to provide a quality service when transmitting online classes. The challenge for the area of Ergonomics is to reach a standardization of methods and tools to assess the exposure factors of teaching work to help as far as possible to provide timely attention for the care of their health.

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ERGONOMIC REDESIGN FOR MANUAL ASSEMBLY WORKSTATIONS. CASE: "BRACKET ASSEMBLY" CAPSA HEALTHCARE

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Resumen: En estos últimos dos años, la humanidad ha visto la necesidad de modificar la forma en que se estructuran las nuevas relaciones sociales de producción, aprehendiendo las herramientas que le permitan accionar de forma ágil, rápida y adaptable. Esto circunscrito en un ámbito que engloba la disrupción digital, crisis climática, cambios económicos, escasez de mano de obra y movimientos civiles. Toda esta conjunción ha impactado desfavorablemente a los procesos productivos, en especial a los que contemplan en sus distribuciones el ensamble manual, ya que al mantener una acelerada y cambiante demanda; problemas económicos y escasez de la mano de obra, la presión de la competitividad productiva recae en los trabajadores que están frente a los procesos productivos donde se llevan a cabo las tareas de ensamble manual.

Lo anterior lleva consigo una alta exigencia operativa del recurso humano, que desempeña su labor en estos procesos. Situación que compromete la relación sinérgica entre el operador y la estación de trabajo donde se realiza la actividad. Las tareas implicadas en el ensamble manual mantienen un conjunto de acciones repetitivas, tiempos de ciclo cortos, estrés por contacto, posturas inadecuadas y manejo manual de cargas que no contempla las directrices de la biomecánica y la ergonomía ocupacional.

Para el caso específico de las estaciones operativas de "Ensamble de sujetador" en la empresa CAPSA Healthcare. Objeto de estudio de la presente investigación, se ha presentado un impacto negativo del trabajo sobre el operador debido principalmente a los cinco factores complejos definidos anteriormente, generando con lo anterior la presencia de Trastorno Músculo Esqueléticos, específicamente referenciados en la columna vertebral y los miembros superiores.
El ensamble del sujetador se presenta en 7 líneas de producción con flujos intermitentes en línea y una secuenciación en los lotes de producción con alta

demanda, aunado a ello el corporativo mantiene tres turnos con similitud de actividades. Todo ello implica una situación problémica que hizo necesario desarrollar un rediseño ergonómico, con el objetivo de reducir el impacto negativo del trabajo y mejorar los resultados operativos de la entidad productora.

Palabras clave: Rediseño ergonómico, ensamble manual

Relevancia para la ergonomía: La presente investigación valora el impacto productivo del rediseño ergonómico de la estación “Ensamble de sujetador”. Lo anterior mantiene relevancia ergonómica, debido a que la valoración permite establecer de manera cuantitativa la importancia de aplicar las directrices de la ergonomía en el rediseño de estaciones de trabajo, proporcionando a la gerencia datos sobre el incremento en la producción y mejora en la calidad de vida de los trabajadores.

Abstract: In the past two years, humanity has seen the necessity to modify the way in which the new social relations of production structure themselves, apprehending the tools that allow them to act in an agile, fast and adaptable way. This reduced in a scope that involves digital disruption, climate crisis, labor shortage and civil movements. All this conjunction has unfavorably impacted the productive processes, especially those that contemplate in their distributions the manual assembly, because when maintaining a hasty and changing demand; economic problems and labor shortage, the pressure of productive competitiveness falls on workers who are in front of productive processes in which the manual assembly tasks take place.

This carries with a high operative demand of the human resource, which performs its tasks in these processes. This issue compromises the synergic relation between worker and workstation where the activity is done. The tasks involved in the manual assembly keep several repetitive actions, short cycle times, contact stress, inadequate postures and manual handling of loads that do not contemplate the biomechanical guidelines and occupational ergonomics.

For the specific case of operative stations of “Bracket assembly” at CAPSA Healthcare. Object of study of the present research, a negative impact of the work has been presented on the operator mainly due to the five complex factors defined above, generating the presence of Musculoskeletal disorder, specifically referenced in the spine and the upper limbs. The bracket assembly is presented in 7 lines of production with intermittent flows in line and a sequencing in the production batches with high demand, in addition to this the corporate keeps three shifts with activity similarity. All that involves a problematic situation that made it necessary to develop an ergonomic redesign, with the objective to reduce the negative impact of the work and improve the operative results of the productive entity.

Keywords: Ergonomic redesign, manual assembly

Relevance for ergonomics: This research assesses the productive impact of the ergonomic redesign of the "Bracket Assembly" station. This maintains ergonomic relevance, because assessment allows to establish in a quantitative way the importance of applying the ergonomic guidelines in the redesign of workstations, providing management with data on increased production and improvement in quality of life of workers.

1. INTRODUCTION

Production complexes of nowadays are subject to a multifactorial set of actions, requirements and needs, which maintain a high demand of energy, synchronization, product – process empathy, synergistic human-machine interaction and a correct harmonization of the production – inventory – demand level. This conjunction directly affects the operator, who performs his functions in these productive complexes, both in their anatomical and psychological structure (Castro-Castro et al., 2018).

The CAPSA Healthcare company maintains a complex production system that includes the aforementioned characteristics. This company located in the Northeast of the State of Sonora, develops its operations in three shifts with intermittent production lines and workstations where it is necessary to carry out manual assembly tasks.

The jobs that require manual assembly keep special characteristics in their conformation and are of imperative necessity in the operations of the industry under study. Characteristics such as high repetitiveness, monotony, high degree of concentration, low locomotion and short cycle times, make these tasks affect the quality of life of the worker and affect their operational capacity.

The intermittent in-line production systems established in the CAPSA company are responsible for producing a wide range of products, for which they keep different production lines that develop simultaneous activities in compliance of the production standards. A particular case of these productive systems has presented an increase in the number of visits to the doctor and reports of unconformity of the workers who carry out their activities in them. This problematic situation made it necessary to make an ergonomic assessment of the conditions in which the design of the workstation is found.

The analyzed workstation corresponds to the assembly of the drawer used for the storage of utensils and peripheral medical equipment. Figure 1 shows the part that corresponds to this drawer in the final product.

Figure 1. Drawer produced on the workstation under analysis.

The drawer configuration includes two activities, in the first of them the height adjustment lever for the drawer is assembled, this entails an operating cycle time of 38.31 seconds. In the second activity, the complete assembly of the drawer is carried out, with an operating cycle time of 3.8 minutes and a tolerance of plus – minus .4 minutes.

The production standard that is requested from the workstation is 70 pieces in the shift. This day includes a break for the operator to take their food. It is important to establish that the two operations are carried out by the same operator, concentrating his activity on the assembly of the height adjustment lever, from the start time of the day, until the scheduled rest for lunch. After returning from rest, the operator concentrates his activity on the complete assembly of the drawer.

The object of study that is established in this document, is the assembly workstation of the adjustment lever for different heights, in it the taking of videos of the movements made by the worker in the development of his activity, the description of the activities and the corresponding ergonomic study is carried out. Figure 2 shows the workstation under analysis.

The operation is performed standing, starts when the operator reaches the base component for the lever, places it on the workspace and subsequently takes the adjustment component for the lever, these two components must be screwed with two screws that carry a plastic support. Conforming in this way the assembly.

This operation is carried out in the three shifts in which the company develops its operational functions, at the same time in each shift there are 7 production lines where it is necessary to carry the analysis activity out. Due to this situation, the observational study that was carried out contemplates each of the workstations that keeps this task, in the 7 production lines of the three shifts, since in the ergonomic risk map defined in the productive entity they are in high risk.

Figure 2. Workstation, adjustment lever assembly for different heights.

The observational study that was contemplated in the analysis is framed in three phases: in the first the direct observation of the workstation is carried out, in the second the video recordings that were considered necessary are carried out and in the third the technical - ergonomic assessment of each of the workstations framed as high risk in the ergonomic risk map is carried out. It is important to frame that in each workstation the analysis was carried out in two parts, 30 minutes after the start of the shift and 30 minutes before the end of it, this is contemplated due to the increase that occurs in the cycle time throughout the shift.

2. OBJECTIVES

2.1 General objective

Develop a procedure that assesses the risk conditions in workstations with manual assembly and establishes the principles and ergonomic guidelines necessary for the redesign of the operation: "Bracket Assembly" CAPSA Healthcare.

2.2 Specific objectives

1. Structure in a methodological way, a referential theoretical framework about the theoretical and scientific aspects related to the work made in assembly operations; ergonomic principles; musculoskeletal disorders; ergonomic redesign; productive improvement assessment and life quality.
2. Redesign the CAPSA Healthcare "Bracket Assembly" workstation applying the guidelines and principles of occupational ergonomics.
3. Validate the designed procedure, based on comparing the assessments: work risk and productive efficiency, before and after the redesign of the workstation under study.

2.3 Delimitation

The research work was developed in the maquiladora and manufacturing export industry, located in the Northeast of the State of Sonora, specifically in those intermittent production lines with inline flows, which due to their own requirements is necessary to assemble small components: Case "Bracket Assembly" CAPSA Healthcare.

3. METODOLOGÍA

The methodology used in this project is based on mixed research, stipulating three phases in its achievement.

1. As a first action, an ergonomic diagnosis is made that indicates the risk grade in which the workstation is located and the possibility that the worker who performs his work in that station suffers a Musculoskeletal Disorder. To carry out the diagnosis, the Art Tool method was applied through direct observation and video recording, using the procedure described in the introduction section. At this point it is of the utmost importance that the research team is qualified in the usability and application of the method, to obtain the greatest reliability in the results of the diagnosis. In addition to the quantitative evaluation of the workstation is carried out

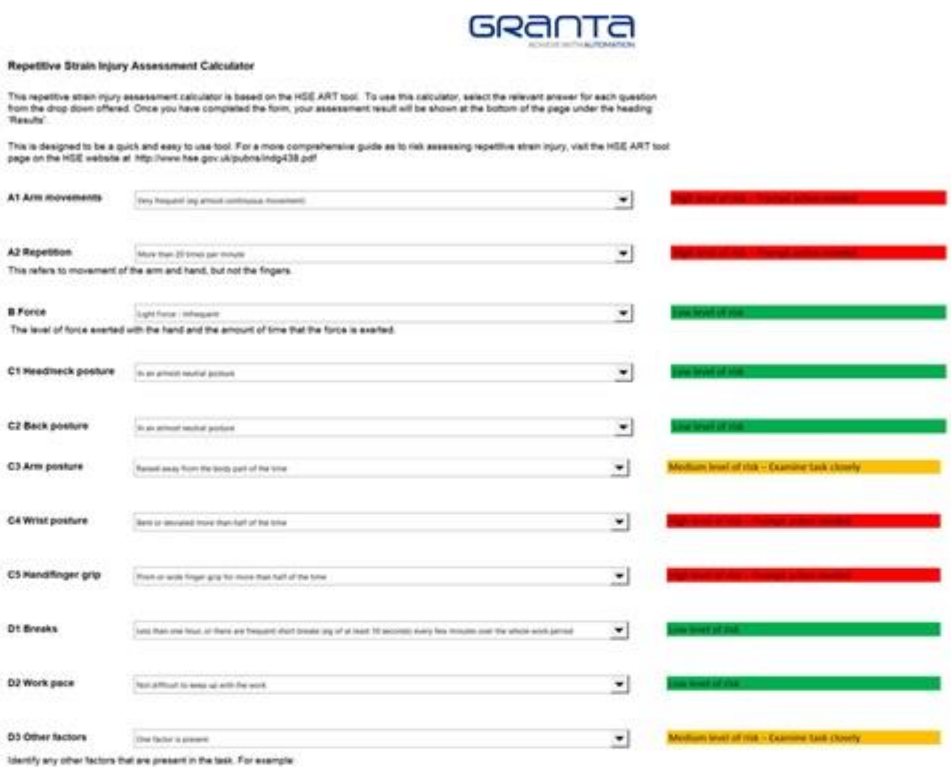
with the obtaining of cycle time of the operation and the production volume made by the workstation, using the predetermined time method called Modapts.

2. The second part of the methodology consists in developing the redesign of "Bracket Assembly", applying the guidelines of occupational biomechanics and ergonomic principles. It is of utmost importance to maintain the minimum distance between the neutral position of the worker and the posture in which he performs his activity, this consideration implies a significant decrease in the possibility that the operator presents a Musculoskeletal Disorder, when he is performing his function.

3. As a third point of this methodology, a comparison of the two main variables involved in the research is made, the reduction of work risk from the comparison of the results of the application of the Art Tool method; and the comparison between the cycle times of the redesigned workstation.

4. RESULTS

Complying with the first point established in the methodology used in this research, the application of the Art Tool method was carried out, with the main objective to define the risk grade that the operator keeps when he develops his work activity. Figure 3 shows the results obtained by the Art Tool method. The rating obtained by the Art Tool method was 19, this rating being considered as a medium risk and it is recommended to carry a detailed study of the activity out.



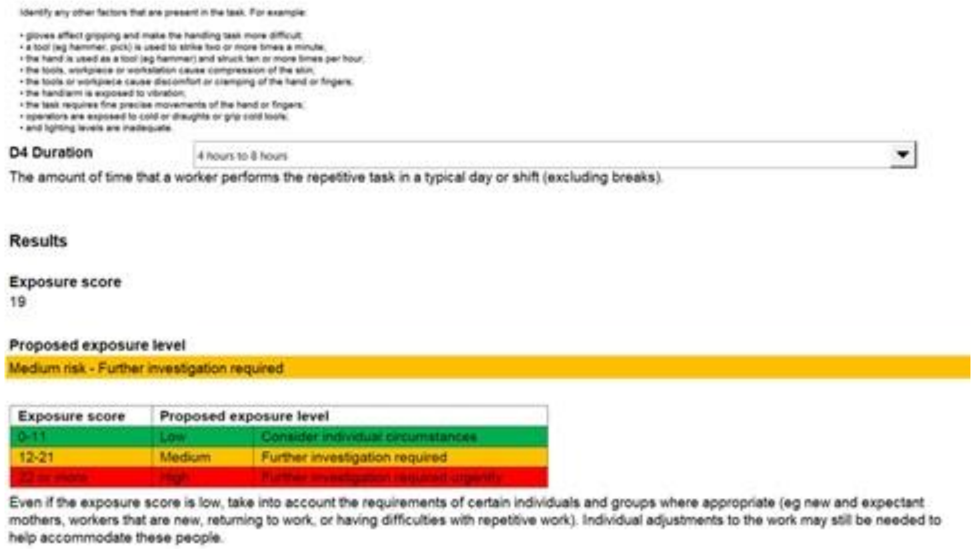


Figure 3. Ergonomic evaluation with the Art Tool Method.

In addition to the normal operating time of the workstation is obtained, applying the method of predetermined times called Modapts, and its consequent standard time, considering the tolerance policies issued by the company. It is defined that the normal working time in the analyzed station is 38.31 seconds per piece, being one of the company's policies to add a percentage of time for supplements and tolerances of 12%, which results in a standard time of 42.9 seconds per piece. Table 1 shows the normal time calculation with the Modapts method.

Table 1. Calculation of normal time with the Modapts method.

	Operación	Ensamble de palanca													
Número o paso	Descripción	Codigo										Mods	Frecuencia	Ocurrencia	Tiempo en seg.
1															
1	El operador toma la base de la palanca (RH)	M	5	G	1							6	1	1	0.774
2	Coloca la base de palanca en la mesa de trabajo (RH)	M	5	P	5							10	1	1	1.29
3	El operador toma 2 arandelas de contenedor (LH)	M	3	G	3	J	2					8	1	1	1.032
4	Coloca las 2 arandelas en la base de la palanca	M	3	P	5	M	2	P	5	E	4	19	1	1	2.451
5	El operador toma la capa superior de la palanca (RH)	M	5	G	1							6	1	1	0.774
6	El operador desempaca la capa superior de la bolsa plastica	M	3	G	1	J	2					6	1	1	0.774
7	Coloca la capa superiro de la palanca en la mesa de trabajo (RH)	M	5	P	5	J	2	E	2			14	1	1	1.806
8	Coloca la bolsa de empaque en el contenedor de basura (LH)	M	7	P	0	B	17					24	1	1	3.096
9	El operador toma 2 arandelas de contenedor (LH)	M	3	G	3	J	2					8	1	1	1.032
10	Coloca una arandela en la mano derecha	M	3	P	2							5	1	1	0.645
11	Coloca las dos arandelas en la parte superior de la palanca	M	2	P	5	E	4					11	1	1	1.419
12	El operador toma 2 arandelas plasticas del contenedor (RH)	M	3	G	3	J	2					8	1	1	1.032
13	Coloca una arandela plastica en la mano derecha	M	3	P	2							5	1	1	0.645
14	Coloca las dos arandelas plasticas en la parte superior de la palanca	M	2	P	5	E	4					11	1	1	1.419
15	El operador toma 2 arandelas del contenedor (RH)	M	3	G	3							6	1	1	0.774
16	Coloca las 2 arandelas en su mano izquierda	M	3	P	2							5	1	1	0.645
17	El operador toma un tornillo del contenedor (RH)	M	3	G	3							6	1	1	0.774
18	Traslada el tornillo a la mesa de trabajo (RH)	M	3	P	2							5	1	1	0.645
19	Coloca una arandela en el tornillo	M	2	P	2							4	1	1	0.516
20	Coloca el tornillo con la arandela en la mesa de trabajo	M	2	P	2							4	1	1	0.516
21	El operador toma un tornillo del contenedor (RH)	M	3	G	3							6	1	1	0.774
22	Traslada el tornillo a la mesa de trabajo (RH)	M	3	P	2							5	1	1	0.645
23	Coloca una arandela en tornillo	M	2	P	2							4	1	1	0.516
24	El operador toma una herramienta suspendida en el aire	M	5	G	1							6	1	1	0.774

25	Posiciona el tornillo en la punta de la herramienta	M	2	P	5	E	4				11	1	1	1.419
26	Coloca el tornillo junto con la herramienta en la parte superior de la palanca	M	2	P	5	E	4				11	1	1	1.419
27	Acciona la herramienta para atornillar durante 2.6 segundos	T	20								20	1	1	2.58
28	El operador ajusta el ensamble a la mesa de trabajo	M	2	P	2						4	1	1	0.516
29	El operador toma el segundo tornillo de la mesa de trabajo (LH)	M	2	G	1						3	1	1	0.387
30	Posiciona el tornillo en la punta de la herramienta	M	2	P	5	E	4				11	1	1	1.419
31	Coloca el tornillo junto con la herramienta en la parte superior de la palanca	M	2	P	5	E	4				11	1	1	1.419
32	Acciona la herramienta para atornillar durante 2.6 segundos	T	20								20	1	1	2.58
33	Libera la herramienta	M	1	G	0						1	1	1	0.129
34	El operador toma el ensamble terminado	M	2	G	1						3	1	1	0.387
35	El operador acciona el movimiento de palanca para verificar funcionamiento	M	2	P	5						7	1	1	0.903
36	El operador coloca el ensamble terminado en un area de inventario provisional	M	3	G	0						3	1	1	0.387
							Total de mods				297	Tiempo total		38.313

Once analyzed, established and quantified the problematic of the current design of the workstation "Bracket Assembly", from the ergonomic perspective, after that structure a set of proposals for the redesign of the workstation based on the principles of occupational biomechanics and ergonomic guidelines.

Figure 4 presents: an outline of the ergonomic problems detected in the workstation; the main ergonomic risks defined; the proposals that supported the redesign of the workstation.

Ergonomic risk factor.	Proposal for the redesign of the workstation.
The arm is located higher than the height of the shoulder >90° and even the forearm is with ulnar deviation next to the body. In this case one arm of the worker is located below the level of the shoulders and the other above the level of the shoulders. FRE: Workstation, forced posture, repetitiveness and pace of work (Urrejola-Contreras et al., 2021).	Reducing the height of raw material containers at the height where man remains at less than 90° degrees.

Ergonomic risk factor.	Proposal for the redesign of the workstation.
The posture shows that there is flexion >20° of the neck. The risk factor is the repetitiveness of the operation. FRE: Static posture, repetitiveness and fast pace.	Increasing the assembly area 20 centimeters.

Ergonomic risk factor.	Proposal for the redesign of the workstation.
The observed risk factor involves the moment of getting down, presenting a flexion of the trunk and rotation simultaneously and even when getting the trunk down there is a flexion >60°. What could cause a problem of scoliosis by compressive forces, in addition to this, keeps a great compression of the intervertebral discs in the lumbar area of the spine, specifically in	Placing a container that has the same height as the work table. .

the functional spinal units: L3-L4, L4-L5 and L5-S1. FRE: Forced posture and repetitiveness.	

Figure 4. Diagram of the ergonomic problems detected in the workstation; the main ergonomic risks defined; the proposals that sustained the redesign of the workstation.

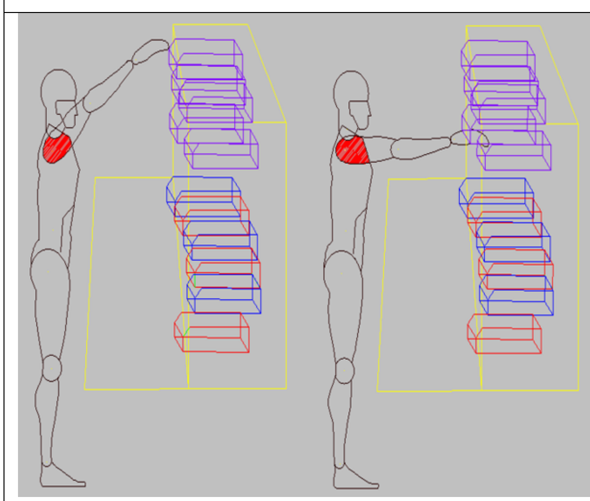
After defining the actions by means of which the redesign of the workstation is carried out, the redesign model is realized according to the proposals presented and considering in the redesign procedure the main guidelines of ergonomics and occupational biomechanics.

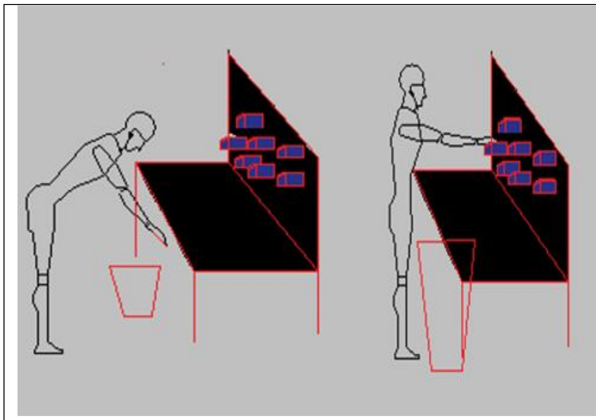
Table 2 presents the model for the development of the workstation redesign.

It is important to frame that the proposed changes in the redesign model do not entail a high cost in its conformation and application, coupled with the fact that the physical effort of carrying it out can be considered very low. In addition to redesign does not influence the productive and operational procedures of the workstation.

In the process of the worker coupling to the new requirements of the workstation, no great complexity was contemplated in the adaptation, this mainly occurs because there is no radical change in the station or in the work method, they are only small distribution changes in the containers that together contribute a substantial improvement to the operability of the workstation.

Table 2. Workstation redesign model.

Model for redesign.	Justification.
	Reducing the height at which the raw material containers are located to a height where the shoulder does not exceed 90° grades in elevation. This reduces the effort made by the arm, decreases the travel distance of the arm, reduces the possibility of generating a musculoskeletal disorder, decreases the operating cycle time, improves the productivity of the workstation and the life quality of the operator.

	Increasing the height of the garbage container, the worker is prevented from tilting his torso to deposit the plastic wrap of the raw material in the current garbage container, this leads to a decrease in the asymmetric contractions of the intervertebral cushions, specifically those corresponding to the functional spinal units L3-L4, L4-L5 and L5-S1. Reducing the possibility of herniated discs, wear of the intervertebral cushions, dorsolumbar problems and involvement of the sciatic nerve. In turn, with this modification of the workstation the operating cycle time is reduced.
A production standard of 70 pieces is requested.	Time required to comply the production standard, once the workstation redesign has been applied: 38.97 minutes.

In compliance with the third phase of the proposed methodology, the following procedure is presented to validate the quantitative results in the redesign of the workstation. In this validation, the same mechanisms and methodological tools were applied as in the diagnosis, in order to compare the different parameters obtained and quantify the improvement.

Table 3 presents a comparison of the quantitative parameters obtained, before and after the ergonomic redesign of the workstation.

Table 3. Comparison of quantitative parameters.

Comparative procedure.	Before the application of biomechanical principles and ergonomic guidelines.	Redesigned workstation.
Work risk, assessed through the Art Tool method.	Score achieved 19. Medium risk (future research required).	Score achieved 5.25, low risk (individual circumstances should be considered).
Operating cycle time obtained with the Modapts method.	38.31 seconds.	33.41 seconds.
Production standard time.	37.41 seconds.	42.90 seconds.
Time required to produce all 70 pieces of the production standard.	44.69 minutes.	38.97 minutes.

5. CONCLUSIONS

The "Bracket Assembly" involves a set of sequentially operational activities that carry with them a high demand for energy, work and concentration from the operator. The main demands of these workstations are concentrated in the inadequate postures in which the task is carried out, short cycle times and contact stress. All this together make the probability that the worker who develops his activities in this type of tasks, develops a musculoskeletal disorder in a short period of time.

The research work contemplated the application of the occupational biomechanics and ergonomic guidelines to redesign the "Bracket Assembly" workstation, for which it is framed with main analysis tools the Art Tool ergonomic evaluation method and the predetermined times method called Modapts, which together allow a quantitative assessment of the ergonomic risk and the operating cycle time of the activity.

The comparative results of the workstations show a reduction in workstation risk according to the Art Tool method from 19 to 5.25. As well as a reduction in operating cycle time of 15.26%. This allows to establish in a quantitative way the importance, transcendence and strength of the ergonomic design applied.

The application of the principles of ergonomics and occupational biomechanics, allow the workstations belonging to the intermittent production lines, which contemplate manual work in their operators, to benefit in two main aspects: the improvement in the life quality of the operators and an increase in the operating performance of the producing entity. Which, as a final consequence strengthens the productive plant of the country, the main guideline of ergonomics.

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EVALUATION OF ERGONOMIC RISKS IN THE USE OF COMPUTERS IN ONLINE CLASSES

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Resumen: Esta investigación tiene como finalidad conocer el nivel de riesgo al que se encuentran expuestas las personas por el uso de las computadoras en un escritorio durante sus clases en línea. Para esto, se aplican los métodos OCRA, RULA y ROSA a una sola estación de trabajo donde un alumno toma clases en modalidad virtual. En base a los resultados obtenidos en la aplicación de estos métodos que se aplican, se harán recomendaciones de mejora, buscando reducir el nivel de riesgo al que se encuentran expuestas las personas que usan una computadora para sus clases en línea, en este caso, el alumno a investigar.

Palabras clave: OCRA, RULA, ROSA, movimientos repetitivos y posturas inadecuadas

Relevancia para la ergonomía: La relevancia de esta investigación apoya a la ergonomía, pues después de analizar y desarrollar los resultados, se concluye en que existe un alto de nivel de riesgos en todo el mundo, ya que, debido a la pandemia del 2020, muchas personas se vieron obligadas a continuar sus trabajos y estudios a través de clases en línea, evitando el contacto social al no tener que ir a las empresas, universidades, escuelas, etc. Muchas de estas personas corren el mismo riesgo, ya que necesitan de estas herramientas como el Internet, el escritorio, la computadora y demás, para poder adaptarse al nuevo cambio. Por lo cual este trabajo de investigación expresa el nivel de riesgo que presentan estas personas y fomenta a la concientización y análisis específico para cada persona que cuente con esta estación de trabajo, con la finalidad de cuidar el bienestar y salud de todos los que hacen trabajo desde su casa y toman clases en línea.

Abstract: The purpose of this research is to know the level of risk to which people are exposed using computers at a desk during their online classes. For this purpose, the OCRA, RULA and ROSA methods are applied to a single workstation where a student takes classes in virtual mode. Based on the results obtained in the application of these methods, recommendations for improvement will be made, seeking to reduce the level of risk to which people who use a computer for online classes are exposed, in this case, the student to be investigated.

Keywords: OCRA, RULA, ROSA repetitive movements, awkward postures

Relevance to ergonomics: The relevance of this research supports ergonomics, because after analyzing and developing the results, it is concluded that there is a high level of risks throughout the world, since, due to the 2020 pandemic, many people were forced to continue their jobs and studies through online classes, avoiding social contact by not having to go to companies, universities, schools, etc. Many of these people run the same risk, since they need these tools such as the Internet, the desktop, the computer and others, to be able to adapt to the new change. Therefore, this research work expresses the level of risk that these people present and encourages awareness and specific analysis for each person who has this workstation, in order to take care of the well-being and health of all those who do work. from home and take classes online.

1. INTRODUCTION

According to the International Ergonomics Association, ergonomics (or human factors) is the scientific discipline that is responsible for the study of the interactions between humans and other elements of a system, and the profession that applies theory, principles, data and methods to the design in order to optimize human well-being and the overall performance of the system. In this research, the ergonomic risks of the use of the computer during online classes will be evaluated, with the current economic and social situation the possibility of working from an office is restricted and part of the population does not have a work area. study at home. Therefore, the document presents the risk factors evaluated by the posture that people can take during online classes, since they can resort to ergonomic risks by maintaining inappropriate positions for several hours every day, and in this case, the investigation will evaluate the risk factors present at present. The main risk factors for sitting for more than 8 hours are:

- **Weight gain.** The body by not having activity gains weight.
- **Postural problems.** Sitting for a long time combined with a sedentary life in your spare time has clear disadvantages for your muscles and your joints. In addition, the bad postures that we place while we work cause the appearance of contractures, herniated discs, protrusions, neck pain, and even headaches.
- **Impairment of heart health.** Your heart and pulse can also be affected. In fact, accustoming the heart to be in a relaxed pulse can influence later when it comes to doing some physical activity.
- **Impaired metabolism.** The body gets used to sitting and resting and it is increasingly difficult for you to go out to do any activity. The body gets used to sitting and resting and it is increasingly difficult for you to go out to do any activity.

There are 3 types of people who regularly have these problems:

- People with sedentary jobs. For example, clerical and administrative positions.
- Housewives and retired people.
- Students

2. OBJECTIVE

The objective of this research is to identify the ergonomic risks of continuous computer use during the school day.

3. LITERATURE REVIEW

3.1. RULA (Rapid Upper Limb Assessment) Method

The RULA method evaluates individual positions and not sets or sequences of positions, therefore, it is necessary to select those positions that will be evaluated from among those adopted by the worker in the position. Those that, a priori, suppose a greater postural load, either because of their duration, or because of their frequency, or because they present a greater deviation with respect to the neutral position, will be selected.

To do this, the first step consists of observing the tasks performed by the worker. Various work cycles will be observed and the postures to be evaluated will be determined. If the cycle is very long or there are no cycles, evaluations can be performed at regular intervals. In this case, the time spent by the worker in each position will also be considered.

This method provides us with general information about the activity of the workstation to be analyzed. Table 1 lists action levels according to the final score obtained.

Table 1. Action levels according to the final score obtained. Source: McAtamney, L. Y Corlett, E. N., (1993)

Score	Level	Action
1 o 2	1	Acceptable risk
3 o 4	2	Changes to task/workstation may be required; it is convenient to deepen the study.
5 o 6	3	Task/ workstation must be redesigned.
7	4	Urgent changes to the task/workstation are required.

3.2 OCRA (Occupational Repetitive Action) Method

Check List OCRA allows assessing the risk associated with repetitive work. The method measures the level of risk as a function of the probability of the appearance of musculoskeletal disorders in a certain time, focusing on the assessment of risk in the upper limbs of the body. The OCRA (Occupational Repetitive Action) method considers in the assessment the risk factors recommended by the IEA (International Ergonomics Association): repetitiveness, inappropriate or static postures, forces, forced movements and the lack of rest or recovery periods, assessing them as length of the worker's activity time. Consider other influencing factors such as vibrations, exposure to cold or work rhythms. For this reason, there is international consensus on using the OCRA method to assess the risk of repetitive work in the upper limbs, and its use is recommended in the ISO 11228-3 and EN 1005-5 standards. Table 2 shows the risk levels and the implications of each section.

Table 2. OCRA risk levels and implications. Source: Diego-Mas, J. A. (2015).

Check List OCRA index	Risk level	Recommended action	Equivalent OCRA index
< 5	Optimum	Not required	< 5
5.1 - 7.5	Acceptable	Not required	1.6 - 2.2
7.6 - 11	Uncertain	Job analysis or improvement is recommended	2.3 - 3.5
11.1 - 14	Unacceptable Mild	Job enhancement, medical supervision, and training recommended	3.6 - 4.5
14.1 - 22.5	Unacceptable Medium	Job enhancement, medical supervision, and training recommended	4.6 - 9
> 22.5	Unnaceptable High	Job enhancement, medical supervision, and training recommended	> 9

3.3 ROSA (Rapid Office Strain Assessment) Method

ROSA, acronym for Rapid Office Strain Assessment, is a checklist whose objective is to assess the level of risks commonly associated with office jobs. The method is applicable to jobs in which the worker remains seated in a chair, in front of a table, and operating a computer with a data display screen. The most common elements of these workstations (chair, work surface, screen, keyboard, mouse and other peripherals) are considered in the evaluation. As a result of its application, an assessment of the measured risk is obtained and an estimate of the need to act on the position to reduce the level of risk. Table 3 shows the risk levels of ROSA method.

Table 3. Risk levels used in the ROSA method. Source: Diego-Mas, J. A. (2015).

Score	Level	Risk	Action
1	0	Inapreciable	Action no necessary.
2-4	1	Mejorable	Some elements of the task or warkstation can be improved.
5	2	High	Action is necessary.
6-8	3	Very High	Action is necessary as soon as possible.
9-10	4	Extreme	Action is urgently needed.

4. METHODOLOGY

The methodology in this research is transversal, not experimental. This section shows the materials necessary to carry out the investigation, as well as the steps of the procedure to follow.

4.1 Materials

The necessary materials to carry out this investigation are the following:

- Computer
- Software Online (Ergonautas)
- Internet
- Videocamera

4.2. Method

4.2.1. Subject

To carry out the research, the work performed by a 22-year-old student, in one workstation, will be evaluated. This student has been studying Industrial Engineering for three years at the Technological Institute of Tijuana. His school day lasts 7 hours, not counting the two-hour classes.

4.2.2. Procedure

The methodology of the present investigation is composed of seven stages. Figure 2 shows the stages of this methodology, being those described below.

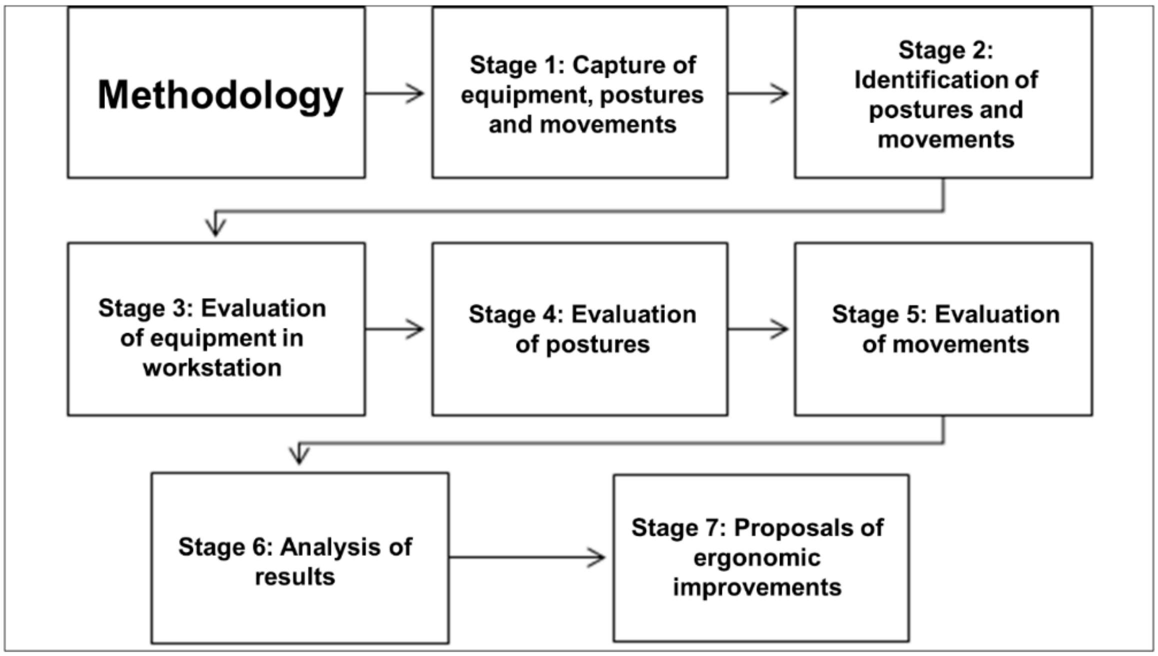

Figure 2. Methodology and its stages.

Stage 1. Capture of equipment, postures, and movements. At this stage, the student will be recorded, and photographs will be taken throughout his school day in order to capture the movements he performs, as well as the postures he adopts sitting at the worktable, where he carries out his activities.

Stage 2. Identification of movements and postures to evaluate. Once the data and information of the first stage have been obtained, an analysis will be made of the movements and postures that the student performs, identifying those that represent a greater risk for the student when doing his activities.

Stage 3. Evaluation of the equipment at the workstation. Corresponding information will be obtained from the seat, the backrest, and the armrest, and the peripheral data corresponding to the screen, the keyboard, and the mouse will also be entered, to carry out the corresponding diagnosis by applying the ROSA method within the online software of Ergonautas.

Stage 4. Posture evaluation. After identifying the most critical postures and movements, they will be evaluated to make known the level or degree of risk they present, helping us to locate these using the RULA method within the Ergonautas online software.

Stage 5. Movement evaluation. The repetitive movements identified in the third stage will be evaluated using the OCRA method available in the Ergonautas online software to know the level of risk that these movements represent for the student. These movements can range from using the computer keyboard, repeating the click of the computer mouse, and even using the notebook to make notes by hand.

Stage 6. Analysis of results. Upon obtaining the results of the evaluations, an analysis will be carried out where we can determine the risk of repetitive movements when doing a task and the postures adopted by performing them, supporting us with the RULA and OCRA methods.

Stage 7. Ergonomic improvement proposal. A proposal for improvements is made in the study area in support of the degree of risk obtained in the analysis of results.

5. RESULTS

This section explains the results obtained for repetitive motion and postural load

5.1 Results of Repetitive movements

The results obtained from the analysis of repetitive movements indicated the presence of fatigue and muscular tension in the elbow area when flexing constantly, as well as in the joints of the hand, caused by a notable variation and without any sequence, between size and weight. of the appliances. Table 4 shows the score obtained by means of the OCRA method.

Table 4. OCRA results for the work area. Source: Own elaboration.

Factor	Reason	Score
Recovery Factor	The recovery period is included in the work cycle, where there are 10 minutes between classes or breaks.	0
Frequency factor	ATD: Arm movements are slow, more than 50 actions / minute when using the keyboard. Only occasional and irregular small breaks are allowed. ATE: The mouse is held for at least 5 consecutive seconds with one or more static actions being performed for 3/3 of the cycle or observation time.	6 4.5
Force factor	Moderate strength most of the time.	8
Posture and movement	PHo: The arm / s are not supported and remain slightly elevated for more than half the time.	1

factor	PCo: The elbow makes sudden movements. PMu: The wrist remains bent in an extreme position or adopts forced postures (high degree of flexion-extension or lateral deviation) at least ⅓ of the time. PMa: You hold the monitor and mouse almost all the time. PMu: There is repetition of identical movements of the shoulder, elbow, wrist or fingers, almost all the time due to the use of the keyboard.	8 2 8
Additional risk factor	Fso: The pace of work is partially determined by the work required while using the computer, with small periods of time in which the pace of work can be slowed or sped up.	1
Duration multiplier.	MD: Networking time 421-480 minutes.	1

The result obtained through the OCRA CheckList shows a value of 15.5, which indicates that the risk is unacceptable medium. Figure 4 shows said result calculated by means of the Ergonautas software.

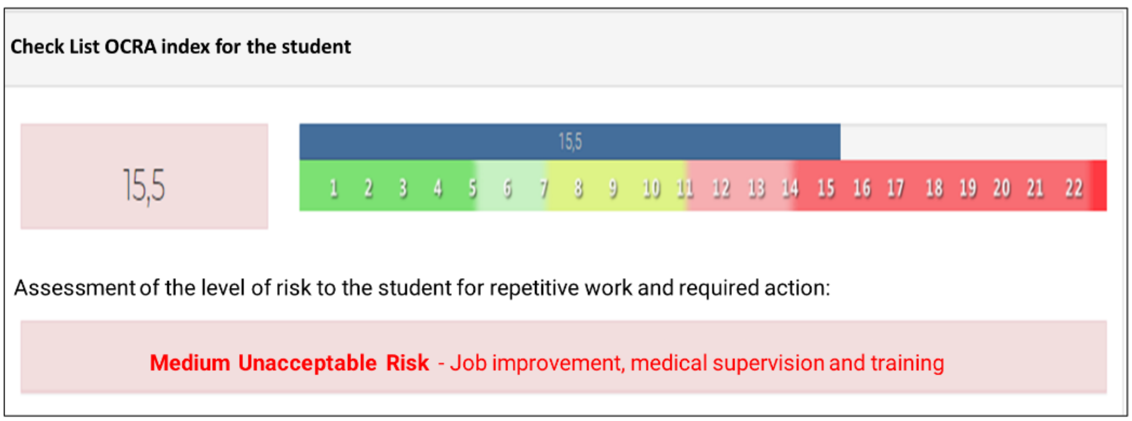

Figure 4. Result of repetitive movement with Check List OCRA. Source: Diego-Mas, J. A. (2015).

5.2 Results of postural load

In relation to the postural load analysis, the worker presents fatigue in the lower extremities and tension in the neck. Table 4 represents the score awarded by the RULA method.

Table 4. Results postural evaluation for a student. Source: Own elaboration

Part to evaluate	Score	Part to evaluate	Score
Group A		Group B	
Arm	2	Flexed neck < 20°	3
Abducted arms	+1	Rotated head	+1
Forearm	1	Trunk flexed between 0° and 20°	2
Forearm that crosses the midline	+1	Rotated head	+1
Neutral wrist	1	Legs	1
Radial deviation3 of the wrist	+1	Load or force: Load between 2 and 10 kg repetitively	+2
Type of activity: Repetitive	+1		

Figure 5 shows the score obtained when applying the RULA method through the Ergonautas software, in which an action level of 4 was obtained, which indicates that changes have to be made immediately in the task or position.

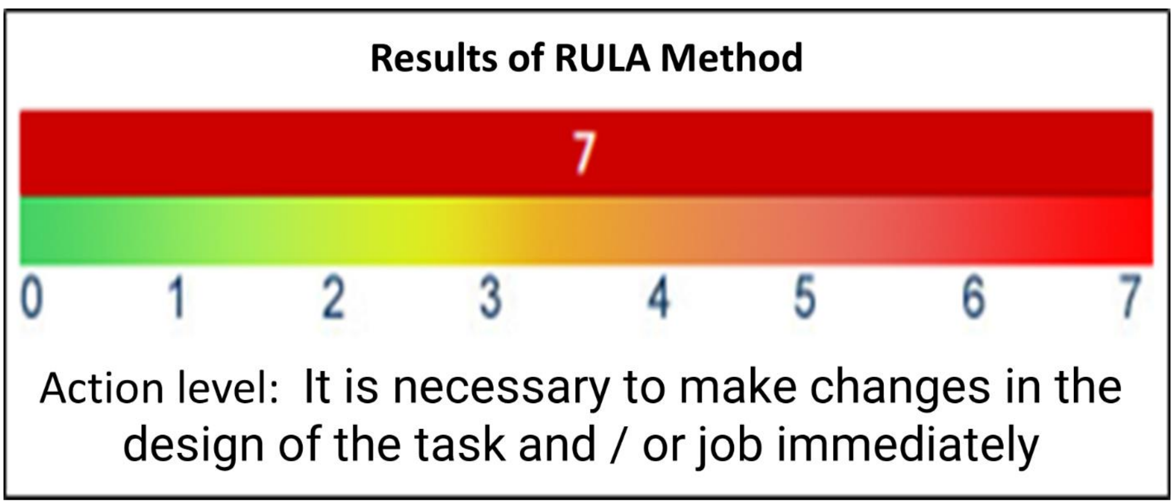

Figure 5. Results for postural evaluation with RULA method. Source: McAtamney and Corlett (1993).

5.3 Results of the equipment in the workstation

The ROSA score obtained is 4 on a scale of 1 to 10. This score corresponds to Risk Level 1, which indicates that, although there is no significant ergonomic risk level, it can be improved, and some aspects of the position could be optimized so that the situation was completely satisfactory. The partial scores of the chair and the peripherals can guide the measures to be adopted to reduce the risk level.

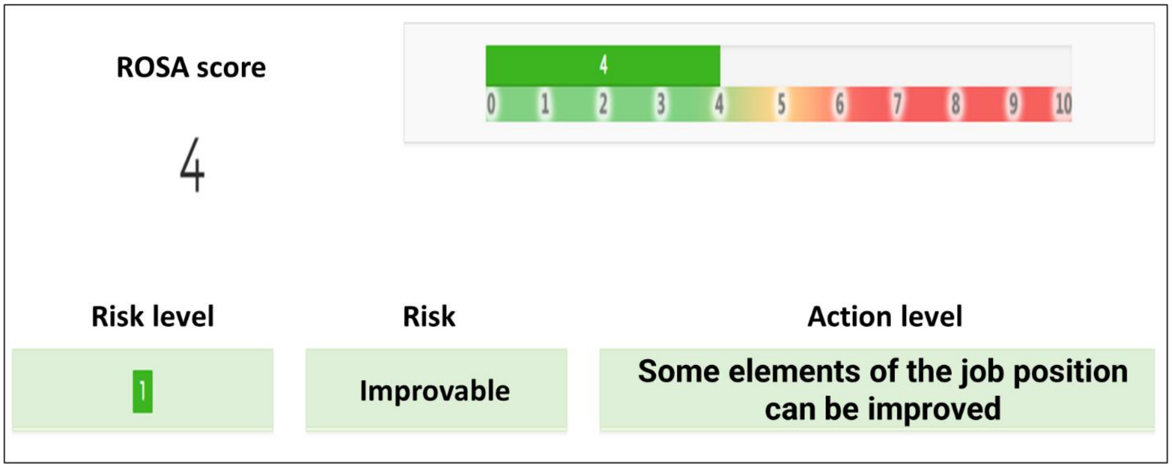

Figure 6. Results of the equipment in the workstation. Source: Diego-Mas, J. A. (2015).

6. CONCLUSIONES Y RECOMENDACIONES

According to the objective of the research mentioned in the second chapter that says: "Identify the ergonomic risks of continuous computer use during the school day." It is concluded that the objective has been achieved by identifying ergonomic risks through the use of the OCRA, ROSA and RULA methods, giving rise to an opportunity to improve the comfort level for students on school days. After analyzing the results obtained, it can be concluded that the station where you work and / or study during the online classes is of a medium-high risk, considering the activities that are carried out, so it is necessary to implement immediate changes. The risks observed were work posture, repetitive work and physiological fatigue due to the long work / study shift, as well as work pressure. Long-term work in this position can cause health problems, so the institute or company in charge must implement ergonomic improvements that improve and facilitate work and eliminate the risk that these activities present to users. Some recommendations are presented according to the results obtained to reduce the level of risk at the workstation:

- La mesa o escritorio de trabajo debe estar lo bastante extensa y espaciosa para que se puedan colocar cómodamente todas las herramientas y materiales necesarios para realizar el trabajo.
- El diseño de la silla de trabajo dependerá del alumno para que pueda mantener, durante su trabajo, una postura recta y relajada, también una posición no forzada el cuello. Así como permitir una buena circulación extremidades inferiores.
- Se recomienda que la ubicación del teclado permita, al alumno, mantener los brazos doblados por el codo, en un ángulo de 90º, con la espalda recta y los hombros en postura relajada mientras trabaja. también debe poder apoyar los brazos encima del escritorio.
- El trabajo con el ratón debe ser con la mano y la muñeca recta, el codo debe mantener un ángulo recto y el brazo debe poder reposar sobre el escritorio.

también tiene que existir un espacio mínimo de 10cm para apoyar brazos y manos.

- Es recomendable la práctica del ejercicio físico, porque permite mantener un ritmo muscular adecuado, que ayude a la prevención de lesiones y asimismo a liberar la tensión acumulada durante la jornada estudiantil.
- The worktable or desk should be large and spacious enough to accommodate all the tools and materials needed to do the job.
- The design of the work chair will depend on the student so that he can maintain, during his work, a straight and relaxed posture, also a non-forced neck position. As well as allowing a good circulation of the lower extremities.
- It is recommended that the placement of the keyboard allows the student to keep the arms bent at the elbow, at a 90º angle, with the back straight and the shoulders in a relaxed posture while working. You should also be able to rest your arms on the desk.
- Work with the mouse must be with the hand and the wrist straight, the elbow must maintain a right angle and the arm must be able to rest on the desk. There must also be a minimum space of 10cm to support arms and hands.
- The practice of physical exercise is recommended because it allows for maintaining an adequate muscular rhythm, which helps to prevent injuries and also to release the tension accumulated during the student day.

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CRITICAL SUCCESS FACTORS FOR THE IMPLEMENTATION OF ERGONOMICS PROGRAMS FROM THE WORKER'S PERSPECTIVE: A SYSTEMATIC LITERATURE REVIEW

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Resumen: La Ergonomía es una ciencia multidisciplinaria que se encarga de adaptar el trabajo al hombre, teniendo en cuenta como aspecto principal las características del individuo que realiza un trabajo para optimizar el bienestar físico y la productividad. Es por ello que las organizaciones buscan su implementación para obtener beneficios en sus trabajadores y para ellas mismas. La finalidad de este estudio es desarrollar una revisión sistemática de literatura para determinar el estado del arte de los factores críticos de éxito en la implementación de programas de Ergonomía, desde la perspectiva del trabajador. Utilizando las bases de datos relacionadas al tema. Para la búsqueda de referencias se utilizaron los operadores booleanos AND y OR, considerando una muestra de 5 artículos de 85 extraídos de las bases de datos PUBMED, SCIENCE DIRECT, WEB OF SCIENCE y SCIELO.

Dentro los criterios de inclusión se han considerado artículos científicos y tesis publicados entre los años 2015 y 2022, escritos en inglés y español que contenían es su título los términos "implementation of Ergonomics", "critical success factors", "workers ", "ergonomics program", "Participatory Ergonomics Program" para las bases de datos en idioma inglés y "Ergonomía Participativa" para las bases de datos en idioma en español, así como la definición y desarrollo de los factores cítricos de éxitos en la implementación de programas de Ergonomía.

En el apartado de los criterios de exclusión, se descartaron artículos no científicos como páginas web. Los resultados encontrados están relacionados con el enfoque utilizado por los autores en los artículos científicos que componen la muestra final de 5 documentos, donde se observa que predomina el enfoque cuantitativo con un 60%. Respecto a las herramientas metodológicas aplicadas, se observa un matiz amplio de técnicas, como las medidas de tendencia central (40%), análisis de contenido (40%) y análisis por mínimos cuadrados parciales (20%). También se puede apreciar coincidencias en los aportes de los autores en relación con los factores críticos de éxito, como el compromiso gerencial (60%), participación de los empleados (80%), análisis de riesgos laborales (60%) y capacitación (60%). Como limitantes de los artículos finales se observa, la ausencia de datos que permitan conocer la etapa de implementación de Ergonomía, donde dichos factores son destacables y así lograr un análisis más profundo. La metodología prisma permite hacer un análisis de la aplicación de herramientas metodológicas en diferentes campos de aplicación de la Ergonomía, para identificar factores críticos de éxito.

Palabras clave: Factores críticos de éxito, Ergonomía, Programas de Ergonomía.

Relevancia para la ergonomía: Esta revisión contribuye a dar a conocer aquellos estudios en la frontera de conocimiento sobre los factores críticos de éxito en la implementación de programas de Ergonomía desde la perspectiva del trabajador. A través de este trabajo se propone a futuras investigaciones considerar la perspectiva del trabajador, no solo los problemas que existen causados por la falta de Ergonomía en las organizaciones.

Abstract: Ergonomics is a multidisciplinary science that oversees the adaptation of work to man, considering as a main aspect the characteristics of the individual performing a job in order to optimize physical well-being and productivity. For this reason, the organizations seek its implementation to obtain benefits for their employees and for themselves. The purpose of this study is to develop a systematic literature review to determine the state of the art of the critical success factors in the implementation of Ergonomics programs, from the worker's perspective, using databases related to the subject. The Boolean operators "AND" and "OR" were used for the reference research, considering a sample of 5 articles out of 85 extracted from the PUBMED, SCIENCE DIRECT, WEB OF SCIENCE and SCIELO databases. Scientific articles and theses published between 2015 and 2022, written in English and Spanish that contained in their title the terms "implementation of Ergonomics", "critical success factors", "workers" and "ergonomics program" were considered within the inclusion criteria, "Participatory Ergonomics Program" for the English language databases and "Ergonomía Participativa" for the Spanish language databases, as well as the definition and development of the key success factors in the implementation of Ergonomics programs.

In the exclusion criteria section, non-scientific articles such as web pages were excluded. The results found are related to the approach used by the authors in the scientific articles that make up the final sample of 5 papers, where it is observed that the quantitative approach predominates with 60%. Regarding the methodological tools applied, a wide range of techniques were used, such as measures of central tendency (40%), content analysis (40%) and partial least squares analysis (20%). There are also coincidences in the authors' contributions in relation to critical success factors, such as management commitment (60%), employee participation (80%), occupational risk analysis (60%) and training (60%). As limitations of the final articles, there is a lack of data that would allow us to know the stage of implementation of Ergonomics, where these factors are important, and thus achieve a more in-depth analysis. The prism methodology allows an analysis of the application of methodological tools in different fields of application of Ergonomics to identify critical success factors.

Keywords: Critical success factors, Ergonomics, Ergonomics programs.

Relevance to Ergonomics: This review contributes to the edge of knowledge of studies on the critical success factors in the implementation of Ergonomics programs. Through this work we propose future research to consider the worker's perspective and not only the problems that exist caused by the lack of Ergonomics in organizations.

1. INTRODUCTION

Ergonomics is defined by the International Ergonomics Association as a science that studies the relationship of human beings with their environment in order to adapt it (International Ergonomics Association, 2021). Subsequently, Ergonomics applied in organizations such as in work lines, machinery, operations and procedures aims to preserve the physical and health integrity of the worker, identifying, eliminating or minimizing exposure to different risks (Tirado, 2016). For this reason, the organizations design and implement Ergonomics programs, engaging all those involved in the change through the preparation, evaluation, and improvement plan of the programs (Rodríguez & Pérez, 2016). For example, the ergonomic intervention program proposed by Capodaglio (2022), consists of the following stages: Integration of an Ergonomics group, general Ergonomics training, questionnaires and surveys, analysis of critical activities, analysis of information, discussion, and intervention. On the other hand, the Ergonomics application methodology proposed by Xie et al., (2015), starts with the formation of the team in charge, data collection activities, development, and implementation of intervention. Finally, Guimarães et al., (2015) points out that assessment and diagnosis, followed by proposal development, prototyping, validation and implementation are the steps to follow for the implementation of Ergonomics programs.

Studies show that the implementation of Ergonomics programs has benefits to organizations due to the improvement in workers' wellbeing, increase in productivity, increase in income, reduction of rejection costs, reduction of musculoskeletal disorders, reduction of injuries, number of claims, days lost from absences and sick leave (Sain & Meena, 2016; Koma et al., 2019; Selamat et al., 2021). However, implementing an effective and sustainable Ergonomics program in the workplace is not a simple task, organizations may feel intimidated and therefore hesitate to intervene or develop a prevention program (Wells, 2009). There are a variety of challenges and barriers during the implementation of an ergonomic intervention, difficulties such as: lack of time, resources, communication, support, commitment, management involvement, training, trust, resistance to change, work environment, difficult to define scope of activities, fear of losing job or loss of authority (Yazdani & Wells, 2018).

This research refers to the state of the art of the critical success factors in the implementation of Ergonomics programs from the worker's perspective. To defend this idea, the research for information was conducted through a systematic literature review.

2. OBJECTIVES

The objective of this research is to develop a systematic literature review using PRISMA statement to determine the state of the art of the critical success factors in the implementation of Ergonomics programs from the worker's perspective, using databases related to the subject.

3. METHODOLOGY

For the systematic review, the PRISMA method was used for the literature review. The systematic review is particularly useful in critical aspects since it provides a synthesis of the state of the art in each area. It allows addressing specific research questions that require the analysis of more than one study, identification of problems in primary research that need to be addressed in future studies, and the generation or evaluation of theories about how or why phenomena of interest occur (Page et al., 2021).

To ensure the quality of the information and avoid bias in the results, these bibliographic databases that provide reliable information were used: PUBMED, SCIENCE DIRECT, WEB OF SCIENCE and SCIELO. In this way, information was obtained from articles published in indexed databases that are contrasted with theoretical evidence. The research was performed using keyword terms in each of the databases mentioned, "implementation of Ergonomics", "critical success factors", "workers ", "ergonomics program", "Participatory Ergonomics Program" for the English language databases and "Ergonomía Participativa" for the Spanish language databases. Boolean operators "AND" were applied to show only results containing the specified search terms. This operator was used to eliminate the articles obtained in the search of each of the selected databases that did not meet the inclusion criteria. The "OR" operator was also used to show results containing at least one of the search terms (Ronconi, 2020). The standards of the PRISMA flowchart for systematic reviews, a tool designed to refine and clarify the publication of systematic reviews, were considered.

As part of the inclusion criteria, scientific articles and theses published in English and Spanish between the years 2015 and 2022 were considered, containing in their title the terms mentioned above, as well as the definition and development of critical success factors, in the implementation of Ergonomics programs. In the exclusion criteria section, non-scientific articles such as web pages were considered (Hernández-Sampieri & Mendoza, 2018).

4. RESULTS

This section details the procedure for obtaining the study sample of 5 scientific articles from various sources and databases with which the research was conducted. The search was performed based on keywords that influenced the result, which is why independent words combined with each other were used so that the nouns would allow an extensive search, as can be seen in Figure 1.

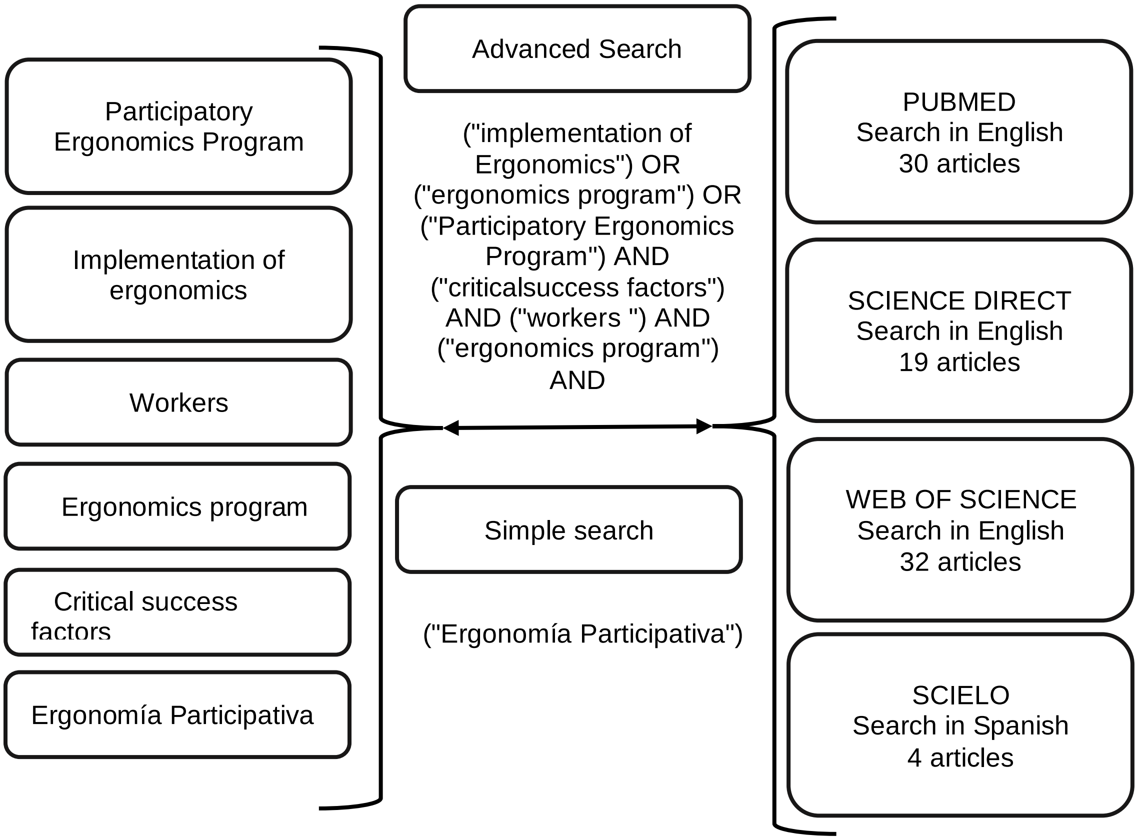

Figure 1: Search strategy.

The advanced search (shown in Figure 2) conducted in the WEB OF SCIENCE database provided the largest number of initial references for the study, with 32 articles representing 37.64% of the initial references for the research. In second place was the PUBMED database, from which 30 articles were obtained, representing 35.29% of the total number of initial references. This was followed by SCINCE DIRECT with 19 articles (22.35%) and SCIELO with 4 articles (4.7%).

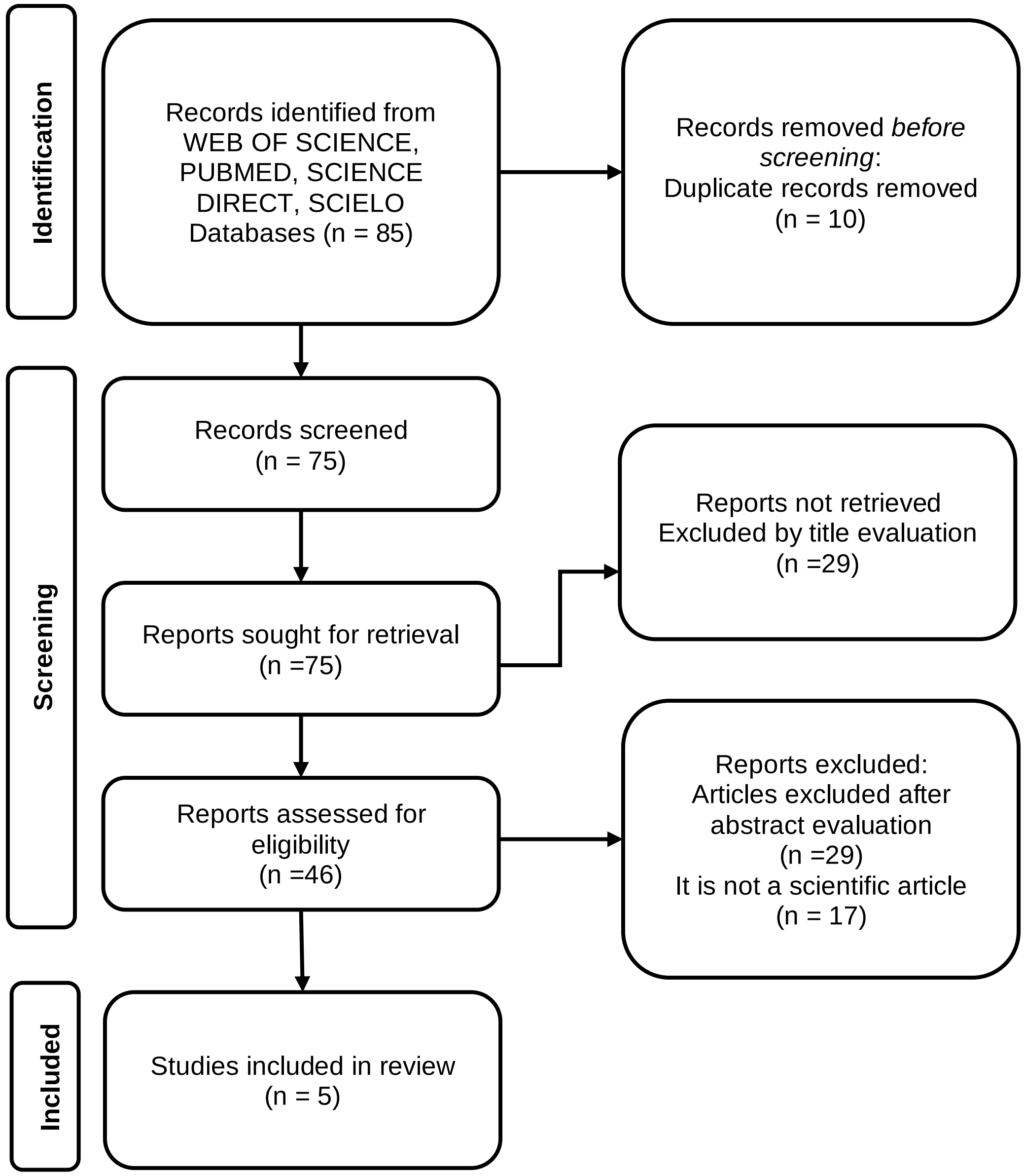

Figure 2: PRISMA flow chart.

After elaborating the PRISMA flow chart, from the advanced search in the four databases consulted, it is observed that a total of 85 scientific articles were obtained and 10 were eliminated because they were duplicated. Then, 29 studies were excluded due to evaluation, leaving a partial total of 46. Finally, 29 articles were discarded after abstract evaluation, as well as the exclusion of 17 documents for not being classified as articles, leaving 5 research studies as a sample for the literature review. Applying those filters, 5 potential articles that met the inclusion criteria were identified, which are described in Table 1.

Table 1. Theoretical input from research.

No	Author	Description		Methodological tools	Contribution
1	(Hoffmeister et al., 2015)	**Approach**	Quantitative	Survey application Means Standard deviations Correlations of variables	The authors conclude that, to ensure success in the implementation of Ergonomics programs, organizations must have employee participation, a climate that supports operational performance as well as employee well-being. This by providing resources and management commitment, occupational risk analysis, training and team knowledge.
		Research type	Field investigation		
		Methodological design	Longitudinal		
		Field	Vehicle manufacturing company.		
2	(Fernandes et al., 2015)	**Approach**	Qualitative	Content analysis	It establishes that the key to the success of Ergonomics programs in organizations is to consider employee complaints and feedback, workload, accidents, staff training, occupational diseases, and risk management models for the anticipation of events. In addition, it is necessary to structure a committee for the discussion of ergonomic solutions.
		Research type	Experimental		
		Methodological design	Pre-experiment		
		Field	Household appliance manufacturing company		
3	(Nørregaard et al., 2016)	**Approach**	Quantitative	Measures of central tendency: Frequencies Median	It demonstrates that factors such as the financial resources applied to ergonomics programs, the implementation time of the programs, as well as the involvement of the workers, are key factors to consider within an Ergonomics program.
		Research type	Experimental		
		Methodological design	Pre-experiment		
		Field	Medical		

4	(Hong et al., 2018)	**Approach**	Quantitative	Survey application Partial Least Squares Analysis Convergent validity (by examining loadings, average variance extracted and composite reliability) Discriminant validity	They state that the implementation of Ergonomics programs requires an adequate safety management system, management commitment, training, worker participation, government regulation, safety culture, consideration of the impact of organizational culture and long-term strategies.
		Research type	Field investigation		
		Methodological design	Cross-sectional		
		Field	Manufacturing		
5	(Burgess-Limerick, 2018)	**Approach**	Qualitative	Content analysis	It emphasizes that successful implementation of an Ergonomics program requires continuous commitment from management at all levels and genuine involvement of workers, internal specialists and others affected by the proposed changes. Also important is training in Ergonomics principles, teamwork, problem solving, the use of tools for efficient risk analysis of manual tasks.
		Research type	Documentary		
		Methodological design	Non-experimental		
		Field	Manufacturing		

Regarding the approach used by the authors in the scientific articles that make up the final study sample, it is observed that the quantitative approach predominates with 60%. Regarding the methodological tools applied, a wide range of techniques were used, such as measures of central tendency (40%), content analysis (40%) and partial least squares analysis (20%). There are also coincidences in the authors' contributions in relation to critical success factors, such as management commitment (60%), employee participation (80%), occupational risk analysis (60%) and training (60%). It is important to emphasize that although the studies are applied in different fields, are based on different scientific approaches and apply different methodological techniques, they coincide in multiple critical success factors.

In addition, Table 2 highlights the critical success factors proposed by the authors of the study sample in the implementation of Ergonomics programs in organizations. However, they did not meet completely the inclusion criteria that were established in the methodology.

Table 2. Critical success factors in the implementation of an Ergonomics program.

No	Author	Critical success factors
1	(Ahmadi et al., 2016)	Involve operational employees. Establish work plan. Analyze risks.
2	(Anizar et al., 2021)	Involve operational employees. The willingness of workers to accept changes
3	(Rost & Alvero, 2018)	Involve operational employees. Establish work plan. Training and coaching.
4	(Yazdani & Wells, 2018)	Involve operational employees. Establish work plan. Training and coaching. Effective communication between employee and management.
5	(Pazella et al., 2007)	Establish a committee. Involve operational employees. Establish work plan.
6	(Virmani & Ravindra, 2021)	Management commitment. Allocate resources. Establish work plan. Training and coaching. Workers' willingness to accept changes. Effective communication between employee and management.
7	(SIRAT, 2017)	Establish a committee. Establish work plan. Training and coaching.
8	(Pinto, 2015)	Management commitment. Establish a committee. Involve operational employees. Training and coaching. Analyze risks. Implement solutions. Effective communication between employee and management.
9	(García et al., 2012)	Management commitment. Establish a committee. Involve operational employees. Establish work plan. Training and coaching. Analyze risks. Implement solutions.
10	(García et al., 2009)	Management commitment. Establish a committee. Involve operational employees. Establish work plan. Analyze risks. Analyze the cost of solutions.

11	(Hasheminejad et al., 2021)	Involve operational employees. Training and coaching. Establish work plan. Analyze risks. Analyze the cost of solutions.
12	(Rostami et al., 2021)	Management commitment. Establish a committee. Involve operational employees. Training and coaching.
13	(Capodaglio, 2022)	Involve operational employees. Establish work plan. Training and coaching. Analyze risks. Implement solutions.
14	(Miguez et al., 2012)	Involve operational employees. Establish work plan. Analyze risks. Implement solutions.
15	(Heidarimoghadam et al., 2022)	Establish a committee. Involve operational employees. Establish work plan. Analyze risks. Implement solutions. Analyze cost of solutions. Conduct feedback sessions.
16	(Nunes, 2015)	Establish work plan. Training and coaching.
17	(Koma et al., 2019)	Establish work plan. Analyze risks. Analyze the cost of solutions.
18	(Tappin et al., 2016)	Training and coaching. Risk analysis.
19	(Ishwarya & Rajkumar, 2021)	Establish a committee. Establish work plan. Analyze risks. Implement solutions. Effective communication between employee and management
20	(Yuan, 2015)	Establish a committee. Establish work plan. Training and coaching. Analyze risks.

The authors concur that the worker involvement factor is essential for the success of Ergonomics programs. However, it is evident the lack of a tool to evaluate the worker's perspective. In addition, these factors are similar to the obligations of the employer and the employee within an operational health and safety management system in organizations as indicated in the Mexican Official Standards (NOM, for its acronym in Spanish). NOMs are "mandatory technical regulations, which have the objective of establishing the particularities that processes or services must meet when these may constitute a risk to the safety of people or harm human health" (Secretaría de Salud, 2015).

5. DISCUSSION

The analysis of the results shows the predominant factors. While financial resources are important, it is not an essential for the successful implementation of Ergonomics programs. On the other hand, it is remarkable the predominance of the factor participation of employees, followed by the management commitment, the analysis of risk factors in the work environment and Ergonomics training.

As limitations of the included studies, the absence of data that would allow to know the stage of ergonomics implementation where these factors are outstanding and thus achieve a deeper analysis of them is observed. The PRISMA methodology allows an analysis of the application of methodological tools in different fields of application of Ergonomics to identify critical success factors.

It is imperative to develop instruments with theoretical and normative guidelines to evaluate the critical success factors to be found in Ergonomics programs, at various stages and application areas. In addition, there is a gap from the worker's perspective.

6. CONCLUSIONS

Through the established criteria, it was possible to identify those studies that have addressed the workers and the state of the art on the critical success factors in the implementation of Ergonomics programs. The results obtained allow us to determine that the management commitment, risk and safety management system, as well as the involvement of workers, are key factors for positive project results.

The intervention model proposed in this systematic literature review is a contribution to the implementation of current Ergonomics programs as it includes new variables. The importance of involving workers is to empower them with authority, responsibility, and ownership of decisions (Vinodkumar & Bhasi, 2010).

For further studies, it would be convenient to analyze this phenomenon from the employee's perspective, since the literature only mentions their participation in Ergonomics program activities, however, it is not evaluated whether the factors identified are appropriate from the employee's point of view.

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A LITERATURE REVIEW OF THE CHARACTERISTICS OF THE ENVIRONMENT FOR THE OLDER PEOPLE WHEN AGING IN PLACE

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Resumen: Ante el desafío de una población que está envejeciendo rápidamente, es necesario generar estrategias que mejoren la calidad de vida de sus ciudadanos. La ergonomía es clave en este desarrollo ya que puede ayudar a comprender desde un enfoque sistémico la relación entre el ser humano y los sistemas alrededor de él. Este trabajo tuvo como objetivo identificar, a través de una revisión de literatura, los aportes en investigación de la ergonomía con relación a las características del entorno para los adultos mayores al envejecer en el lugar. Para realizar la búsqueda se definieron las palabras claves y se eligieron los artículos según el título y el resumen; finalmente se revisaron aquellos artículos que en su resumen respondían al objetivo de la búsqueda. Se revisaron 24 artículos que brindaban información sobre la relación que tienen los adultos mayores con su entorno. Estos se clasificaron en 4 temas de los que posteriormente se van derivando más subtemas. Estos 4 temas principales fueron: envejecimiento saludable, entorno, servicios y envejecer en el lugar. Los resultados de la investigación muestran como desde la gerontología, la salud y el transporte existe un interés por mejorar las condiciones del entorno al entender a los adultos mayores.

Palabras clave: Ergonomía, adultos mayores, envejecer en el lugar, ciudades amigables, revisión literatura.

Relevancia para la ergonomía: Esta revisión de literatura ayuda a tener un panorama más amplio sobre la integración de los adultos mayores con su entorno y al hacer uso de los servicios. Al entender estas interacciones se pueden diseñar mejores sistemas, se puede mejorar la experiencia para los usuarios, su bienestar físico, psicológico y social ajustando los servicios a las características y necesidades de quien lo utiliza. Ayuda también a ampliar los campos de aplicación de la ergonomía generando conocimiento sobre los actuadores del sistema en sus distintas escalas.

Abstract: Faced with the challenge of a rapidly aging population, it is necessary to generate strategies to improve its citizens' quality of life. Ergonomics is vital in this development as it can help to understand the relationship between human beings and the systems around them from a systemic approach. The objective of this work was to identify, through a literature review, the research contributions of ergonomics to the characteristics of the environment for older adults as they age in place. To perform the search, keywords were defined, and articles were chosen according to the title; finally, those articles that responded to the objective of the search were reviewed. Twenty-four papers on older adults' relationship with their environment were reviewed. These were classified into four themes from which further subthemes were subsequently derived. These four main themes were: healthy aging, environment, services, and aging in place. The results of the research show gerontology, health, and transportation research areas are interested in improving the conditions of the environment when understanding older adults.

Keywords: Ergonomics, older adults, aging in place, friendly cities, literature review.

Relevance to Ergonomics: This literature review helps get a broader picture of the integration of older adults with their environment and when using services. By understanding these interactions, better systems can be designed, the user experience can be improved, and their physical, psychological, and social well-being can be enhanced by adjusting services to the characteristics and needs of the user. It also helps to broaden the fields of application of ergonomics by generating knowledge about system actuators at different scales.

1. INTRODUCTION

Over the years, the world population has been growing at an accelerated rate such that it has increased sevenfold in the last 200 years. In this scenario, the number of older adults is expected to double in most countries worldwide (UN, 2021). Faced with the challenge of a rapidly aging population, it is necessary to generate strategies to improve the quality of life of its citizens.

Many countries are implementing programs that can benefit people's perception of older adults (HelpAge, 2014). However, it is essential to understand what elements are required for older adults to have a dignified life and to develop in society. In this way, policies can be generated that improve the quality of life, and thus there is a social and economic benefit (Cano Gutiérrez et al., 2019).

Ergonomics as a scientific discipline and in conjunction with other disciplines plays an important role since it can help understand the relationship between the human being and the systems around him from a systemic approach.

2. OBJECTIVES

This work aimed to identify, through a literature review, the research contributions of ergonomics to the characteristics of the environment for older adults when aging in place.

3. METHODOLOGY

The search was performed in different databases such as Taylor & Francis, Science Direct, Research Gate, and Google Scholar, with the following terms "ergonomics", "older adults", "aging in place" and "friendly cities". Once the keywords were defined, the articles were chosen according to the title and abstract, and finally, those articles that in their abstract responded to the objective of the search were reviewed.
The articles reviewed were published in ergonomics, aging, city, health, and gerontology journals. The oldest article reviewed was published in 1997 and the latest was in 2021.

4. RESULTS

In the literature review, 24 scientific articles were identified that provide information on older adults' relationship with their environment. The selected studies were conducted in several countries and the review allowed the articles to be classified into four themes from which further subthemes were subsequently derived. These four main themes were: healthy aging, environment, services, and aging in place.

The first theme includes articles on healthy aging. In 2007, WHO published a guide for restructuring cities to make them age-friendly. The guide identifies three main areas for action: the physical environment, the social environment, and the social environment and services (WHO, 2007). Menec and Chipperfield (1997) talk about how locus of control is positively related to the perceived health of older adults, enabling them to be active. In their research they use an activity index, a questionnaire to measure locus of control, and a life satisfaction index. They found that health locus is positively related to exercise and exercise is linked to a better perception of health and satisfaction with life, however, it is unlikely to be a determining factor for performing leisure activities, since these activities are performed because they help to improve their mood and make them feel good. Another finding was that neither exercise nor activity level affected health problems, and this is consistent with other studies, suggesting that there are diseases implicit in the aging process. Being active may not eliminate health problems, but it does improve people's mood. On the other hand, Sanchez-Gonzalez (2015) from environmental gerontology analyzes which are the physical-social conditions of the environment, necessary to be able to have healthy aging in Latin American countries. When analyzing the experience of people in their space, two main contexts have an influence: the physical and the social. The first refers to building spaces such as housing and the environment, and the second refers to people and the social networks they develop. When the context is studied, it must be in an environment, whether tangible or intangible, and it must be friendly, adaptable, attractive, usable, safe, clean, walkable, attractive, connected, and accessible, to mention some favorable characteristics for people and especially for older adults. He concludes that the environment plays a fundamental role and influences the connection and bonds generated with people and encourages quantitative research that can provide implementations in the environment, for the benefit of users.

The second theme was the environment. As part of the components of a friendly city, physical space is present in neighborhoods large and small. To meet the needs of a growing group, it is important to know their interests and how they move. Hirsch et al., (2016) assessed whether the places older adults go to are associated with their physical activity. Different instruments were used to help measure and track older adults' travel, which helped to evaluate a geographic area for each participant. It was found that the neighborhoods have a lack of destinations to which older adults have access, so they must move outside their radius of activity, and it is important to understand the capabilities they have due to their age. Despite what was found, no association was detected between destinations and physical activity. Older adults perform most of their trips on foot, however, due to their age, this population presents limitations that can create challenges when moving through the built environment. Menec et al., (2011) highlight, therefore, the importance of studying the environment and in the design strategies that are made since this will influence in facilitating or hindering its use; aspects such as crossing a busy street, the presence of cracked sidewalks, or the access that can be had to a building, are just some aspects to consider. Knight et al., (2018) found that, when talking about the place, public space plays a fundamental role in the development of activities outside the core of the dwelling. When studying public space, they identified that the four main themes that related to it were: the reasons for visiting the place, the accessibility it has, the equipment, and the barriers when using the park. The space should be studied in terms of its use at different times and in different seasons to design according to the interest of the people who use it. Aceves-González et al. (2020), when carrying out a physical audit of the environment in an area of the state of Jalisco, found that due to the characteristics of the users, there may be different perceptions regarding safety and the conditions of the space for transit. They found that older people, as well as people with disabilities, are more susceptible to observing the deficiencies of the environment. In their results, they found that the characteristics of crosswalks, sidewalks, and organizational factors should be improved to provide safety to users. To the extent that this is of quality, it will contribute to the walkability of people.

Redfern et al. (1997) studied how the type of floor influences people's balance. They evaluated different combinations and found that softer floors condition the stability of older people. This finding should be considered when designing public spaces since a fall in older adults can result in serious health problems.

The environment impacts the social sphere as it allows interaction between people and, therefore, their attachment to the place; when they find a motive that allows them to establish relationships, participation in their neighborhood increases (Cano Gutiérrez et al., 2019, Hernández, 2021). Gibney et al., (2020) in their study, applied a survey that included the WHO dimensions to assess friendly environments. They observed that most people who had a long time living at home, tried to keep their core within the area that was familiar to them, so they evaluated their health status positively. Also, those who had greater social connections reported greater well-being than those with fewer ties. The results regarding the environment show that when the neighborhood is not favorable for older adults, there are negative effects on their health. A friendly environment favors social interaction because people feel safer going out. Peralta et al. (2021) conducted a series of experiments to evaluate some of the environmental factors that influence the emotional well-being of older adults and that knowing them will help to promote a better living environment. In their results, they found that lighting and stress are the main factors that influence well-being. Lighting as the presence of light influences brightness, comfort, and perceived well-being.

The third theme was services. In this topic, public transportation and health services are addressed, due to their frequency and importance for the older adult. Lowen et al., (2015) in their research introduce an indicator that measures access to services for older adults and how this can be used for the development of friendly cities. They conclude that the frequency of use only sometimes determines the importance of the service. So, we must understand that there are services that are important such as going to the doctor and there are services that are more used such as shopping and leisure activities. As people get older, they start to increase walking and public transport trips and decrease the use of cars. Then, the supply and quality that exists in public services will be a determining factor for the mobility of older adults, their independence, and therefore their quality of life (Hounsell et al., 2016). Aceves-González et al., (2015) recognize that there are barriers to the transportation system being used by all people, specifically by older adults. The problems encountered (related to drivers, bus design, waiting times, distances, payment methods, etc.) influence the user's experiences with the system and impact the actions users take to move from one place to another. Older adults tend to evaluate the use of the system due to the health problems that could arise when using it. Woodcock (2015) contributes from ergonomics, that when the transportation system design has a user-centered approach, it can improve inclusion, efficiency, and effectiveness. When the service is analyzed from a systemic approach, there are many actors involved. Considering people's needs will make the service more inclusive and accessible. Unfortunately, in many countries, especially in Mexico, policies have not favored the system and there are gaps between people and their use.

On the other hand, health care is one of the essential services in the lives of older adults due to the conditions that may arise as time goes by. There needs to be more research to understand the interaction of people with health systems. It is important to know the actors in the system to understand how this interaction influences the system. The priorities of patients will not always be those presented by the system, so it is necessary to work on linking these two areas to build results for the benefit of all (Landa-Ávila et al., 2021). Tilikainen et al., (2019) when studying the perception that older adults have when accessing health and social assistance services, find that it is of utmost importance that accessibility exists since it acts as a bridge between the limitations and demands of people and indicate that for this to happen, easy access, walkability, proximity, adequate and dignified infrastructure must be considered. Luoma-Halkola & Jolnaki, (2021) mention the importance of having the ability to move within the community to maintain well-being. They conclude that for community living to occur correctly, it is necessary to fully understand the service and a suitable environment that facilitates mobility.

The fourth and final theme was aging in place. As social human beings, we tend to stay in the place that is familiar to us, but many times cities and their policies prevent this from being of quality. Vasunilahorn et al. (2012) identified trends in articles published from 1980 to 2010 that mentioned the concept of aging in place and noted that from 2000 onwards there is a difference in the number of articles published. In the oldest studies, the concept is understood indirectly, and it is in 2001 when it already appears as "aging in place". In analyzing the articles, they identified four predominant themes: the research has a wide range of approaches, the concept is related to the home and to a community structure, it is not a single concept and, finally, technology has increased its relevance when talking about aging in place. However, each country changes in terms of economics and technological advances. Older adults' activities focus on going out, participating, and interacting with others, performing chores, running errands, and being independent. If there is an environment where they can function freely, they are not likely to feel trapped by their limitations. One participant mentions that attending a community center has facilitated social interaction and has been of utmost importance to her well-being (Grove, 2021). Loo et al., (2017) found that older people living in a walkable neighborhood exhibit better physical health. However, the neighborhood must have a good quality sidewalk surface for it to be usable. It should not be forgotten that as people age, many functions decline, and infrastructure must be modified to compensate for these limitations of people.

When the community generates strategies that support aging through its infrastructure, it enables older adults to be active in the community. In the research conducted by Alley et al. (2007), some characteristics that should be present in age-friendly communities were recognized by older adults and service providers. Some of those mentioned were accessible and affordable transportation, long-term care services, the ability to obtain services with reasonable travel, age-appropriate facilities, and exercise, among others. The needs of an older population can benefit in planning for the future needs of its other inhabitants. When analyzing the attitudes and tendencies that people are presenting to stay at home until their last days of life, we realize the need to understand what this implies; Fausset et al. (2009) conducted a study through focus groups with older adults in which they sought to analyze the dynamics of the tasks performed and their relationship with the physical space where the older adult lives. The results obtained were categorized into four main themes: internal maintenance, mobility within the home, repair, and external maintenance. Although this study focuses on the home, it is concluded that it is necessary for the home to have adequate conditions and to provide security to those who live in it. Rogers et al. (1998) investigated the functional limitations of older adults through focus groups. Their results were divided into types of difficulties. It was found that among the difficulties, motor limitations were the most frequent, referring to activities such as bending, moving furniture, walking, and getting into the car; other types of difficulties were visual and auditory limitations, including reading and driving; among cognitive limitations, the most frequent were difficulties in learning something new due to lack of familiarity or not knowing how to do it; and finally, external limitations, such as insecurity, financial status, and difficulty in using a device. To contribute to potential interventions, each of the difficulties was classified according to the areas in which ergonomics can cooperate. The recommendations were divided into training, redesign of tools or environment, a combination of training and redesign, and the category where neither redesign nor training can help. From the recommendations made can be found elements such as trucks with lower steps, easy opening containers, and user-centered apparatus design.

5. CONCLUSIONS

This literature review aimed to identify the contribution of ergonomics to the relationship of older adults with their environment. The research results suggest that gerontology, healthcare, and transportation are interested in improving the conditions of the environment when understanding older adults.
The literature review is a brief look at global policies and strategies. Like some developing countries, Mexico needs to restructure its policies to benefit its citizens so that they can live their old age with dignity.

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PHYSICAL, COGNITIVE AND EMOTIONAL EFFECTS IN OLDER ADULTS DUE TO CONFINEMENT

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Resumen. La pandemia por COVID-19 expuso a todos los grupos demográficos del planeta a cambios y adaptaciones en las actividades de vida diaria, los adultos mayores fueron señalados como un grupo poblacional con alta vulnerabilidad, por lo que su restricción de movilidad en el ámbito urbano fue mayormente observada y prolongada. El objetivo de este trabajo es develar los efectos auto percibidos en bienestar físico, cognitivo y emocional en adultos mayores a causa del confinamiento y la restricción de movilidad durante la pandemia de covid-19, en un estudio cualitativo transversal, con una muestra de casos tipo de 23 adultos mayores de entre 69 y 92 años, con características heterogéneas respecto a su condición de independencia funcional, economía, conexión social, nivel educativo, tipo de vivienda y acompañamiento, que habitan en la zona urbana de la ciudad de Aguascalientes, México. La metodología de estudio consistió en la aplicación de entrevistas a profundidad, sobre los cambios percibidos en su bienestar físico, cognitivo, social y emocional durante los 15 meses posteriores al decreto de la pandemia en marzo del 2020. El resultado evidencia un efecto negativo generalizado destacando el aumento en la fragilidad física, deterioro de la memoria, y alteraciones emocionales de tristeza, miedo, soledad y enojo, dicho efecto es proporcional al nivel de aislamiento. Se concluye que el largo período de confinamiento generó estados emocionales negativos prevalecientes aún después de la reapertura de actividades sociales y pone en discusión la pertinencia del confinamiento para los adultos mayores y la necesidad de desarrollar estrategias de continuidad biográfica en futuros escenarios de pandemia.

Palabras clave: Adultos mayores, confinamiento, efectos físicos, cognitivos y emocionales.

Relevancia para la ergonomía: Es de suma importancia estudiar las características y capacidades de la población de adultos mayores en México, para promover y posibilitar su independencia funcional a través de un contexto accesible y seguro. Reconocer el estado físico, cognitivo y emocional que dejó el confinamiento, como medida principal para prevenir el contagio por la pandemia del covid-19, permitirá desarrollar estrategias para posibilitar su reconexión a la vida cotidiana. El envejecimiento de la población en México y América Latina demanda posibilitar y promover en los adultos mayores el desempeño autónomo, la continuidad biográfica y la participación social.

Abstract: The COVID-19 pandemic exposed all demographic groups on the planet to changes and adaptations in daily life activities, older adults were identified as the most vulnerable population group, so their mobility restriction in the urban environment was more observed and prolonged. The main objective of this work is to reveal the self-perceived effects on physical, cognitive and emotional well-being of older adults due to confinement and mobility restriction during the covid-19 pandemic, in a cross-sectional qualitative study, with a sample of typical cases of 23 older adults between 69 and 92 years old, with heterogeneous characteristics regarding their condition of functional independence, economy, social connection, educational level, type of housing and support, living in the urban area of the city of Aguascalientes, Mexico. The study methodology consisted of the application of unstructured interviews, about the changes perceived in their physical, cognitive, social and emotional well-being during the 15 months after the decree of the pandemic in March 2020. The result shows a generalized negative effect highlighting the increase in physical fragility, memory deterioration, and emotional alterations of sadness, fear, loneliness and anger, this effect is directly proportional to the insolation level. The long period of confinement generated negative emotional states that prevailed even after the reopening of social activities and calls into question the relevance of confinement for older adults and the need to develop biographical continuity strategies during a pandemic situation.

Keywords: Older adults, confinement, physical, cognitive and emotional effects.

Relevance to Ergonomics: It is extremely important to study the characteristics and capabilities of the elderly population in México, in order to promote and enable their functional independence through an accessible and safe context. Recognizing the physical, cognitive and emotional state left by social confinement, as the main measure to prevent contagion by the covid-19 pandemic, will allow the development of strategies to enable their reconnection to daily life. The aging of the population in Mexico and Latin America demands enabling and promoting autonomous performance, biographical continuity and social participation in older adults.

1. INTRODUCTION

In March 2020, the World Health Organization (WHO) declared COVID-19 a pandemic (Organización mundial de la Salud, 2021), and given the first cases of contagion and death in the country, the Mexican government through the Official

Gazette of the Federation with DOF registration: 03/27/20202 established extraordinary actions, with the objective of containing the transmission of the virus as a priority, the prevention measures decreed from that moment considered in their most critical moments the total confinement and the restriction of urban mobility, of emphatically, for the so-called high-risk group, made up of people over 60 years of age and people with chronic conditions. By December 2020, the Inter-American Commission on Human Rights (IACHR) expressed concern about the high rates of infection, hospital admission and mortality of older adults in the Latin American and Caribbean area, which urged the states to continue with the confinement measures for this population group (Comisión Económica para América Latina y el Caribe, 2020). In the case of México, it was 9 months and 6 more would be missing to reopen spaces such as Geriatric Centers, day stays, senior citizens' clubs, among others.

1.1 Older Adults in México

In quantitative data, the population of 60 years and over in Mexico is 15.1 million and represents 12% of the total population, according to data from the census of the National Institute of Geography and Information Statistics (INEGI), carried out in 2020, according to the same study, 80% of older adults in Mexico live in urban areas, 1.7 million live alone, 41% have their own income; 25% require support in activities of daily or instrumental living and 20% are not affiliated with any health service institution (Instituto Nacional de Estadística Geografía e Informática, 2021)). On the other hand, the National Survey of Occupation and Employment (ENOE), reported during the first quarter of 2021 the rate of economic activity in older adults in Mexico was 29%, in which 47% work on their own and the labor rate of men is three times higher than that of women (Instituto Nacional de Estadística Geografía e Informática, 2022).

1.2 Early studies on the effects of confinement

Towards the end of 2020, the first studies on the effects of confinement on older adults emerged, pronounced an increase in the level of irritability, initial symptoms of depression and an alteration in stress levels among Cuban elderly (Alcivar G. & Revelo V., 2020). Another study with a population of older adults in Chile, stated that the effects of covid-19 should be measured in terms of impact on social, behavioral and cognitive deterioration in the future (Herrera M. et al., 2021).

Llovet et al. (2021) determined the need to study the dismantling of the social networks of the elderly in Argentina, caused by social confinement measures.

Due to confinement, the first studies carried out with older adults were implemented through interviews with care and support personnel or through online questionnaires, even when the information was limited by the context itself, the psychological impact of confinement was estimated.

Some findings regarding the psychological harm caused by confinement point to the perception of loss of freedom, uncertainty, boredom and separation from loved ones as the origin of negative emotional states (Brooks et al., 2020).

A study carried out in Mexico at the end of 2021, with a wide age range population, found that the most recurrent emotional effect of the pandemic was anxiety, and that women were the most sensitive and vulnerable population to this condition. (Aspera Campos et al., 2021).

One circumstance that aggravated the social isolation of older adults in Mexico during the covid-19 pandemic was the lack of digital technology skills, due to the recent incorporation of communication and information technologies accessible to the urban population, older adults had a late entry to social networks which hindered their digital connectivity unlike other population sectors, who used smart devices to continue their instrumental and advanced activities of daily life (Ramos Bonilla & Zegarra Chiappori, 2021).

2. OBJECTIVES

To reveal the self-perceived effects on physical, cognitive and emotional well-being in older adults due to confinement imposed by the covid-19 pandemic and its implications on functional performance.

3. METHODOLOGY

A non-probabilistic cross-sectional case study was carried out, approached through in-depth interviews (Robles, 2011) a technique that allowed to analyze the effects of voluntary social isolation from the perception of older adults as well as the consequences of these changes in their daily execution of instrumental and advanced tasks in the social context.

3.1 Study Population Sample

The study was conducted with 23 older adults enrolled prior to the pandemic in the day care center: La Casa del Abuelo, an institution attached to the Department of Attention to the Elderly of the Directorate of Family Development and Attention to the Elderly of the Government of the State of Aguascalientes.

The selection criteria included all socio-demographic variables of the population group, including age, gender, marital status, number of children, living arrangements and income. The socio-demographic data corresponding to the 23 older adults interviewed are summarized in Table 1.

Table 1.
Sociodemographic data of the sample, composed of 23 older adults registered in the day stay, La Casa del Abuelo, in the city of Aguascalientes, Mexico.

SOCIO-DEMOGRAPHIC VARIABLE		CATEGORY 1	CATEGORY 2	CATEGORY 3	CATEGORY 4
AGE	Parameter	69 to 75 years	76 to 80 years	81 to 85 years	86 to 92 years
	Iincidence	4	5	9	5
NUMBER OF SONS	Parameter	0 or 1 children	2 to 3 children	4 to 5 children	6 or more children
	Iincidence	3	6	8	6
HOUSING CONDITION	Parameter	Alone in their own house	Own house with a son/daughter	House of a son/daughter	Other older adults
	Iincidence	7	5	5	6
GENDER	Parameter	Women	Men		
	Iincidence	15	8		
MONTHLY INCOME	Parameter	No income	Income up to $3,000	Income up to $6,500	Income up to $10,00
	Iincidence	3	11	3	6

Own elaboration.

3.2 The instrument, in-depth interviews

For the in-depth interviews, a script with three sections was structured, the first one referred to sociodemographic information, the answers were recorded in personal identifiers and emptied in concentrator tables in excell by categories and indicators; the second section referring to well-being was categorized in indicators of: physical well-being, cognitive well-being and emotional well-being. To validate the categories of the indicators, health and day care personnel, including geriatricians, psychologists, physical therapists and nutritionists, were interviewed, the bibliographic data was contrasted with the prevalent conditions recorded in the population sample, and the indicators were categorized as follows; physical well-being: cardiovascular events, diabetes, hypertension, musculoskeletal impairment, gastro-intestinal problems and respiratory problems. Cognitive indicator: senile dementia, Parkinson's, Alzheimer's and memory loss and emotional well-being indicator: sadness, loneliness, fear, anger, anxiety, depression, joy, tranquility and gratitude. For the third section, adults were invited to share life histories, before and during the pandemic, changes in their affective social relationships, use of social networks, including narratives of lived experiences, reflections and opinions.

In the analysis of results, the first section was categorized and coded by the described socio-demographic variables, while for the analysis of the physical and cognitive well-being variable, an interval scale was used regarding self-perceived severity of pre-existing conditions with the criteria of equal, more or less in relation to the periods before confinement and during confinement. For the analysis of emotional well-being, the following procedure was followed: first, the interviewees were asked to identify the 4 most prevalent emotions during the period of confinement, and then a Likert scale was used to measure the frequency with the indicators: almost always, frequently, occasionally and almost never. The third section was analyzed by means of thematic content matrices (Robles, 2011), referring to the state of their social and support networks during the pandemic, life stories and reflections regarding the confinement.

The in-depth interviews were face-to-face and individual, carried out by the researcher herself, after obtaining informed consent (Figure 1) and for each individual interview, 2 to 3 sessions of 2.5 hours each were required depending on the saturation point, the study was carried out during the period from June 14 to December 13, 2021.

Figure 1. Informative session and consent registration. Own elaboration.

4. RESULTS

The results regarding physical well-being were synthesized in Table 2, which shows the main recurrences and aggravation during the 15 months of social isolation.

Table 2.
Frequency of illnesses prior to the COVID-19 pandemic and post-confinement alterations.

Main Sufferings	Pre-pandemic recurrence	Has the condition worsened during the lockdown?		Self-perceived alterations or aggravations during confinement
Sequelae of cardiovascular events	9	Yes	4	It increased the damage of body paralysis, memory loss and muscle strength.
		No	5	
Diabetes	7	Yes	3	Weight gain, abandoned treatment, presented skin problems and decreased visual capacity.
		No	4	
Hypertension	12	Yes	5	Tachycardia, insomnia, memory loss, weight gain.
		No	7	
Sequelae of blows and falls (fractures, sprains, etc.)	2	Yes	2	Lack of physiotherapy after the fall, joint pain, loss of mobility.
		No	0	
Musculoskeletal (articulatory) problems	3	Yes	3	Prosthesis operations were suspended, eventual falls and loss of mobility were presented.
		No	0	
Gastrointestinal problems	3	Yes	2	Gastritis, colitis, diarrhea, lack of appetite, bloating stomach.
		No	1	
Breathing problems	2	Yes	2	Asthmatic complication, low levels of oxygenation.
		No	0	

Source: Own elaboration.

The 23 older adults reported a decrease in their physical capacity during confinement: reduced mobility, decreased stability when standing, weakness or frailty and only 12 of 23 reported perceiving a condition of deterioration in their chronic condition, 14 of them gained weight during confinement.

Regarding the results of the cognitive effects presented during social isolation, 20 of the 23 interviewees reported having presented adaptive disorders, whose main symptoms were manifested in insomnia, memory loss, difficulty concentrating and solving problems of daily life and decrease in communicative skills or language. In relation to the self-perceived emotional effects, similarities were found with the results of studies of the general population (not only of older adults) in which depression and anxiety were the conditions of greater recurrence. In countries such as Italy, an incidence of 32.4% was reported, China of 27.1% and Spain of 21.6%, while for the Mexican population the effect of depression and anxiety in the general population was calculated at 27.5% (Aspera Campos et al., 2021).

The results of the emotional evaluation are shown in Figure 2, in which each older adult identified the 4 self-perceived emotions with the highest incidence during the period of confinement; the color category indicates the frequency criterion, as can be seen, the most reiterated emotions of self-perception fear, sadness and loneliness.

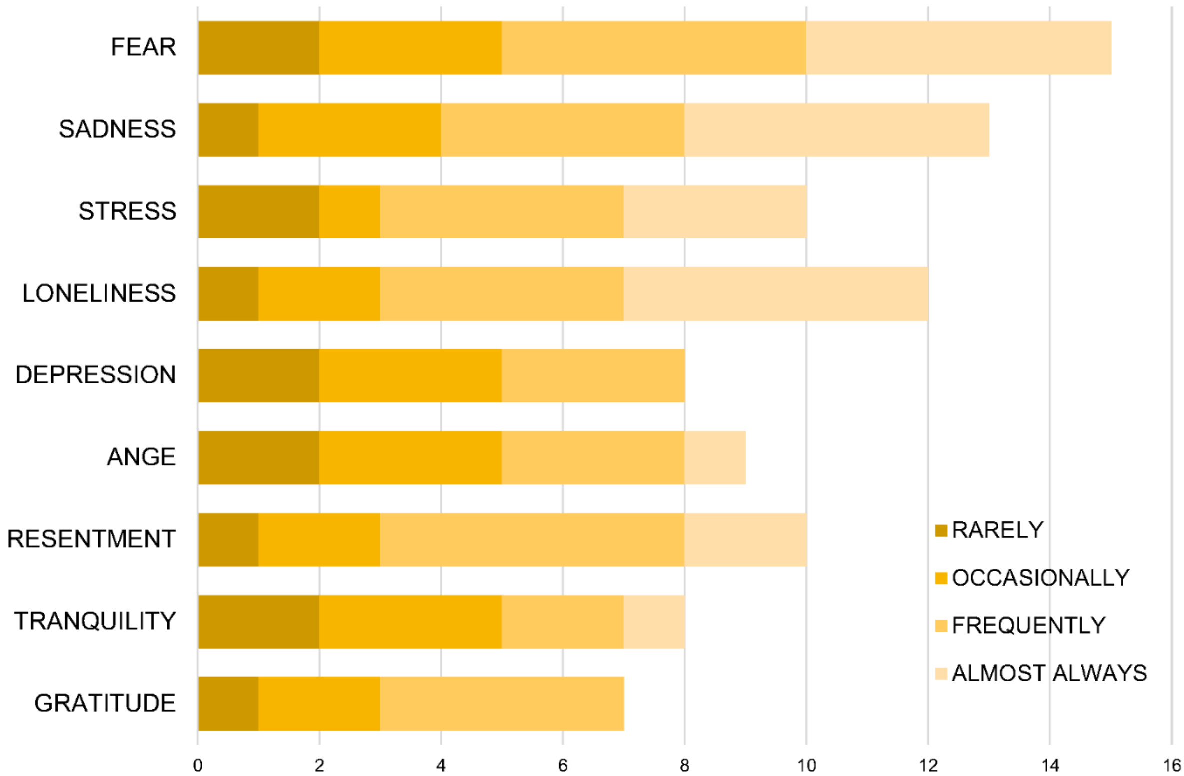

Figure 2. Emotional states manifested by older adults during confinement, in Aguascalientes, Mexico. Source: Own elaboration.

Regarding the main changes in their functional performance, partial or total suspension of instrumental and advanced life activities was found, such as:

- The supply of food and consumables.
- Medical visits for health care.
- Cult activities.
- Socialization with family, friends and neighbors. Among others.

These activities, in addition to enabling social support networks, allowed the development of physical and cognitive activities, in exchange for this, older adults increased the time they spent watching television and sleeping during the day.

Regarding digital connectivity, 16 of the 23 older adults interviewed have a smartphone but mostly only use it to make or receive calls or messages from their children, spouse, and only five of them make use of social networks, five report the use of WhatsApp with personal contacts and groups, four of them have a Facebook profile and follow their family and few friends, only two make use of YouTube, especially the reproduction of tutorials for cooking, knitting or watching mass. None have a Twitter or Instagram account.

5. CONCLUSIONS

Although significant alterations to the physical and cognitive state were identified, such as increased physical fragility, memory loss and weight gain, the greatest self-perceived negative effect of confinement was the emotional state, for which three possible causes were identified: The lack of effective and affective social contact, the change in daily life activities, same that gave meaning to their life and made possible their functional independence and to a lesser extent, the fear of contagion, especially at the beginning of the pandemic and of which it is recognized was partly induced by the news media.

It was identified that the group with the greatest impact on integral wellbeing was the 69 to 75 years old since their functional independence was limited by the social isolation policies, as well as by the healthy distance measures implemented.

Another important conclusion regarding emotional indicators is that men adapted better to confinement than women, as evidenced by a lower rate of emotions and feelings of sadness, loneliness, fear and anger.

Another finding was the degree of digital disablement; unlike other population groups such as children, adolescents, young people and adults of school and working age, who saw in digital media the possibility of continuing their daily instrumental activities and staying socially connected, for older adults it was a barrier that limited their performance in the urban environment, in this regard it is recognized that the current generation of older adults has been identified as late digital and the pandemic condition highlighted the need to enable them in the management of smart devices.

The long period of social isolation, generated a prevailing stay of semi-confinement after the social reopening, which prevails and could be prolonged indefinitely. It is therefore necessary to evaluate the relevance of total confinement as the main pandemic containment measure for the elderly population. It is necessary to learn from the experience and to propose strategies of accompaniment and attention to the biographical continuity of older adults.

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FOUNDRY WORKSHOP ERGONOMIC EVALUATION

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Resumen: Se consideran factores de riesgo ergonómicos aquellos que implican esfuerzo físico, movimientos repetitivos o posturas forzadas en la actividad realizada con la consiguiente fatiga, accidentes y enfermedades profesionales, derivadas del diseño de las instalaciones, maquinaria, equipo, mobiliario o herramientas de trabajo.

Así como también existen riesgos debido al manejo de objetos a temperaturas muy altas, por lo que se pueden asumir posturas forzadas y movimientos repetitivos, junto con estar expuesto a quemaduras por proyección de partículas y reacción por choque térmico debido al contacto entre un metal líquido con arena verde incluso con una humedad mayor a la indicada; estas situaciones pueden ser controladas a través de un proceso de prevención y control de riesgos, análisis ergonómico y seguridad y salud laboral.

El presente trabajo de investigación se realizó primero realizando un análisis ergonómico basado en la NOM-036-1-STPS-2018, y debido a los resultados se tomó la decisión de diseñar un prototipo que ayude a mejorar el proceso de agarre y maniobra del crisol con aluminio fundido, así como la mejora y seguridad en la etapa de fundición, el cual se utiliza para la docencia de estudiantes en los Programas Educativos de Ingeniería Industrial y Mecatrónica del TECNM, campus Cd. Cuauhtémoc.

Palabras clave: NOM-036-1-STPS-2018, Análisis ergonómico del lugar de trabajo, Taller de fundición, Seguridad industrial.

Relevancia para la ergonomía: Debido al análisis y ejecución de la Norma Oficial Mexicana (NOM-036-1-STPS-2018) Factores de riesgo ergonómico en el Trabajo-Identificación, análisis, prevención y control Parte 1: Manejo manual de cargas. en este proyecto de mejoramiento, se logró reducir el nivel de riesgo en la realización de las prácticas realizadas por los estudiantes guiados por sus profesores, y otros usuarios del Taller de Fundición de los Programas Educativos TecNM Campus Cd. Cuauhtémoc

El análisis nos muestra cómo el conocimiento de la Ergonomía aplicada al lugar de trabajo puede marcar una gran diferencia para la organización a corto y largo plazo, afectando al entorno laboral y a la salud y seguridad del trabajador.

Se considera que es de gran importancia entender que este tipo de estudio se puede aplicar a cualquier empresa, ya sea pequeña, mediana, o grande, ya que utilizar esta en cualquier actividad que se realice mejorará cada uno de los aspectos que la componen.

Abstract
Ergonomic risk factors are considered those that involve physical exertion, repetitive movements, or forced postures in the activity carried out with the consequent fatigue, accidents, and occupational diseases, derived from the design of the facilities, machinery, equipment, furniture, or work tools.

As well as there are also risks due to the handling of objects at very high temperatures, so forced postures and repetitive movements can be assumed, along with being exposed to burns due to particle projection and reaction by thermal shock owing to the contact between a liquid metal with green sand even with a humidity greater than indicated; these situations can be controlled through a process of risk prevention and control, ergonomic analysis and occupational health and safety.

The present research work was carried out first doing an ergonomic analysis based on the NOM-036-1-STPS-2018, and due to the results the decision was made to design a prototype that helps to improve the process of grip and maneuvering of the crucible with molten aluminum, as well as the improvement and safety in the casting stage, which is used for the teaching of students in the Educational Programs of Industrial Engineering and Mechatronics of the TECNM, campus Cd. Cuauhtémoc.

Keywords. NOM-036-1-STPS-2018, Ergonomic workplace analysis, Foundry Workshop, Industrial Safety.

Relevance to Ergonomics Due to the analysis and execution of the Official Mexican Standard (NOM-036-1-STPS-2018): Ergonomic risk factors at Work-Identification, analysis, prevention, and control Part 1: Manual handling of loads.in this improvement project, it was possible to reduce the risk level in the realization of the practices done by the students guided by their professors, and other users of the Foundry Workshop of the TecNM Campus Cd. Cuauhtémoc Educational Programs.

1. INTRODUCTION

One of the goals of ergonomics is to design or modify people's work activities so that they can develop them within their capabilities and limitations. One result of this poor harmonization is musculoskeletal disorders (MSDs). Since work is essential to our society and the nature of work is largely predetermined, it seems that little can be done to change this situation. However, understanding the causal mechanism of occupational accidents and diseases will put us in a better position to design effective control and prevention strategies (Grozdanovic, 2002).

Ergonomic risk factors are defined as factors that involve physical exertion, repetitive movements, or forced postures in the activity carried out with the consequent fatigue, accidents, and occupational diseases, derived from the design of the facilities, machinery, equipment, furniture, or work tools (OMS, 2017)

There can also be risks due to the handling of objects at very high temperatures, in which forced postures and repetitive movements can be assumed. Also, there is a risk of potential burns due to particle projection and thermal shock, which may occur due to the liquid metal having contact with green sand of a humidity greater than indicated; these situations can be controlled through a process of risk prevention and control, ergonomic analysis and occupational health and safety.

The present research work was carried out to design a prototype that helps to improve the process of grip and maneuvering of the crucible with molten aluminum, as well as improvement of safety in the casting stage, which is used for the teaching of students in the Educational Programs of Industrial Engineering and Mechatronics of the TECNM, campus Cd. Cuauhtémoc.

In the foundry workshop, academic practices related to handling and material properties are carried out, as well as different manufacturing processes and casting methods, to produce parts that are useful in the development of other Study Plan subjects or projects.

Ergonomic risk factors have been identified when manually manipulating the model brand crucible with aluminum at 650°C, to empty/pour it into the green sand mold, in the engineering workshop casting area; hence, the decision to design a prototype to carry the task was made. The first task was the evaluation of the foundry workshop spaces, we then began the elaboration of the design and analysis of essential materials for its manufacture, considering the instruments of measurement and students' ergonomic analysis who carry out practices in this laboratory, seeking to offer them a safe and comfortable environment.

2. OBJECTIVE

Design a prototype that meets the ergonomic and safety conditions during the process of fastening, lifting, transporting, and casting the crucible with cast aluminum, in the Foundry Workshop, where academic practices of the TECNM, Cuauhtémoc Campus, Industrial Engineering, and Mechatronics Educational Programs are carried out.

3. DELIMITATION

With the realization of this project, the current conditions are observed, analyzed and evaluated, carrying out improvements in the Foundry Workshop of the Engineering Laboratory II of the TECNM, Cuauhtémoc Campus.

4. METHODOLOGY

This methodology consists of the following steps to determine the level of risk of the practices:

a) The work process is observed during the practice carried out by the student, detecting the risks and inadequate conditions in the handling of the crucible.
b) A preliminary analysis of the activities is carried out to determine the ergonomic tools to be used. The procedure that is performed to empty the molten metal is described below:
   - The student extracts the crucible with the molten aluminum, with the help of metal tongs to position it in the metal structure (Figure 1)

Figure 1. Initial task

   - The metal structure is moved with the crucible, held at the ends by two students, 1.5 meters away from the oven to the mold (Figure 2).

Figure 2. Moving metal structure.

- The casting of the molten metal is carried out to the green sand mold, observing the risk of accident in this activity, because the students have to maintain balance in their arms, coordinating to carry out the emptying (Figure 3).

Figure 3. Pouring molten metal in the mold.

- The empty crucible is returned to the smelting furnace, concluding the emptying procedure (Figure 4)

Figure 4. Returning the empty crucible.

c) A report is prepared with all the findings that include recommendations based on ergonomic guidelines to reduce the risk of accidents in the foundry workshop.

The following schedule of activities (Table 1) explains the activities to be carried out during the methodology of this project:

Table 1. Scheduling

ACTIVITIES	WEEKS							
	1	2	3	4	5	6	7	8
1. DRAW THE PARTS OF THE STRUCTURE								
2. DESIGN THE ERGONOMIC STRUCTURE								
3. ANALYZE THE POSSIBLE MATERIALS TO BE USED								
4. WEIGHTING OF PHYSICAL PROPERTIES (WEIGHT AND FINAL DIMENSIONS)								
5. ASSEMBLY OF THE PROTOTYPE								
6. PERFORM PHYSICAL TESTS								
7. RESULTS								

5. RESULTS

Based on the methodology applied, favorable results were obtained, minimizing the level of risk existing in the handling of the crucible with molten aluminum by the users.

As mentioned before the NOM-036-1-STPS-2018 was taken into account, to know the level of work ergonomic risk the students are exposed to when performing the practice; Table 2 considers the maximum mass in kilograms, depending on age and gender, and it is established that for men it is 25 kg and for women, it is 20 kg with an age range of 18 to 45 years, of which the weight of the crucible, molten aluminum and tongs have a total weight of 15 kg, so it is concluded that it is within the guidelines that Standard NOM-036-1-STPS-2018 establishes.

Table 2. Maximum weight established by the NOM-036-1-STPS-2018

Maximum Mass **kg**	**Gender**	**Age (In years)**
7	Female	Less than 18
	Male	
15	Female	More than 45*
20	Female	Between 18 and 45
	Male	More than 45*
25	Male	Between 18 and 45

The ergonomic risk estimation by the manual lifting and transport of loads to evaluate the conditions in which this activity referred to in Standard 036 must be carried out in accordance to before beginning to apply the method, you should consider the following:

a) Use as much time as necessary to observe the activity. Ensure that what is observed is representative of the normal working procedure.
b) Involve students, professors, or workshop managers in the workplace and tasks during the evaluation process.
c) Identify the type of activity, whether it is lifting/lowering by students, Equipment lifting/lowering, or transporting loads. If the process involves a combination of these activities, consider all.
d) Analyze the Appendixes included in NOM-036-1-STPS-2018 before estimating the level of risk.
e) Follow the assessment guide to determine the level of risk for each identified risk factor.
f) Classify the risk level according to table 3.

Table 3. Risk Level.

Low - Acceptable: No corrective actions are required. The risk is zero or although it is low, it is considered acceptable.
Medium - Possible: Short-term corrective actions are required. Although there is no high-risk situation, activities should be examined in greater detail.
High - Significant: Corrective action is required soon. A significant proportion of workers may be exposed to being at risk for an occupational musculoskeletal disorder.
Very high or unacceptable: Corrective actions are required immediately. Such operations can pose a serious risk of injury, and should be thoroughly examined, and improved.

To estimate the risk level, the factors color and value obtained for each activity type should be recorded, results from the foundry workshop are shown in table 4.

Table 4. Risk Level Table.

Risk factors	Lift		Transport		Equipment	
	Color	Value	Color	Value	Color	Value
Weight and ascent of the load/transport frequency		0		0		0
The horizontal distance between the hands from the back lower part.		3		3		6
Vertical lift region.		0		0		0
Torso torsion and lateral flexion; Torso Asymmetrical load (transport)		1		0		0

Postural restrictions (uncomfortable, forced, or restricted postures)		0		0		0
Hand-load coupling (clamping elements)		1		1		1
Work surface		1		1		1
Other environmental factors		2		2		2
Transport distance		0		0		0
Obstacles on the route (only in transport)		0		0		0
Communication, coordination, and control (only manual handling of equipment loads)		0		0		0
Punctuation	8		7		10	
Risk Level	**MEDIUM**		**MEDIUM**		**MEDIUM**	

Determine the level of risk according to the guidelines shown in Table 5.

Table 5. Risk Level determination.

RISK LEVEL	**PRIORITY**	**TOTAL** SCORE
Low - Acceptable	No corrective action required	0 to 4
Medium - Possible	Corrective actions in a short term are required	5 to 12
High - Significant	Corrective actions are required soon	13 to 20
Very High - Unacceptable	Corrective actions are required immediately	21 to 32

Define the actions, according to the level of risk obtained, and the guidelines in Table 6.

Table 6. Actions corresponding to each risk level.

RISK LEVEL	**ACTIONS**
Low - Acceptable	Only the most vulnerable groups, such as pregnant women or underage workers, are required.
Medium - Possible	Tasks should be examined in greater detail, through the application of a specific assessment, or control measures implemented through an Ergonomics Program for the manual handling of loads.
High - Significant	Rapid action is required, so control measures must be established through an Ergonomics Program for manual handling of loads.
Very High - Unacceptable	Activities must be stopped, and control measures implemented through an Ergonomics Program for the manual handling of loads.

6. DISCUSSION/CONCLUSIONS

Following the analysis and applications of the different methodologies described in the NOM-036-1-STPS-2018, the need to design, build and use a piece of equipment to ensure the physical integrity of the users is defined.

The following pictures show the design that was proposed and is currently being built

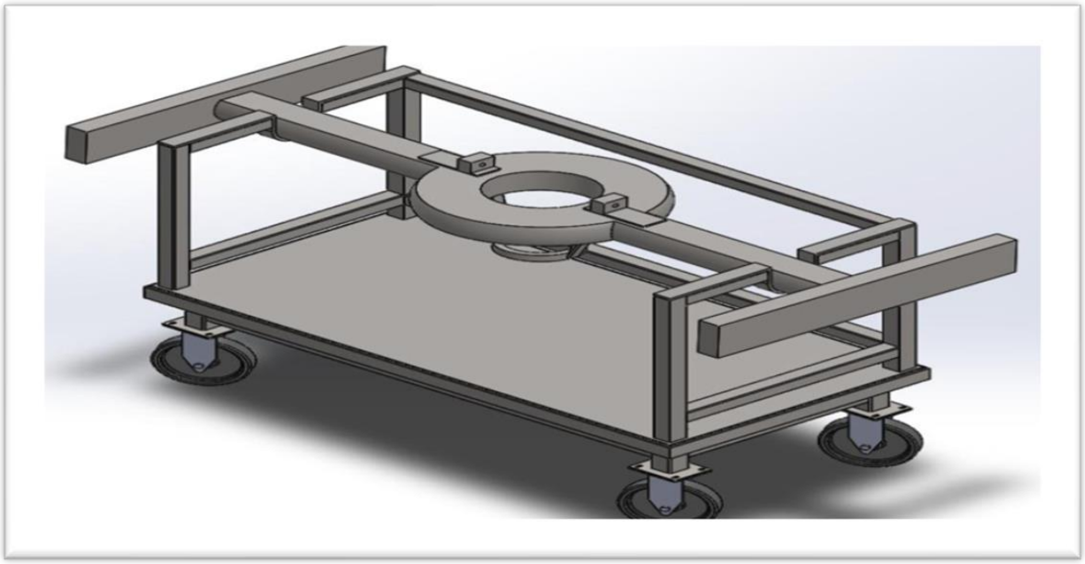

Figure 5. Complete design

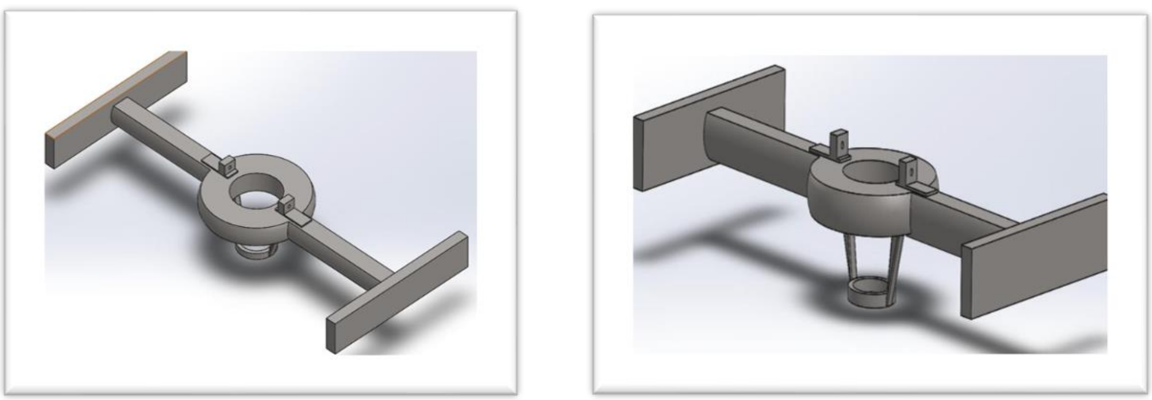

Figure 6. Crucible holder.

Based on the results obtained, it is concluded that the research project carried out is of great benefit, both for the students and for the institution, since the level of risk in the execution of the practices in the Foundry Workshop was reduced and therefore satisfaction is obtained in the users.

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ERGONOMIC RISK FACTORS IN TEXTILE COMPANIES, NIOSH METHOD

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Resumen La presente investigación es un análisis documental del tipo exploratorio de corte transversal sobre las condiciones de trabajo de las personas que se dedican al lavado y teñido de ropa, tanto en el ámbito industrial como doméstico. La metodología se aplicó en una muestra de 8 personas del género femenino adultas y se evaluó la actividad de tendido a través del Método del Índice de NIOSH valorado con Criterios basados en la norma Oficial Mexicana NOM- 036-STPS-2018, identificando riesgo de adquirir enfermedades musculo esqueléticas, y riesgo ambiental. Se utilizó un enfoque biomecánico que permite identificar aspectos que pueden constituir un daño para el sistema músculo-esquelético y que son particularmente importantes de abordar por la Medicina del Trabajo, especialmente en el tratamiento de personas que sufren tanto enfermedades crónicas como artritis reumatoide o artrosis y enfermedades agudas, como lumbalgias o tendinitis, entre otras, debido a que las trabajadoras ya habían presentado algunos síntomas de dolor y malestar en sus articulaciones, por lo cual se sugiere realizar estudios más amplios del tema.

Palabras clave: Riesgo ergonómico, lesión musculo-esquelética, Ambiente.

Relevancia para la ergonomía: Se identifica la importancia de la implementación de Normas Oficiales Mexicana para disminuir los accidentes y lesiones en el desempeño de las actividades en el trabajo, tales como la NOM-035-STPS-2016 y la NOM-036-STPS-2018.

Abstract: This research is a documentary analysis of the exploratory cross-sectional type on the working conditions of people who are dedicated to washing and dyeing clothes, both in the industrial and domestic spheres. The methodology was applied to a sample of 8 adult females and the laying activity was evaluated through the NIOSH Index Method valued with Criteria based on the Mexican Official Standard NOM-036-STPS-2018, identifying the risk of acquiring musculoskeletal diseases, and environmental risk. A biomechanical approach was used to identify aspects that can constitute damage to the musculoskeletal system and that are particularly important to address by Occupational Medicine, especially in the treatment of people suffering from chronic diseases such as rheumatoid arthritis or osteoarthritis and acute diseases, such as low back pain or tendinitis, among others, because the

workers had already presented some symptoms of pain and discomfort in their joints, for which it is suggested to carry out more extensive studies on the subject.

Keywords: Ergonomic risk, musculoskeletal injury, Environment

Relevance to Ergonomics: The importance of Ergonomics and the relevance of the implementation of Official Mexican Standards to reduce accidents and injuries in the performance work activities, such as NOM-035-STPS-2016 and NOM-036- STPS-2018.

1. INTRODUCTION

Ergonomics is a discipline that is applied with great relevance in all areas of human activity, and has the purpose of improving the interaction of individuals with their physical environment. The consequences of not considering ergonomic aspects in work stations and production methods generates an inadequate man-machine interface, causing physical and/or mental overloads in people, which in extreme situations can cause serious illness. Ergonomics in practice, multidisciplinary, is based on knowledge generated by other sciences and disciplines that deal with the individual, such as health sciences, psychology, sociology, design and Industrial Engineering, among others. The term ergonomics comes from the Greek words ergon (work) and nomos (law, norm or doctrine); the first reference to ergonomics appears in the book “Compendium of Ergonomics” of the Polish Wojciech Jastrzebowki (1857). (Muñoz, 2017)

The International Ergonomics Association (IEA), defines ergonomics as "the scientific discipline that deals with the understanding of the interaction between human beings and the other elements of a system", among the objectives of ergonomics is contemplated the achievement of job satisfaction, considering responsibilities, attitudes, beliefs and values for personal development as well as “individual and cultural differences”. (IEA, 2016)

Based on the above, the interest arose to carry out the present work in order to know the labor situation that prevails in the workers and focuses mainly on performance productivity and Ergonomic factors, considering that this discipline is little exploited in Mexico for To analyze the ergonomic risks of laundry and dyeing clothes, both domestic and industrial, the reason for this article, a biomechanical approach will be used to identify aspects that can constitute a risk for the musculoskeletal system and that are particularly important for addressed by Occupational Medicine, especially in the treatment of people suffering from both chronic diseases such as rheumatoid arthritis or osteoarthritis, and acute diseases, such as low back pain or tendinitis, among others.

Such diseases are caused because the physical limits of ligaments, tendons, intervertebral discs, joint capsules, muscles and other structures involved in movement have not yet been precisely determined in the human body. This difficulty derives from the fact that the limits vary for reasons as diverse as genetic predisposition, age or cumulative efforts. This complexity has been addressed by biomechanics, identifying the conditions in which the movements subject the different body structures to levels of tension that increase the probability of producing injuries. These conditions are identified as overexertion or overload and are explained by the effect produced by certain postures, the handling of loads, the frequency with which movements are performed, or the combination of these factors on certain body segments or structures. These conditions are identified in Ergonomics as risk factors and constitute the focus of analysis. (Figueroa 2017)

1.1 Security and health at work

On the other hand, the impact generated by environmental conditions. The Ministry of Labor and Social Welfare (STPS) is the body that establishes the mechanisms, Laws, Regulations and Standards, through which Labor, Safety and Health relations are governed, as well as keeping them updated according to the needs of society and monitor compliance with them in order to guarantee the balance of production factors. (DOF, 2018)

2. METHODOLOGY

This company "Alfa" focuses its activity on washing and dyeing clothes, merchandise is received from different suppliers and placed manually and piece by piece on shelves in its corresponding location. On the other hand, each time a customer is received, the sold parts have to be classified on the shelves and transported to their final destination.
The company "Alfa" is made up of a total of 102 workers, but only the warehouse area where 11 people work was studied, of which only 8 participated voluntarily in the study.

The commercial activity of the company "Alfa" can be summarized in 5 jobs:

• **ADMINISTRATIVE PERSONNEL**: Administrative tasks are included, considering the management, administration department and HR, logistics, purchases, sales, information technology and accounting.

• **COMMERCIALS**: The commercials, at the beginning of the day, present the orders from the previous day and the rest of the day they visit customers.

• **SALESMEN:** Most of the workers attend to clients by telephone and some to the public in person. After taking note of the orders by consulting the different catalogues, they collect the merchandise from the corresponding areas of the warehouse and deliver it to the customer. In the event that it is necessary to deliver the part to the customer's facilities.

• **MECHANIC:** There are two people in charge of carrying out small repairs on equipment that the company has a workshop in which it has a press to make license plates, a column drill, a kit for riveting shoes, a grinder, a compressor and various manual tools. . The worker can travel to customer workshops to pick up the equipment or even repair it on site. When he doesn't have a job, he works as a delivery man.

• **DISTRIBUTOR:** The work of the company's 15 distributors consists of loading the material in the vans, which they have prepared in an area of the warehouse where they receive the route to follow to deliver the merchandise. They can use carts to bring the material closer to the van. Once at the client's facilities, they unload the material manually. Each of the delivery men has a vehicle with which he usually works.

• **WAREHOUSE**: Includes the tasks of unloading merchandise, placing it in the warehouse and sending it to the end customer. This department is made up of a total of 11 people.

The laundry and dyeing activity consists mainly of cleaning and retouching or changing the color of clothing. Depending on its scope and dimensions, it can be classified into:

• Domestic laundry.
• Self-service laundries, where the machines are used by customers.
• Laundries of small establishments, usually used for cleaning the clothes of individuals or workers.
• Industrial laundries, where large amounts of clothing are treated, mainly from hotels, hospitals or restaurants.

In each one of them, regardless of the size of the place or the type of company, whether in a home laundry room, a public laundry room or a large industrial plant, the activities will be based on mechanical aids and of automation that and the process tasks can be practically manual or reach a high degree of automation. However, there are specific tasks that operators must do manually regardless of the type of company in question. As they are:

Clothes reception.

Once the clothes arrive at the laundry, they are classified according to color. The reception of clothes in the laundry facilities can be carried out in baskets, boats, cages, cars, bags or buckets; which if they are very deep force to flex the trunk and extend the arms when removing the clothes from the bottom. Likewise, there may be a risk due to manual handling of loads when removing clothes, moving buckets or emptying bags.

• Transfer to the washing area.

When taking the clothes from the carts or buckets and when loading and unloading the drums of the machines, manual handling of loads with bending of the trunk can take place, if the opening of the washers or dryers is located a little distance from the ground.

• Manual washing

Manual washing is done on a grooved surface on which the garment is rubbed repeatedly. Also the use of detergents and softeners.

• Mechanical washing

In automated laundries, where the loading of clothes, detergents and fabric softeners is done manually, so they must bend over, load clothes, insert them, take them out repeatedly, with their arms moving above their shoulders

• Drying with manual laying in the open air

The worker loads the container with the garments to the place where they are hung, then takes the garment, lifts it and accommodates it on the ropes or ties, takes the clips or fasteners, presses and releases the number of times necessary for the garment to be secure. . The movements are crouch, select, hold, lift, extend, select press, release, repetitively. It is worth mentioning that the containers have an inadequate grip and the weight of the load is between 5 and 10 kilograms

• Automatic drying

Take clothes out of the dryer stretching the arms in opening and closing, in addition to stretching them depending on the dimensions and quantity of the garments.

• Folded and arranged.

Clothes are placed in buckets, cages, carts or boxes. During the process, the risk of over-exertion may appear when you have to work with sustained forced postures of the arms, extension of the arms, back tension and repetitive twisting of the wrists, which can be when bending it or making efforts both to push the carts as if to load and unload them.

The working conditions related to the laundry stations usually entail a series of common risks that can affect the health of the workers if the appropriate preventive measures are not adopted and it must be borne in mind that musculoskeletal disorders They are the leading cause of both occupational accidents and professional illnesses, so the risks to which people engaged in this activity are exposed are set out below.

2.1 Risks

Knowing and detecting the risks associated with this work activity is the first step to avoid accidents and professional illnesses, most of the risks associated with these positions can be avoided through an adequate design of the position, a correct organization of work and information and staff training. (Martinez & Rubio 2015)

2.1.1. Ergonomic

Due to overexertion that can occur when manually handling loads, when forced postures are maintained and when repetitive movements are made, it is important to know the appropriate preventive measures to reduce the physical load in the main tasks that are carried out carried out in this sector, such as overexertion in cases where hands must be raised above the shoulders to do activities.

2.1.2. Biological

During activities that involve contact with biological waste in the handling of dirty clothes. (blood, urine, feces, skin.). Handle dirty clothes with care in case there is any object - (needles, syringes.), which must be immediately and carefully deposited in suitable containers located in the vicinity of the workplace. Do not exceed the filling limit of the container: replace it with an empty one.

2.1.3. Falls of different level

When transporting or handling heavy loads or in large containers on stairs, which compromises the safety of the worker.

2.1.4. Same level falls

In very small places or with liquid spillage, unsafe conditions can be caused and cause slipping, tripping and falls, resulting in damage to the worker such as sprains, hitting objects, among others.

2.1.5. Machines and tools

The use of machinery always exposes to a risk, for which its use must be responsible on the part of the worker for what they have been designed by the manufacturer and with their safety devices (guards, locks, among others.), reporting any anomaly in its operation.

2.1.6. Thermal contacts

When removing clothes from washing machines and dryers or when connecting and disconnecting in the case of manual washing or when there are wet areas, feet, hands or wet clothes.

2.1.8. Chemical products

Use of cleaning products that may be harmful to health, irritant, explosive, toxic or corrosive; which can damage the skin, eyes and respiratory tract, in serious cases brain damage or cause death.

2.1.9. Environmental conditions

The effects of the noise of the machines, the temperatures that are generated with the conditions of amplitude of the available space, as the most direct.

2.1.10. Physical load

Lifting containers of between 5 and 10 kg, placing clothes on ties or high shelves, lack of space for mobility, which generates forced postures, forward bending, stretching, bending over, bending over, and turning the trunk in front of machinery, among others.

3. METHODOLOGY

The development of methods to evaluate working conditions from an ergonomic point of view is based on the specific needs and conditions of the activity being evaluated, making them focus on the analysis of an area of the task, and although some of the methods involve various aspects within their evaluation, there is no single method that is generally applicable to all activities. (Escuer, 2017)

The selection of the evaluation method depends on factors that predominate and represent a greater risk for the person who performs the work, as well as the depth of the analysis required in time and the analysis conditions available. In general, the evaluation of working conditions represents great advantages because they are simple and fast, allowing the evaluation of the activity in the workplace without having to carry it out in a laboratory with simulated and controlled conditions, which may be different from the actual situation real.

This allows finding and knowing the critical factors that must be corrected to reduce the level of risk. However, it is important to consider that the result provided by ergonomic evaluations with these methods only represents a reference or approximation to the level of risk to which the user is exposed and in no case is it an absolute measure.

The most representative methods for the type of laundry work will be presented below: **(**Diego-Mas, J. A. 2015)

3.1 Ovako Working Analysis System (OWAS) method.

The Owas method allows the assessment of the physical load derived from the postures adopted during work, it is characterized by its ability to globally assess all the postures adopted during the performance of the task, despite being a relatively old method, continues being one of the most used in the evaluation of postural load. **(**Diego-Mas, J. A. 2015)

The observed postures are classified into 252 possible combinations according to the position of the worker's back, arms, and legs, in addition to the magnitude of the handled load, and each observed posture is assigned a posture code. Each code is associated with a Risk Category. The application of the method begins with the observation of the task developed by the worker. If there are different activities throughout the observed period, a division into different phases of work will be established.

This division is convenient when the activities carried out by the worker are very different at different times of their work. Thus, if the task performed by the worker is homogeneous and the activity performed is constant, the evaluation will be simple; if the task performed by the worker is not homogeneous and can be broken down into various activities or phases, the evaluation will be multiphase. If phases have been established, the evaluation will be carried out separately for each phase. The sampling frequency is determined, with which the postures adopted will be recorded. Postures should be collected at regular time intervals, usually between 30 and 60 seconds. (SEMAC, 2016)

The frequency of observation will depend on how often the worker changes posture and the variety of postures adopted. In general, the higher the frequency of change and diversity of postures, a higher frequency of sampling and registration of postures will be necessary. It should be considered that the estimation error increases as the total number of observations decreases.

Previous studies have found that the upper limit of this error (with 95% probability) when 100 observations are made is 10%. The error limits based on 200, 300, and 400 observations are 7%, 6%, and 5%, respectively. Once the phases, the observation period and the sampling frequency have been defined, the task will be observed during the defined observation period and the postures will be recorded at the sampling frequency. (SEMAC, 2016)

This can be done through on-site observation of the worker, photo analysis, or viewing of previously taken videos of the activity. There are four Risk Categories numbered from 1 to 4 in order of increasing risk with respect to their effect on the musculoskeletal system. Each, in turn, establishes the priority of possible corrective actions. (SEMAC, 2016)

Once the risk categories of each posture are known, it is possible to determine which are those that can cause a greater postural load for the worker. To consider the risk of all positions globally, the relative frequency of each position adopted by each member will be calculated below. From this information it will be possible to identify which parts of the body bear greater discomfort and decide on the corrective measures to apply. **(**Diego-Mas, J. A. 2015)

3.2. Rapid Upper Limb Assessment (RULA) method.

RULA is the acronym for (Rapid Assessment of the Upper Limbs). Although the application of the method requires data from other parts of the body such as the trunk and legs, the assessment is of the risk in the upper extremities.

The RULA method was developed in 1993 by Mc. Atamney and Corlett, from the University of Nottingham (Institute for Occupational Ergonomics), with the aim of evaluating the exposure of workers to risk factors that cause a high postural load and that can cause disorders in the upper limbs of the body. For risk assessment, the posture adopted, its duration and frequency, and the forces exerted when it is maintained are considered. **(**Diego-Mas, J. A. 2015)

For a certain posture, RULA will obtain a score from which it allows the evaluator to detect possible ergonomic problems derived from an excessive postural load, establishing a certain Level of Action. The Performance Level will indicate whether the posture is acceptable or to what extent changes or redesigns are necessary in the position. The RULA method evaluates individual postures and not sets or sequences of postures, therefore, it is necessary to select those postures that will be evaluated among those adopted by the worker in the position.

Those that, a priori, suppose a greater postural load due to their duration, their frequency or because they present a greater deviation from the neutral position will be selected. To do this, the first step is to observe the tasks performed by the worker. Various work cycles will be observed and the postures to be evaluated will be determined. If the cycle is very long or there are no cycles, evaluations can be carried out at regular intervals. In this case, the time that the worker passes in each posture.

The measurements to be made on the postures adopted by the worker are fund amentally angular (the angles formed by the different members of the body with respect to certain references). These measurements can be made directly on the worker using angle protractors, goniometers, or any device that allows angular data to be taken.

It is also possible to use photographs of the worker adopting the studied posture and measure the angles on these. The method should be applied to the right and left sides of the body separately. The expert evaluator can choose a priori the side that appears to be subject to the greatest postural load, but in case of doubt it is preferable to analyze both sides. RULA divides the body into two groups, Group A which includes the upper limbs (arms, forearms and wrists) and Group B which includes the legs, trunk and neck. Through the tables associated with the method, a score is assigned to each body area, based on these scores, assign global values to each of the groups A and B.

The final value provided by the RULA method is proportional to the risk involved in carrying out the task, so that high values indicate a greater risk of the appearance of musculoskeletal injuries. The method organizes the final scores into performance levels that guide the evaluator on the decisions to be made after the analysis. The proposed levels of action range from level 1, which considers that the evaluated posture is acceptable, to level 4, indicating the urgent need for changes in activity. **(**Diego-Mas, J. A. 2015)

3.3. Revised NIOSH 1991 equation for manual movement of loads

In 1985, NIOSH and a group of experts met to make a new review of the literature and analysis procedures related to manual lifting of loads, from which a document with updated information related to physiological, biomechanical, psychosocial and epidemiological aspects was obtained. , which resulted in the "revised NIOSH equation for load lifting" and was published in 1991. The manual lifting and movement of loads is one of the most frequent causes of musculoskeletal injuries among workers, which also causes loss of time and money to industries, as well as increased production costs. (SEMAC, 2016)

4. RESULTS

Regarding the Official Mexican Standards (NOM), for Safety at Work; General provisions for Security are established, in the following matters: The Employer must:

Review NOM-001-STPS-2008 Buildings, Premises, Facilities and Work Areas. Prevention and protection against fire.

Review NOM-002-STPS-2010 Use of Machinery, Equipment and Tools.

Review NOM-004-STPS-1999 Prepare a study to analyze the risk to which workers are exposed.

Review NOM-006-STPS-2014 Handling, Transportation and Storage of Materials.

The second item is Health at Work, which deals with the following aspects:

A. Noise. NOM-011-STPS-2011
B. Vibrations. NOM-024-STPS-2001
C. Lighting. NOM-025-STPS-2008.
D. Ionizing Radiation. NOM-012-STPS-2012
E. Non-Ionizing Electromagnetic Radiation. NOM-013-STPS-1993.
F. High or Low Thermal Conditions. NOM-015-STPS-2001
G. Abnormal Environmental Pressures. NOM-014-STPS-2000 [9].
H. Chemical Agents Capable of Altering Health. NOM-010-STPS-2014
I. Biological Agents Capable of Altering Your Health. NOM-047-SSA1-2011

The following risk factors stand out:

- Have an analysis of the Ergonomic Risk Factors of the jobs exposed to them.
- Adopt preventive measures to mitigate the Ergonomic Risk Factors in its facilities, machinery, equipment or tools of the Work Center.
- Carry out medical examinations for Occupationally Exposed Personnel
- Inform workers about the possible alterations to health due to exposure to Ergonomic Risk Factors.
- Train occupationally exposed personnel on safe work practices and keep records on preventive measures taken and medical examinations performed.

The standards of lighting, noise and temperature are essential for the evaluation of environmental conditions; their characteristics are specified below.

The rational lighting of workplaces is an element that affects the worker's work efficiency, increases the capacity of the visual system and helps reduce errors.

Table 1 is shown below, where the permissible luminosity levels are concentrated by the NOM-025-STPS-2011 Standard. (DOF, 2018)

Table 1. Light levels
Source: Own creation, NOM-025-STPS-2008

Tarea Visual del puesto de trabajo	Area de trabajo	Niveles mínimos (luxes).
En exteriores: distinguir el área de tránsito, desplazarse caminando, vigilancia, movimiento de vehículos.	Exteriores generales patios y estacionamientos	20
En interiores: distinguir el área de tránsito, desplazarse caminando, vigilancia, movimiento de vehículos.	Interiores generales almacenes de poco movimiento, pasillos escaleras, estacionamientos cubiertos, labores en minas subterráneas, iluminación de emergencia.	50
En Interiores	Areas de circulación y pasillos, salas de espera; salas de descanso; cuartos de almacén; plataformas, cuartos de calderas.	100
Requerimiento visual simple: inspección visual, recuento de piezas, trabajo en banco y máquina.	Servicios al personal: almacenaje rudo, recepción y despacho, casetas de vigilancia, cuartos de compresores y pailera.	200

NOM-011-STPS-2011. Industrial hygiene-work environment-determination of the equivalent continuous noise level, to which workers are exposed in the workplace. It determines how the sound levels should be measured, the maximum permissible levels and times, as well as the elements of a hearing conservation program that should be implemented in areas where the levels are potentially dangerous.

The decibel, symbol dB, is a logarithmic unit and is one tenth of a bel, which would actually be the unit, but is not used because it is too large in practice. On the other hand, compliance with the Standard ensures that no worker will see their hearing capacity diminished (and other negative effects on their health), which results in greater productivity and lower insurance premiums, among other positive aspects. In addition, any exposure without hearing protection to levels of 105 dB(A) and higher is prohibited. Table 2 shows the intensities and the range of exposure permissible by the Standard. **(**DOF, 2018)

Table 2. Noise levels in decibels

Intensidad en Decibeles	Tiempo de Exposición
90 dB(A)	8 HORAS
93 dB(A)	4 HORAS
96 dB(A)	2 HORAS
99 dB(A)	1 HORA
102 dB(A)	30 MINUTOS
105 dB(A)	15 MINUTOS

The Ministry of Labor and Social Welfare has issued NOM-015-STPS-2001 to establish the minimum safety requirements for workers who are exposed to high or low temperatures and, where appropriate, to carry out a control of the extreme thermal conditions that Due to the nature of the process, they may occur in the workplace. Table 3 shows the maximum permissible thermal conditions in degrees Celsius for each type of work and is complemented by the maximum exposure times and essential recovery times, in accordance with the characteristics established in NOM-015-STPS-20. **(**DOF, 2018)

Table 3. Temperature Levels
Source: Own creation, NOM-015-STPS-2001

Régimen de trabajo			Porcentaje del tiempo de exposición y recuperación.
Ligero	*Moderado*	*Pesado*	
30	26.7	25	100% de exposición
30.6	27.8	25.9	75% de exposición. 25% de recuperación/hora
31.7	29.04	27.8	50% de exposición. 50%de recuperación/hora
32.2	31.1	30	25% de exposición. 75% de recuperación/hora

DEVELOPING
For this study, a sample was taken from a group of housewives with the following characteristics:

Female gender
Age: 45 to 52 years
Weight: 55-70 kg.

The Method chosen was the NIOSH Index, because the need to use force is related to having to move objects and tools, or having to maintain the body in a certain posture. This requirement is present in many tasks and they are potentially dangerous for both the spine and the upper extremities. Due to the frequency with which spinal conditions occur, biomechanical studies have shown that there is a safe limit on weight for manipulation.

Above this limit, the intervertebral disc L5 – S1 is exposed to injury. This limit has been established at 25 Kg for men and 10 Kg. For adult women, in the case of minors it is 7 kg. According to the Official Mexican Standards and the Federal Labor Law. [6].

It is applicable only if certain conditions for handling are met, such as: keeping the load paid to the body and at waist height, not turning while holding the load, that it is supported safely and that the frequency of handling is not excessive very high. If some of these conditions are not present, the limit of 10 kg, for the case study that includes only women, decreases.

Below is the calculation of the lifting index, according to the NIOSH equation method, to estimate the risk when moving a container with 10 Kg of wet clothes, to the place of manual hanging.

- Container weight: **10 Kg**
- Height of the washing machine: **110 cm**
- Height of the railing of the lid of the washing machine: **160 cm**
- **Horizontal displacement**: 1.47 meters (distance from the center of gravity of the operator and the place of laying.
- **Vertical displacement: 135 cm** (distance from the container to the laying place)
- Grip safety: Good
- Spine twist: Yes
- **Frequency: Low** (considering only once).

Each of the handling conditions determines a factor, which corrects the acceptable weight limit by applying the following equation:

LC x HM x VM x DM x AM x FM x CM = RWL (1)
where:
LC, is "Load Limit" (23Kg)
HM, is the factor "Horizontal Multiplier"
VM, is the factor "Vertical Multiplier"
DM, is the "Distance Multiplier" factor
FM, is the "Frequency Multiplier" factor
AM, is the factor "Asymmetry Multiplier"
CM, is the factor "Coupling Multiplier"
RWL, is the "Recommended Weight Limit"

With a Lifting Index (real weight/recommended weight) for this situation of a NIOSH Index of: 1.4, which means that in the proposed situation the recommended value is exceeded by 40%, presenting a significant exposure to lumbar injuries. With the indicated conditions, the recommended weight would be: **6.2 Kgs. This biomechanical tool allows,** on the one hand, to demonstrate the importance of handling conditions and, on the other, to estimate the **level of risk of injury to the** spine. The same can be applied to seemingly innocuous tasks like carrying a dry laundry basket and carrying it up or down stairs. For the other activities, direct observation was carried out.

5. CONCLUSIONS

Some tasks are preferably performed standing up and their duration, on some occasions, can be quite long. This position can cause fatigue due to the muscular effort used to block the hip and knee joints and produces a decrease in venous return, which accentuates some circulatory disorders in the lower limbs. However, in this position the body has great mobility and prevents the tensions that appear in the spine and upper extremities when trying to reach distant objects, from the sitting position.

For the Therefore, it is recommended to stand up when the tasks require large movements and/or the handling of medium or large objects, and to be seated to carry out fine or precision tasks, since in the seated position energy expenditure is reduced, decreases the fatigue and greater control of movements (precision), but it must be considered that these recommendations are general and have not considered the physical condition of the person who performs them.

As there is no rule to recommend one position or another, only the analysis of the physical demands of each task and the capabilities or limitations of those who perform them, finally determine the most recommended position. Ergonomics proposes the alternation of positions as the main strategy to mitigate the risks of a particular position, which is obtained by dividing long tasks with similar physical demands and interspersing tasks that demand the action of other muscle groups. Some adaptations of the environment that facilitate the tasks they perform.

The execution of any task should not cause pain or exceed a level of effort, so the ergonomic intervention should be carried out by modifying the aspects of the physical environment that generate demands, such as forced postures, movements over comfort ranges and weight manipulation. Postural overload, whether of the upper extremities or the spine, should be evaluated in association with the exposure time, but in general terms, postures that require keeping the arms in ranges that exceed 45° of flexion should be avoided.

Shoulders and spinal flexion, in any range, since their muscles tire quickly and these postures are responsible for the development of inflammatory processes of soft tissues in the shoulders and spine, and accentuate ailments such as lumbago or pain syndromes in the upper limbs. It is suggested to consider that the main aspects to be evaluated in the analysis of the activity are:

- Identify the presence of pain: For this, in addition to the tasks, the specific operations within each task that cause discomfort or pain must be identified.
- Effort measurement: To assess the effort involved in performing each task and its operations.
- Have mechanical means to facilitate the emptying of the bags, such as hoist-type equipment.
- Limit the depth of the carts or use collapsible carts, depending on the amount of clothes they must hold.
- Use trolleys with a mobile bottom to always be able to remove the load from the same height. The spring of the trolleys with mobile bottom allows the bottom of the trolley to be raised as it is emptied to avoid having to flex the trunk and extend the arms to pick up the clothes that remain in the bottom.

Transport the clothes on mobile supports, wheeled buckets or other mechanical aids that serve to avoid manual transport.

- Have work tables with wheels to avoid, whenever possible, picking up the clothes from the ground.

- Carry out good maintenance of the wheels of mobile equipment, to ensure that they continue to offer the same service as when they are new.
- Preventing washing machine drums from being too low helps prevent musculoskeletal injuries.
- Ensure that the effort when pushing or pulling trolleys does not exceed 250 newtons (25.5 kg/force) to start or stop a trolley, and 100 N (10.2 kg/force) to keep it moving. To reduce the effort, the weight of the carts can be reduced by limiting the amount of clothing to be transported, as well as having suitable wheels, taking into account the slope of the ground or improving the type of floor.
- Whenever possible, alternate tasks where the postures or movements are different.
- Alternate the use of the right and left arm to distribute the muscular work between both limbs.
- Take small breaks every hour or hour and a half, where they can take advantage of stretching exercises for the shoulders, arms and legs.

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ERGONOMIC EVALUATION IN WAREHOUSE EMPLOYEES OF A SHOESTORES.

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Resumen El manejo manual de cargas y la constante adopción de posturas forzadas producen alteraciones que llegan a afectar la mecánica corporal. El manipular grandes pesos causa sobreesfuerzo que al momento de combinarse con posturas inadecuadas o forzadas representan un factor de riesgo ocasionando lesiones musculoesqueléticas.

Según la Organización Internacional del Trabajo (OIT) “La manipulación manual provoca una parte importante de las lesiones que se producen en el lugar de trabajo”. Las lesiones causadas por la manipulación manual de cargas o materiales incluyen trastornos musculoesqueléticos tales como dolores y lesiones en piernas, brazos, espalda o articulaciones, a su vez, lesiones por esfuerzos repetitivos. Actualmente, los desórdenes musculoesqueléticos representan un gran problemade salud en los trabajadores a nivel mundial, además son una de las causas principales del ausentismo y la pérdida de productividad en diversas empresas

Palabras clave: Manejo manual de cargas; Método OWAS; Transtornos musculoesqueléticos; Evaluación ergonómica; Gasto metabólico de energía.

Relevancia para la ergonomía: Los efectos de los riesgos ergonómicosdentro del almacén, se centran en que este sector vulnerable de población que se encuentra expuesto en mayor medida que el resto de la sociedad a los riesgos que puede implicarlas actividades realizadas de manera habitual por los trabajadores. Se pretende ayudar a alertar acerca de estos peligros, así como generar conocimientos queayuden en el tratamiento de los efectos producidos por la exposición que ocurre durantelas jornadas laborales que implican el manejo manual de cargas.

Abstract: The manual handling of loads and the constant adoption of forced postures produce alterations that affect body mechanics. Handling heavy weights causes overexertion, which when combined with inadequate or forced postures represent a risk factor causing musculoskeletal injuries.

According to the International Labour Organization (ILO) “Manual handling causes a significant part of the injuries that occur in the workplace”. Injuries caused by manual handling of loads or materials include musculoskeletal disorders such as pain and injuries to the legs, arms, back or joints, as well as repetitive strain injuries. Currently, musculoskeletal disorders represent a major health problem in workers worldwide, they are also one of the main causes of absenteeism and loss of productivity in various companies.

Keywords. Manual handling of loads; OWAS method; Musculoskeletal disordes; Ergonomic evaluation; Metabolic energy expenditure.

Relevance to Ergonomics: The effects of ergonomic risks within the warehouse are focused on this vulnerable sector of the population, which is exposed to a greater extent than the rest of society to the risks that may be involved in the activities carried out on a regular basis by workers. It is intended to help alert about these dangers, as well as generate knowledge that helps in the treatment of the effects produced by the exposure that occurs during working hours that involve the manual handling of loads.

1. INTRODUCTION

The manual handling of loads and the constant adoption of forced postures produce postural alterations that affect body mechanics. Handling heavy weights causes overexertion, which when combined with inadequate or forced postures represent a risk factor causing musculoskeletal injuries.

According to the International Labor Organization (ILO) “Manual handling causes a significant part of the injuries that occur in the workplace”. Injuries caused by manual handling of loads or materials include musculoskeletal disorders such as pain and injuries to the legs, arms, back or joints, as well as repetitive strain injuries. Currently, musculoskeletal disorders represent a major health problem in workers worldwide, they are also one of the main causes of absenteeism and loss of productivity in various companies.

The activities to which the 7 employees between 22 and 43 years of age in a shoe store are exposed can be detrimental to their health due to the high handling of manual loads of merchandise. This exposure occurs throughout the working day, which covers a schedule from Monday to Friday from 9 am to 6 pm and Saturdays from 8:30 am to 5:30 pm in a work area of approximately 400 square meters.

Are there considerable ergonomic risks for the warehouse workers of the shoe store due to the manual loading of merchandise during the working hours of the objects of study?

Can the distance traveled and the size of the load be considered as representative variables to know the possible risks?

Factors such as the posture of the employees when performing their tasks and the repetitions of each one can represent a cause in their discomfort?

Do the ergonomic methods used for their study allow generating adequate conclusions aimed at solving the problem?

2. OBJECTIVES

To identify the relationship between the ergonomic risks of physical load with back pain in workers in the warehouse area of a shoe store.

3. METHODOLOGY

The investigation will be carried out in the warehouse of a shoe store, to the 7 employees between 22 and 43 years old, who are directly involved in the analyzed tasks. In the investigation, the data collection of the employees will be carried out, as well as a study of the work positions through various ergonomic evaluation methods to establish if the back pain of the warehouse operators is related to the ergonomic risks of the position. of work they perform.

The type of study that will be developed is cross-sectional descriptive, since data will be taken only once and conclusions will be reached through the application of ergonomic evaluation methods to warehouse employees, without studying the changes in ergonomic indicators after applying recommendations made in this research.

The risk factor variables are independent and will help calculate the ergonomic risk represented by the tasks in the warehouse, the ergonomic variables will be obtained with the OWAS, Mac Tool and AAMA method depending on these risk factor variables.

To develop the study, a series of tools or instruments will be used in which the evaluators can help each other to reach the risk category, compile information or create a design in which the information is displayed in a more friendly way.

To carry out the data collection process correctly in the 3 types of ergonomic evaluation methods that are OWAS, MAC TOOL and AAMA, which will be used in the warehouse of a shoe store, videos will be taken of the tasks performed by workers during their working day in said warehouse. On the other hand, obtaining these videos seeks to apply the ergonomic evaluation method that is most appropriate for the study, taking into account that each ergonomic evaluation method (OWAS, MAC TOOL and AAMA), are applied differently and have with several steps to develop.

The factors to consider in making the videos are: the age of the workers, the weight of the load being handled, time and task performed, this is because, based on the objectives and hypotheses raised above , seeks to determine if some of these factors have a relationship between ergonomic risks in workers in a shoe store.

Once you have the necessary number of videos, each of these videos will be analyzed in order to determine which videos are the most related and have the necessary characteristics to carry out the study correctly and that they have the best results, on the other hand, if the number of videos is not enough, the process of taking videos will be repeated to meet the requirement of the sample size of the analysis.

4. RESULTS

The OWAS method was used to analyze the postures adopted by employees in the warehouse area during the development of a task. To carry out this study, 7 employees of a shoe store participated, the activities carried out by employees during the working day mainly involve loading shoe boxes in the warehouse. With the completion of this ergonomic study, it is sought to identify the main inadequate postures of the employee during the working day, which the method takes into account the postures of the back, arms, legs and load. A total of 7 videos were taken in which the postures that each employee adopts when performing the task can be observed, once the videos were fully analyzed and the postures were identified, the OWAS method was carried out.

According to the video taken from employee 1, it can be seen that the employee carries out 2 different activities, therefore a multi-phase evaluation was carried out, the total time of the observation was 17 seconds. As can be seen in figure 4.1 Record of postures employee #1 shows the 2 postures made by the employee and an image of the posture.

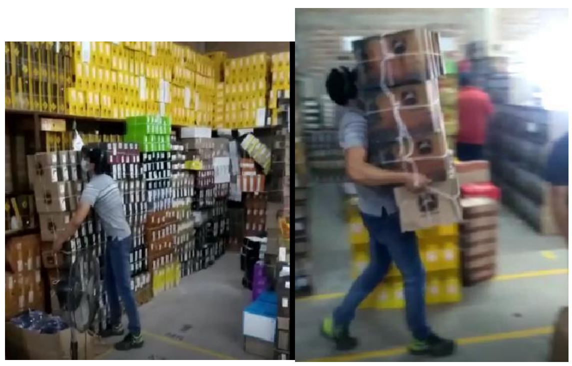

Figure 4.1 Employee Posture Record #1

Subsequently, the coding of the observed postures was assigned, with this the results shown in tables 4.1 and 4.2 are obtained.

The risk category for posture 1 was 2, which means that posture 1 has the possibility of causing damage to the musculoskeletal system and corrective actions are required in the near future. On the other hand, in posture 2, a risk category 1 was obtained, it can be seen that posture 2 is a natural posture and without harmful effects on the musculoskeletal system and does not require corrective action.

Table 4.1 Posture analysis 1

	PIERNAS	1			2			3			4			5			6			7		
	CARGA	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
ESPALDA	BRAZOS																					
1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1
	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1
	3	1	1	1	1	1	1	1	1	1	2	2	3	2	2	3	1	1	1	1	1	2
2	1	2	2	3	2	2	3	2	2	3	3	3	3	3	3	3	2	2	2	2	3	3
	2	2	2	3	2	2	3	2	3	3	3	4	4	3	4	3	3	3	4	2	3	4
	3	3	3	4	2	2	3	3	3	3	3	4	4	4	4	4	4	4	4	2	3	4
3	1	1	1	1	1	1	1	1	1	2	3	3	3	4	4	4	1	1	1	1	1	1
	2	2	2	3	1	1	1	1	1	2	4	4	4	4	4	4	3	3	3	1	1	1
	3	2	2	3	1	1	1	2	3	3	4	4	4	4	4	4	4	4	4	1	1	1
4	1	2	3	3	2	2	3	2	2	3	4	4	4	4	4	4	4	4	4	2	3	4
	2	3	3	4	2	3	4	3	3		4	4	4	4	4	4	4	4	4	2	3	4
	3	4	4	4	2	3	4	3	3		4	4	4	4	4	4	4	4	4	2	3	4

Table 4.2 Posture analysis 2

	PIERNAS	1			2			3			4			5			6			7		
	CARGA	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
ESPALDA	BRAZOS																					
1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1
	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1
	3	1	1	1	1	1	1	1	1	1	2	2	3	2	2	3	1	1	1	1	1	2
2	1	2	2	3	2	2	3	2	2	3	3	3	3	3	3	3	2	2	2	2	3	3
	2	2	2	3	2	2	3	2	3	3	3	4	4	3	4	3	3	3	4	2	3	4
	3	3	3	4	2	2	3	3	3	3	3	4	4	4	4	4	4	4	4	2	3	4
3	1	1	1	1	1	1	1	1	1	2	3	3	3	4	4	4	1	1	1	1	1	1
	2	2	2	3	1	1	1	1	1	2	4	4	4	4	4	4	3	3	3	1	1	1
	3	2	2	3	1	1	1	2	3	3	4	4	4	4	4	4	4	4	4	1	1	1
4	1	2	3	3	2	2	3	2	2	3	4	4	4	4	4	4	4	4	4	2	3	4
	2	3	3	4	2	3	4	3	3		4	4	4	4	4	4	4	4	4	2	3	4
	3	4	4	4	2	3	4	3	3		4	4	4	4	4	4	4	4	4	2	3	4

An ergonomic evaluation was carried out using the Mac Tool method in the shoe store with the aim of knowing the ergonomic risk to which the 7 employees of the store are exposed, who work from Monday to Friday from 9 am to 6 pm and on Saturdays from 8:30 am to 5:30 pm and carry out the task of loading and transporting shoe boxes.

This section describes the tasks and a format was used to obtain the category of risk or action faced by each employee. In total, 7 evaluations were carried out, one per employee.

A 21-second video was taken to study a task that the employee repeats numerous times during his working day and the MAC TOOL method was applied. A data collection was carried out for the evaluation of a task that entails a significant physical effort by the employee, in order to know the level of risk and the factors that have a greater probability of risk.

The video and the task were analyzed to use the format and obtain the risk results. Figure 4.2 shows the score obtained in the weight handled and frequency risk factor. The total weight lifted by the employee, which was 20.7 kilograms, is also shown.

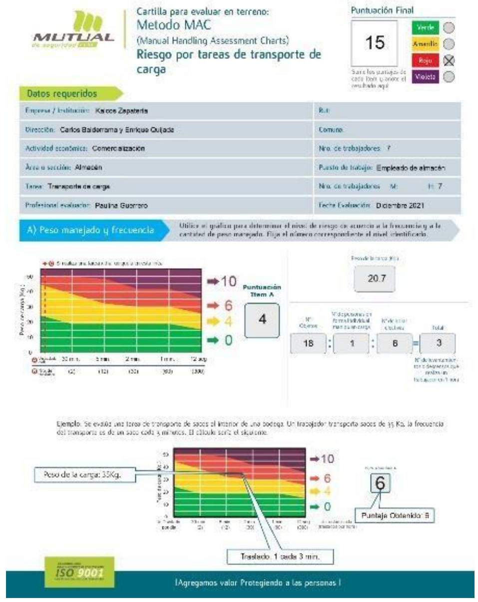

Figure 4.2 Mac Tool form sheet 1 for employee #1

In figure 4.3 it can be seen that the factor distance between hands and back was given a score of 3, because the employee places his hands away from the torso and bends his back at the moment of performing the lift. In the asymmetric load factor, a score of 1 was given, because the load is lifted with both hands but asymmetric to the body.

Figure 4.3 Mac Tool form sheet 2 for employee #1

In the postural restrictions factor, a score of 1 was given for the obstacles in the employee's path, and in the hand-object coupling, 2 points were considered for the lack of an adequate fastening system for the shoe boxes.

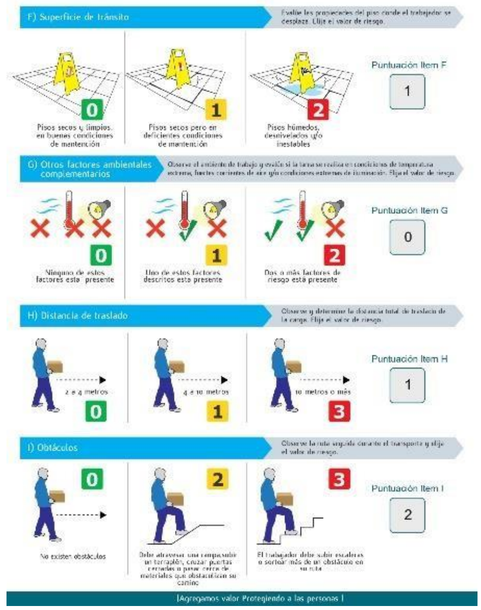

Figure 4.4 Mac Tool form sheet 3 for employee #1

En la figura 4.4 se puede observar que la puntuación del factor superficie de transito es de 1, para otros factores ambientales se dio una puntuación de 0, en el lugar de trabajo no se tienen condiciones de temperatura extrema, fuertes corrientes de aire o condiciones extremas de iluminación.

En el factor de distancia de traslado se dio una puntuación de 1, debido a que la distancia que el empleado recorre con la carga se encuentra entre 4 a 10 metros. Mientras que la puntuación para el factor de obstáculos es de 2, debido a que la ruta quese atraviesa esta obstaculizada en mayor parte por otras cajas de zapatos.

Adding all the scores it was possible to determine that the total score of the task is 15, 7 risk factors can be observed in the orange level, 1 in the red level and 1 in the green level. The risk category that was obtained is 3 and indicates that corrective actions are required soon in the task of employee 1.

The AAMA ergonomic method was used to carry out an evaluation of the activities carried out in the shoe store by 7 employees who work a daily shift of 8 hours on average, where they carry out the tasks of manual loading and transport of boxes. of shoes.

The objective of the application of this method is to know the metabolic energy expenditure required by the activities and the physical work capacity of the workers, in order to later be able to know the maximum work time, as well as the recovery time necessary for each worker to reach conclusions and recommendations on the ergonomic risks that may arise during the working day.

The same videos and tables were used as in the previous sections where the activities of each worker are described to fill out an established format with the values of the AAMA method.

For the evaluation, a 21-second video was taken where the task that the operator repeats in said cycle is exposed. Based on the data corresponding to employee 1, such as his age, working time per day, distance traveled, etc., the format of table 4.3 corresponding to the AAMA method was filled in to know the metabolic energy expenditure.

Table 4.3 Employee #1 metabolic energy expenditure

GASTO METABOLICO DE ENERGIA

Fecha de analisis **nov-21** Analista **Equipo investigación**

Depto/Unidad **Almacén** Puesto **Operador de almacén** Parte/Unidad

- No. De personas expuestas **1** Descripcion del

trabajo **Transporte de cargas de forma manual en almacén**

Duracion Ciclo de Trabajo* **Continuo**

* Continuo > 4 horas Frecuente = 1 a 4 horas Ocasional < 1 Hora Sexo

M Edad **25** Tiempo de trabajo **480 min**

A

Si ocurre poco movimiento de brazos/manos, el valor =	0
Si los movimientos de las manos/brazos está dentro de los 50 cm, el valor =	1
Si los movimientos de las manos/brazos exceden los 50 cm, el valor =	2
Si hay inclinación, giros y alcances extremos, el valor =	3

B

B = (distancia promedio caminada por minuto * 2.1)

B = (5 m por min) (2.1) = 10.5

C

Si la mayoría de las partes pesan menos de 1.8 kgs; el valor =	1
Si la mayoría de las partes pesan entre 1.8 kgs y 5 kgs; el valor=	2
Si la mayoría de las partes pesan mas de 5 kgs; el valor =	3

Los valores de frecuencia son:

Si hay menos de 2 ciclos por minuto; el valor =	1
Si hay entre 2 y cinco ciclos por minuto; el valor =	2
Si hay mas de 5 ciclos por minuto; el valor =	3

C = Contribución de la variable levantar = (valor de A * valor del peso * valor de la frecuencia * 4.4)

C = (3 * 3 * 2 * 4.4) = **79.2**

D

D = [(fuerza promedio empujar/jalar * 2.2) + 5.2] * distancia promedio recorrida en un minuto mientras se empuja/jala

GME = 117 + (brazos*25) + (caminar*2.1) + (levantar*4.4)

A = 3 * 25 = **75**

B = (5 m por min * 2.1 = **10.5**

C = (3 * 3 * 2 * 4.4) = **79.2**

D = (35 * 2.2 + 5.2)* 1 m = **82.2**

GME = 117 + A + B + C + D

GME = 363.9 Kcal/hr

GME = 6.065 Kcal/min

Subsequently, in Table 4.4, the physical work capacity of the same employee was calculated, where the ISF physical health index takes into account already established values and the age variable.

Table 4.4 Physical work capacity of employee #1

Capacidad de trabajo fisico			
CTF = Capacidad de trabajo fisico en kcal/min		Para mujeres:	
Para hombres:		CTF = [log 4400 - logt/0.25] * ISF	
*CTF = [log 4400 - logt/0.187] * ISF*			
t = tiempo de duración de las actividades en minutos			
ISF = Indice de salud fisica			
= a+bX+c/(lnX)+d/[X*(X)^1/2]+(elnX)/X^2			
a =	318.6212	d =	76753
b =	-0.35492	e =	-90577
c =	-1468.29	X = edad =	22
ISF = 1.14231			
CTF = 5.877777			

And finally, in table 4.5, the maximum time and recovery time were calculated with the help of the values obtained previously.

Table 4.5 Maximum time and recovery of employee #1

Tiempo máximo	
para hombres:	para mujeres:
log t = log 4400 - [(GME*0.187)/ISF]	log t = log 4400 - [(GME*0.25)/ISF]
Log t= 2.642383	
t = 438.9175 min	
t = 7.32 horas	
Tiempo de recuperación	
Tiempo de recuperación = [(CTF-GFE)/(ED-GME)]* Tiempo de trabajo	
CTF= capacidad de trabajo fisico	
GME= Tasa de demanda promedio de energía del trabajo (kcal/min)	
ED= Tasa de energía promedio durante la recuperación (1.0 a 2.0 kcal/min)	
TR =[(5.83 - 6.07)/ (2) - 6.1)] * 480 min	
TR = 27.79916 min	

5. DISCUSSION/CLONCUSIONS

As can be seen in the graphs of the data surveyed to the staff that was observed for this research, regardless of the age of the subject, the majority of workers have presented back pain in an average period of 3-6 months.

With the help of the methods established throughout the investigation, the following can be concluded:

Thanks to the OWAS method, it can be determined, after analyzing the videos, that although the work does not seem heavy, the way in which the postures are executed is not correct, ergonomically speaking, thanks to the analysis carried out, it can be observed that risk codings are found; therefore, it is necessary to take corrective actions quickly to avoid future complications.

With the MAC TOOL method, it was determined that the level of risk faced by each employee is category 3, that is, corrective action is required as soon as possible, to avoid risks involving workers.

After analyzing the videos of the same employees, with the AAMA method, it was possible to obtain data on the amount of energy that employees spend every so often, and that on average every 6-7 hours of work, they need approximately 1 hour in order to recover energy.

In conclusion, it is necessary to obtain this data in order to determine what the employees do and thus be able to find an effective solution to correct their posture, avoid a greater waste of unnecessary metabolic energy and in the same way, be able to avoid accidents and/or injuries involving employees.

Obtaining conclusions from the results by means of the previous methods, it was determined that it is necessary to take actions to correct and prevent existing risks; Although age is a factor to take into account due to the wear that occurs over time, it affects more the way in which the postures reported in the research independent of age are performed; and finally, it was found that the way in which the warehouse employees carry out the postures to carry out their activities is not in the most appropriate way, since risk points were reflected in the 3 analyses.

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HEART RATE VARIABILITY, ACUTE FATIGUE INDICATOR IN MANUAL MATERIAL HANDLING.

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Resumen: El manejo manual de materiales es uno de los principales causantes de Trastornos Músculo Esqueléticos (TME) mayormente enfocados en la zona lumbosacra de los operadores que realizan estas actividades. La presente investigación conlleva el estudio de la secuencia operativa, de alta demanda biomecánica en los movimientos, que debe llevar a cabo el trabajador para realizar las operaciones de manejo manual de materiales y su impacto en la capacidad de los sistemas circulatorio y respiratorio para suministrar oxígeno a los músculos esqueléticos.

Las evaluaciones ergonómicas en el manejo manual de materiales definen el riesgo en el que se encuentra un operador al realizar estas actividades, lo que normalmente se resuelve en función a los controles organizativos enfocados en los periodos de recuperación y cambio de actividad dentro de la jornada laboral. Sin embargo, cuando las exigencias de estas tareas son elevadas descontrolan la función normal de acople excitación – contracción – relajación en el músculo, provocando un punto crítico, en donde el músculo no demanda oxígeno y la frecuencia cardiaca disminuye en plena actividad laboral.

El objetivo del presente trabajo se enfoca en el análisis del comportamiento que se presenta en la frecuencia cardiaca del operador cuando realiza el manejo manual de materiales. Identificando el periodo transiente, la frecuencia cardiaca se eleva rápidamente; el periodo estable crece moderadamente y el punto crítico cae súbitamente, llegando con ello a lo que se denomina fatiga aguda.

Palabras clave: Fatiga, fatiga aguda, manejo manual de materiales.

Relevancia para la ergonomía: El presente trabajo investigativo muestra como el esfuerzo demandado por el manejo manual de materiales, impacta en la frecuencia cardiaca al afectar el proceso normal de acople excitación – contracción – relajación, esto en un contexto de trabajo donde el periodo de recuperación es ergonómico. Lo que oculta en gran medida que se logre visualizar el impacto negativo que tiene este tipo de labores. Con ello se abre un campo de aplicación de la ergonomía para diseñar los controles organizativos y de ingeniería que disminuyan la posibilidad de que se presente un Trastorno Músculo Esquelético.

Abstract: Manual handling of materials is one of the main causes of Musculoskeletal Disorders (MSD) mainly focused on the lumbosacral area of the operators who perform these activities. The present research entails the study of the operative sequence, of high biomechanical demand in the movements, that must be carried out by the worker to perform manual material handling operations and its impact on the ability of the circulatory and respiratory systems to supply oxygen to skeletal muscles.

Ergonomic evaluations in manual material handling define the risk in which an operator is in when carrying out these activities, which is normally solved according to organizational controls focused on recovery periods and activity change within the working day. However, when the demands of these tasks are high, they disturb the normal muscle function excitation – contraction coupling, causing a critical point, where the muscle does not demand oxygen and the heart rate decreases in full work activity. The objective of this work focuses on the analysis of the behavior that occurs in the operator's heart rate when performing manual material handling. Identifying the transient period, the heart rate rises rapidly; the stable period grows moderately and the critical point falls suddenly, thus reaching what is called acute fatigue.

Keywords. Fatigue, acute fatigue, manual material handling.

Relevance to Ergonomics: The present investigative work shows how the effort demanded by the manual handling of materials impacts the heart rate by affecting the normal cycle of muscle excitation-contraction-relaxation, this in a work context where the recovery period is ergonomic. What hides to a great extent that it is possible to visualize the negative impact that this type of work has. This opens a field of application of ergonomics to design organizational and engineering controls that reduce the possibility of a Musculoskeletal Disorder.

1. INTRODUCTION

Current production systems must respond to a competitive dynamic of great scope and complexity, where it is necessary to respond forcefully to an uncertain, changing demand that requires high quality, short delivery times and low cost. In order to respond to this current competitiveness, strategies have been developed focused on the diversification of products and processes, based on sophisticated automated systems for planning, execution and production control.

However, these productive systems develop their potential only if the human factor that activates, energizes and controls them is in conditions to do so, which directly affects the man-machine synergy within the work environment. In such a way that all situations not controlled by the automata fall on the worker who performs his activities in these operations. Being one of the main, manual material handling. Mainly due to the costs that automated load handling represents and when these loads are considered relatively small, the use of automated material handling is obviously not affordable. Presenting the need for this load handling to be developed by the human factor.

This responsibility that falls on the worker maintains a high risk in his anatomical structure, since statistics have shown us that musculoskeletal disorders derived from excessive effort during load lifting represented 31% of all cases of labor injuries with downtime. (Castro-Castro et al., 2018).

The multifactorial set of actions that the human body requires to carry out the manual material handling, is made up of the electrical impulse that the brain sends through the spinal cord until it reaches the muscles in charge of making the compression, as a result of the chemical reaction between actin and myosin; the joint that acts as a lever to carry out the movement and the bones that are the structure that supports the movement. When this action exceeds the body's capacity and its recovery period is not long enough, musculoskeletal disorders occur. (Saavedra-Robinson et al., 2021)

Musculoskeletal disorders caused by the manual material handling are mainly related to the spine, because biomechanically the center of mass of the human body generates the counterweight in the development of the activity.(López Torres et al., 2014).

The human spine is a rigid structure, it can withstand pressure, and elastic, which can give a great range of mobility (Mihaila y Slicaru, 2014). These two concepts are opposed, but throughout evolution they have convoluted and the result is a suitable balance for the needs of support and mobility. This almost perfect balance is achieved by the muscular, aponeurotic and mixed protection systems.

When the spine is no longer stable and pain appears, these systems should be checked and it is usually observed that one or more are failing, figure 1 shows the alignment and misalignment of the spine schematically.

The postural load that the spinal column maintains is made up of a multifactorial set that contemplates the weight of the person, the load that they lift or transport, the shape and structure of the load, the posture in which the operator develops for the task and among others the repetitiveness of movements that the operator makes. This produces irregularly shaped compression of the intervertebral discs. This causes what is known as the intervertebral cushion to lose hydration and strength, thereby being able to generate a herniated disc and produce pressure on the nerveous system.

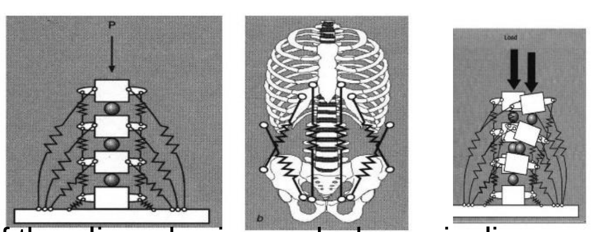

Figure 1: Outline of the aligned spine and when misalignment occurs (Mihaila y Slicaru, 2014).

The main affectation that occurs is an axial misalignment of the trunk, which causes an asymmetric compression of the intervertebral cushion, generating pressure from the nucleus pulposus on the annulus fibrosus with greater intensity in a particular area, resulting in premature wear in its elasticity and functionality.

In addition to the above, the movement necessary to carry out manual load handling is a dynamic activity and on certain occasions requires great energy and effort in a very short period of time, which implies a high demand for oxygen from the muscles. This situation causes the circulatory system to activate in an anormal way, by establishing a high demand and after that inactivity, in a constant repetitive cycle. This creates the possibility that the operator develops coronary diseases, hypertension, cardiorespiratory arrest, heart failure, arrhythmia, among others. Situation that has been little analyzed and studied.

The present paper consists of an analysis of the activities developed in the manual material handling and their impact on cardiovascular work.

2. OBJECTIVES

2.1 General objective

Analyze heart rate variability as an indicator of the critical point of acute fatigue in manual material handling operations.

2.2 Specific objectives

1. Structure a theoretical reference framework on aspects related to the manual handling of materials, acute fatigue and heart rate variability.
2. Develop a procedure to analyze the critical point of acute fatigue, through the variability in heart rate, caused by the manual handling of materials.
3. Validate the designed procedure, based on the analysis of the behavior of the heart rate.

2.3 Project boundaries.

The investigative work is developed in the intermittent production lines with online flows of the maquiladora and export manufacturing industry in northwestern Sonora. That due to their own requirements, manual handling of materials is necessary.

3. PROJECT METHODOLOGY

The methodology used in this project is based on a cross-sectional descriptive observational study with a mixed approach; three stages are framed for its development:

- As a first stage, an ergonomic diagnosis is made to indicate the degree of risk in which the manual handling of materials is carried out. The risk assessment support instruments that were considered in the assessment are: Method MAC (Manual handing assessment chart), Utah estimate method, for disc compression force estimation and FRI (Physical load estimation).
- The second part of the methodology consists of analyzing the variability in the heart rate of the worker, who performs the manual handling of materials.
- As a third action, the behavior of the worker's heart rate is assessed and the critical point where acute fatigue appears is determined.

4. RESULTS

The requirements of the task to be carried out make the activity of manual load handling necessary, in an operative sequence of high biomechanical demand in the movements that the worker must carry out. This carries with it a high possibility that the operator will develop a musculoskeletal disorder or the case may come in which an injury occurs mainly in the lumbosacral area.

The observational studies were carried out in 8 companies, where the activities required by the production line made manual handling of materials necessary. It is important to establish that the analyzed lines are made up of several workstations that contemplate the same need. In addition to this, they work in two or three shifts, so the population exposed to this high demand for work is considerably large.

The load that the operator must handle is a roll of fabric that is used in the manufacture of disposable gowns for medical use; this roll maintains a weight of 25 kilograms.

The operator performs a load lifting which lasts 30 seconds, maintains turns with load and transports it more than two meters.

The lifting is done from the floor to a height above the shoulder; the total working time is 4 hours in this activity.

The investigative work begins with the identification of the risk factors that occur in the manual handling of materials. Figure 2 shows the sequence of actions that an operator performs in one of the analyzed workstations.

The operational sequencing that is required in the task begins when the operator removes the roll of material from the roll conveyor, places it on the floor to be able to rearrange his hands and achieve a more secure grip, this is due to the fact that after that he performs a roll offset and then initiates the formation of a four-roll stack, resulting in a height greater than the operator's shoulder.

In a preliminary ergonomic analysis, it manages to find and define a set of risks for the workstation under study; the main risk factors found are shown in Table 1.

Step 1	Step 2
	
Step 3	Step 4
	
Step 5	Step 6

Figure 2. Operational sequence that involves the manual handling of materials.

Tabla 1. Main risk factors in the workplace.

Load	**Work enviroment**	**Physical effort**	**Activity requirements**
The volume of the load makes it difficult to handle.	There are no adverse conditions for the worker.	There is intense and repetitive effort.	The operator performs the activity 17 times in 4 hours, during the working day that includes 9.6 hours.
Unable to maintain load balance.		The physical effort must be made with torsion and flexion of the trunk.	
It is necessary to make torques with the load.		Sudden movements are required.	
The load has dimensions that complicate its handling.		Load is lifted from the ground to above shoulder height.	

Once the risk factors were identified, the ergonomic evaluation of the operation was carried out. For this, 3 methods were used that include the static load and the dynamic load that the worker carries out in his activity.

The first method of ergonomic evaluation in the manual handling of loads is the so-called MAC (Manual handling Assessment), whose application format is presented in figure 3, this methodology uses a quantitative scale and a color code that frame the risk in which the load lifting action is found.

For the evaluation of the workstation under analysis, the quantitative value that frames is 16 and the color code is red, which implies a significant high level of risk and it is necessary to carry out corrective actions immediately. The same methodology proposes for this case to carry out a quick action, for which control measures must be established, through an ergonomics program for manual handling of loads.

In this first application it is detailed that the critical points are in the distance between the operator's hand and the lower back at the time of lifting, the second critical point is the height to which the roll must be lifted and the third is in the complex shape of the load in the grip, since this is a roll, the grip can only be made from the center to the peripheral ring of the load and there are no clamping mechanisms.

MAC SCORE VER 4.0

ANALISTA Valeria C., Zeus E., Ramon G. — 17 de junio 2022

AREA ____ Shoe cover — PUESTO DE TRABAJO Impresión

DESCRIPCION DEL TRABAJO

El operador realiza un levantamiento de carga que tiene una duración de 30 segundos, mantienen giros con carga y la transporta mas de dos metros. El peso de la carga es de 25 kilogramos y el levantamiento lo hace del piso hasta una altura superior al hombro, el tiempo total de trabajo es de 4 horas en esa actividad.

FACTOR DE RIESGO	COLOR (G,A,R,P)			PUNTUACION		
	L/B	CARGAR	TEAM	L/B	CARGAR	TEAM
PESO/FRECUENCIA	A			4	0	0
DISTANCIA MANO-ESPALDA BAJA	R			6	0	0
ZONA DE LEVANTAMIENTO VERTICAL/CARGA ASIMETRICA	R			3	0	0
TORSION Y/O LATERALIZACION	A			1		0
RESTRICCIONES POSTURALES	G			0	0	0
CALIDAD DE AGARRE	R			2	0	0
SUPERFICIE DEL PISO	G			0	0	0
OTROS FACTORES AMBINTALES	G			0	0	0
DISTANCIA DE TRASLADO					0	0
OBSTACULOS EN LA RUTA					0	0
COMUNICACIÓN, COORDINACION Y CONTROL						0
		SCORE TOTAL		16	0	0

NIVEL DE RIESGO	PRIORIDAD	PUNTAJE TOTAL
Bajo – Aceptable	No se requieren acciones correctivas	0 a 4
Medio – Posible	Se requieren acciones correctivas a corto plazo	5 a 12
Alto – Significativo	Se requieren acciones correctivas pronto	13 a 20
Muy Alto - Inaceptable	Se requieren acciones correctivas inmediatamente	21 a 32

Definir las acciones, conforme al nivel de riesgo obtenido, de acuerdo con lo siguiente:

NIVEL DE RIESGO	ACCIONES
Bajo – Aceptable	Sólo se requiere dar seguimiento a los grupos más vulnerables, como mujeres en periodo de gestación o trabajadores menores de edad.
Medio – Posible	Se debe examinar las tareas con mayor detalle, mediante la aplicación de una evaluación específica, o bien implantar medidas de control mediante un Programa de ergonomía para el manejo manual de cargas.
Alto – Significativo	Se requiere una acción rápida, por lo que se deben establecer medidas de control mediante un Programa de ergonomía para el manejo manual de cargas.

Figure 3. Format of the MAC methodology applied in the workstation.

The second ergonomic evaluation method that was applied in the so-called Utah disc compression force estimation; figure 4 shows the results of this evaluation.

Utah Estimation of Back Compressive Force

Job	Analyst
Manejo de rollo en el área de impresión	Natalia Torres
Task	Date
Levantamiento manual de rollos peso aproximado 25 kilos	08/06/2022

Measure	Symbol	Value	
Body Weight [kg] Average body weight for an even gender distribution is 75 kg	BW	85	[kg]
Load [kg]	L	25.0	[kg]
Horizontal Distance [m] Hands to lower back {L5 - S1 Joint}	HB	0.45	[m]
Back Posture (Angle from Vertical)	θ	92	[°]
	Sin θ	1.00	[--]

Contributor	Computation	Value [N]
Back Posture A = 29 (BW) sin θ	29 * (85) * (1.00)	2463
Load Moment B = 190 (L*HB)	190 * (25.0) * (0.45)	2138
Direct Compression C = 7.5 [(BW)/2 + L]	7.5 * {(85)/2 + (25.0)}	344
Estimated Compressive Force F_c = A + B + C	Comparison Value: 3100 N	4945

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Figure 4: Ergonomic Assessment Method Result Utah Estimation of Disc Compression Force.

This method develops a set of biomechanical calculations that estimate the compression force in the intervertebral discs at the time of lifting the load, giving 3100 newtons as a reference value, for the case of the task under analysis the result of the method is 4945 newtons, which implies a higher value than the reference value, being an imminent risk the one presented by the task.

The third evaluation method used is called FRI physical load estimation. The application made with this method is presented in Figure 5.

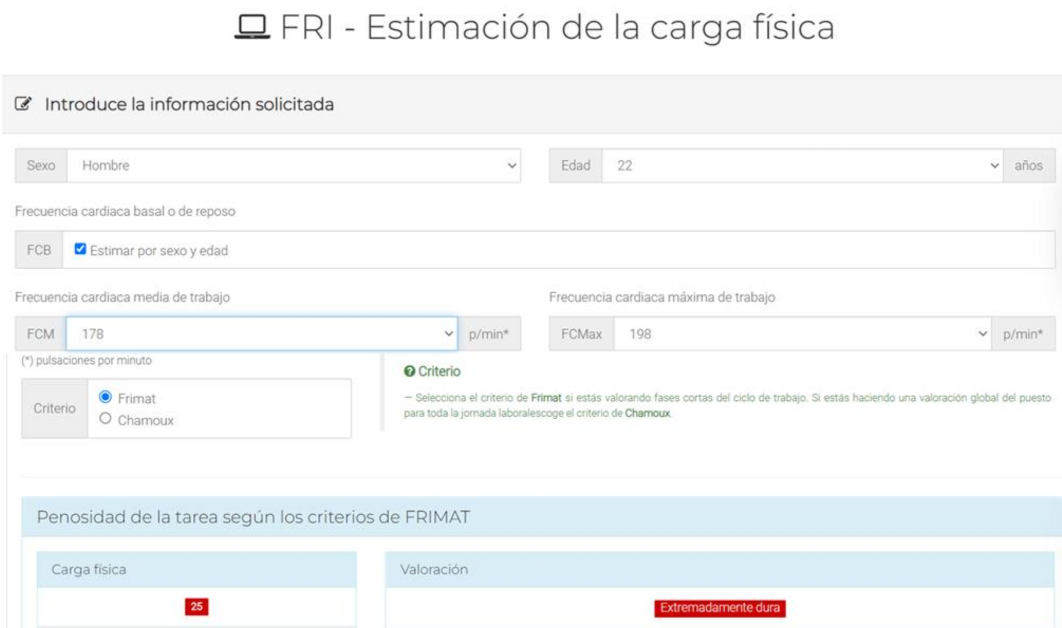

Figure 5: Result of the ergonomic evaluation method FRI (estimation of physical load).

The FRI method assesses the heart rate that the worker maintains in the development of his activity and compares it with the average heart rate and the initial or at rest, with this it is possible to estimate the physical load that the worker has when he performs the work of lifting weights load. In the case study, the assessment of the physical load obtained with the method is 25, considering an extremely hard load. This situation indicates that the effort that the operator has in the task is high and that his cardiovascular system is highly active.

As observed in the previous development, the result of the three ergonomic evaluation methods is similar and indicates that the workstation with manual assembly maintains a high risk for the operator. However, as it is an operation that is carried out for 4 hours and approximately 17 lifts are carried out, the recovery period in the total working day is sufficient so as not to generate excessive wear on the worker.

The main concern of this research focuses on the 4-hour period where the effort is very high and the operator is in a position to generate a serious musculoskeletal injury, mainly in the lumbosacral area, hip and knee joint, in turn the cardiorespiratory function of the operator is at risk, this is mainly due to the fact that the lift is carried out in 30 seconds, it is a load of 25 kilograms and a height greater than the shoulder, which implies a great muscular and cardiac effort.

Neuromuscular fatigue is associated with different mechanisms, central or peripheral, those interacts dynamically with each other, and generate a series of events that leads to a protective decrease in the productive capacity of force, in a reversible way. When Pi (inorganic phosphate) limits release, activity, and sensitivity of Ca2+, reserves of ATP falls creating an oxygen debt in the muscle, generating a point of fatigue where hydrolysis does not potentiate the chemical reaction in the muscle and the demand for oxygen to the central nervous system is not generated, which is why abnormalities in neuromuscular transmission or of action potential propagation through the sarcolemma, at the level of the excitation-contraction-relaxation coupling, this can cause muscle-skeletal injuries when manual material handling activities are carried out during the work stay. (Gómez-Campos et al., 2010).

To assess the above in manual material handling stations, it is necessary to evaluate the variation in the operator's heart rate and build the graph that defines the critical point where acute fatigue appears. The assessment was carried out with a heart rate monitor that performs the measurement through a band that is placed on the operator's chest and sends the results to the analyst's mobile device. The main features of the measuring device are: Weight 15 grams; heart rate range 30 – 240 beats per minute; bluetooth connections 4 y ANT+; Bluetooth working distance 10 meters y ANT 6 meters.

Figure 6 shows the heart rate data of 5 operators who perform manual handling of materials at the analyzed workstations.

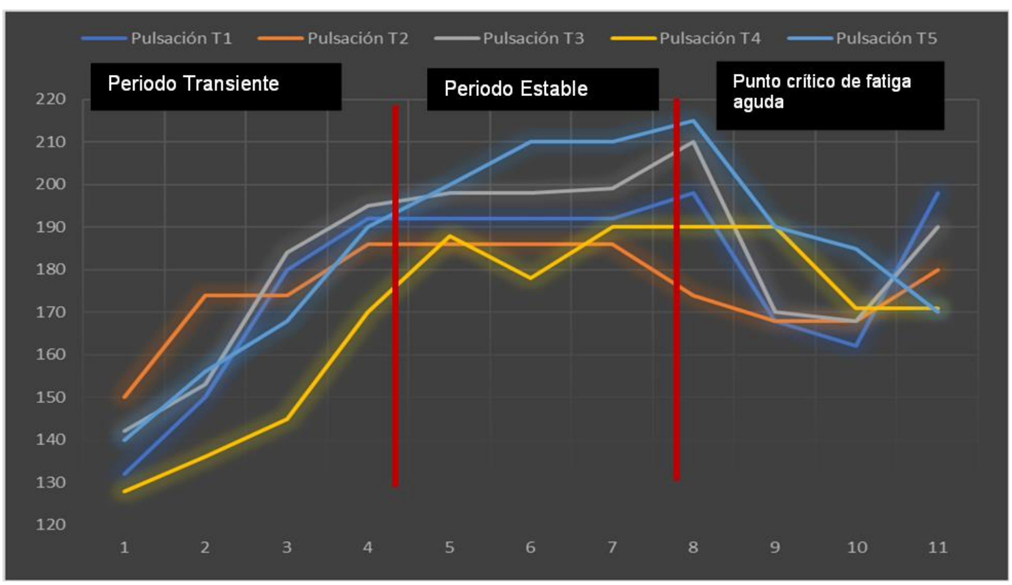

Figure 6: Heart Rate of Manual Material Handling Operators.

Figure 6 shows that there is a transient period where the heart rate rises rapidly, after that its growth can be considered stable and finally there comes a point where it decreases drastically, which indicates that the worker is at the critical point of acute fatigue.

5. CONCLUSIONS

The work overload that manual material handling contemplates carries with it an accelerated increase in the heart rates of the operators who carry out these activities. These increments occur in a very short period of time, moment at which there is an overload of work on the operator's cardiovascular system. In addition to this, a set of complex biomechanical mechanisms are framed by means of which the work is carried out. All this gradually affects the normal function of the cardiovascular system and there is a high possibility of developing heart disease.

The excitation - contraction - relaxation function that occurs in the muscles to perform the movement, demands oxygen for its activation, in this way the heart rate increases while performing the operation of manual lifting of loads.

Research shows how this type of work causes muscle contraction to go out of control from its normal function and does not demand oxygen, which causes its heart rate to decrease in full activity, this being the effect that indicates that the worker is at a point of acute fatigue.

When a worker is at the point of acute fatigue, there is the possibility that the muscle demands a large amount of oxygen and the heart rate is suddenly activated, which puts the health of the operator at high risk, which in extreme cases can go into cardiac arrest.

It is of the utmost importance that an analysis of manual assembly work is considered when the operating conditions are highly demanding and the worker is likely to present acute fatigue.

Ergonomics maintains two important guidelines in its study, the quality of life of the worker and the productive efficiency of the company. However, it is necessary that the studies focused on the manual handling of loads is considered as an extension in the search for acute fatigue and with this, the operator's health care is framed in more detail.

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ERGONOMIC ANALYSIS OF THE MUSCULOSKELETAL SYSTEM IN FISHERMEN OF PUERTO PEÑASCO, SONORA

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Resumen: El proyecto de investigación aplicada denominado "*Análisis Ergonómico del aparato locomotor en los pescadores de Puerto Peñasco Sonora*", tiene a bien analizar y describir hallazgos de las causas de afectación del sistema locomotor en los trabajos de pesca en la ciudad de Puerto Peñasco, Sonora. Para tal caso se desarrollaron tres etapas en el proceso metodológico: en la primera se identifica el sector de análisis, en la segunda se selecciona el instrumento de medición, el cual consiste en un cuestionario nórdico, basado en una serie de preguntas dedicadas a recolectar información acerca del estado del aparato locomotor principalmente de cuello, hombros y espalda lumbar; así mismo en menor especificación el instrumento también genera información relevante sobre las rodillas, tobillos y pies. En la tercera etapa se efectúa la aplicación del instrumento de medición a un grupo de pescadores de diferentes astilleros, los cuales mediante una entrevista brindan la información necesaria.

Finalizada la metodología, se registran los datos obtenidos en el programa estadístico SPSS proporcionando mediciones y representación gráfica de las diversas variables, como la edad, años de experiencia y los problemas en el aparato antes mencionado. Como resultado del análisis se presentan los elementos del aparato locomotor con mayor incidencia de desgaste en los pescadores de Puerto Peñasco Sonora, motivando con esto, futuros estudios más detallados.

Posterior al estudio de los datos, se genera la conclusión de los resultados, proponiendo a su vez sugerencias o recomendaciones de mejora en este o en próximos estudios.

Palabras clave: Pruebas ergonómicas, Cuestionario Nordico, Pescadorers.

Relevancia para la ergonomía: La relación entre la ergonomía y los aportes de este tipo de investigación es la posibilidad de obtener información oportuna y relevante que facilite a las empresas y personas cumplir con las condiciones y requisitos normativos, permitiendo la prevención de riesgos laborales, enfermedades profesionales y la mejora de la productividad. reduciendo los costes de pérdidas por accidentes o incapacidades constantes por una mala gestión de estos. Otra aportación sería en este caso, la detección de los factores que afectan al sistema musculoesquelético del individuo y emitir posibles recomendaciones para su prevención.

Abstract: The applied research project called "*Ergonomic analysis of the musculoskeletal system in fishermen of Puerto Peñasco, Sonora*", has the objective of analyzing and describing findings of the causes of affectation of the musculoskeletal system in fishing jobs in the city of Puerto Peñasco, Sonora. For this case, three stages were developed in the methodological process: in the first stage the sector of analysis is identified, in the second stage the measuring instrument is selected, which consists of a Nordic questionnaire, based on a series of questions dedicated to collect information about the condition of the musculoskeletal system, mainly the neck, shoulders and lumbar back; likewise, in less specification, the instrument also generates relevant information about the knees, ankles and feet. In the third stage, the measuring instrument is applied to a sample of fishermen from different shipyards, who, through an interview, provided the necessary information.

Once the methodology was completed, the data obtained were recorded in the SPSS statistical program, providing measurements and graphic representation of the different variables, such as age, years of experience and the problems in the aforementioned system. As a result of the analysis, the elements of the musculoskeletal system with the highest incidence of wear in the fishermen of Puerto Peñasco Sonora are presented, motivating with this, future more detailed studies. After the analysis of the data, the conclusion of the results is generated, proposing suggestions or recommendations for improvement in this and future research.

Key words: ergonomic testing, Nordic questionnaire, fishermen.

Relevance for Ergonomics: relationship between ergonomics and the contributions of this kind of research is the possibility of obtaining timely and relevant information that facilitates companies and individuals to comply with the conditions and regulatory requirements, allowing the prevention of occupational risks, occupational diseases, and the improvement of productivity, reducing the costs of losses by accidents or constant incapacity due to poor management of these. Another contribution would be in this case, the detection of the factors that affect the musculoskeletal system of the individual and issue possible recommendations for their prevention.

1. INTRODUCTION

Ergonomics aims to protect the worker's health by preventing important risks such as physical fatigue, mental fatigue and stress. Consequences of the application of this discipline in the workplace would have a faithful reflection on the creation of perfectly tolerable work environments, the reduction or elimination of dissatisfaction at work, resulting in the welfare and quality of work life (FUNDAMAR, 2013).

Due to its geographic characteristic, Puerto Peñasco, located in the northwest of the state of Sonora, has tourism and fishing as it is main sources of income, the latter being the reason for which the city was created and therefore, the oldest activity carried out; for this reason, it is really necessary to make efforts to determine the effects that such activity can bring to the individual involved in it.

In this sense, by observing the working conditions in which this activity is carried out, it certainly a useful investigation project to determinate work-related risk in the musculoskeletal system of the fishermen of Puerto Peñasco.

The main fishing activities that undoubtedly cause problems in the musculoskeletal system over time are:

- The constant movement of the ship: the swing of the boat, causes them not to be able to work in a stable way, resenting in their body this instability, according to the fishermen's own words.
- Working days: being at sea, the work is continuous and intense, in addition to working for long periods of time.
- The physical work environment: the fishermen work outdoors, continuously and with little protection.
- Spaces: the fishermen must learn to perform their job in confined or very small spaces in which it is very difficult for the human body to move properly.
- Rest: the resource of time, in the open sea, must be optimized for greater productivity, being almost impossible to have an adequate rest.
- Unhealthy conditions: because seafood products are perishable, they can generate diseases due to their handling and storage.
- Medical care: health complications caused by some type of accident or misfortune during the long shifts.

1.1 Objectives

To analyze and describe findings of the causes of musculoskeletal system affectation in fishing jobs in the city of Puerto Peñasco, Sonora.

1.2 Delimitation

Project is limited to specifically describing the physical conditions of the neck, shoulder and lumbar back due to fishing activity.

2. METHODOLOGY

To conduct the project, the following stages were carried out:

2.1 Sector identification to be analyzed

Analysis was carried out with a sample of fishermen living in the municipality of Puerto Peñasco, Sonora. These persons work aboard large and small or coastal boats in federal jurisdiction waters such as coastal marine waters, bays, estuarine lagoon systems and marshes of the northwest coast of the Mexican Pacific Ocean.

Based on information provided by CONAPESCA (Comisión Nacional de Acuacultura y Pesca), sea workers are classified as deep-sea fishermen, small-scale fishermen, aquaculture fishermen, and recreational or tourism fishermen. This study focuses on the first two cases, due to their physical working conditions, which differ from the others.

In addition, they point out that most of the marine products worked in this area are seasonal, with starting dates, but no official or limited closing dates. Products are shrimp, fish (tarpon fish, sole, triggerfish, whitecap, grouper), hake, shark, stingray and dogfish. For this reason, fishermen do not have stable rest periods or vacations, since they work if there is product to do so; that is, while it may not be shrimp season, they can work on hake, sole or triggerfish, or vice versa.

Nowadays there is no official and updated list of fishermen in the city in government agencies such as the Port Captaincy or CONAPESCA, so it is difficult to determine the size of the population and thus determine a sample size, as well as the type of probability sampling to use (CONAPESCA, 2022). Port Captaincy estimates that there are around 3,000 people dedicated to this activity, but they are not constant due to the product seasons, the conditions of the boats, and their own physical conditions (Capitanía de Puerto Peñasco, 2022).

Fishermen's activities are varied while they are at sea on a larger boat, but the maximum effort is on the deck of the boat since the product is on board and the tasks must be completed until it is stored for preservation in the cold rooms of the boat itself; in addition to the fact that these are trips of approximately 30 days. On the other hand, the activities of coastal boats; besides the time they spend at sea is from 1 to 3 days on average, the effort is slightly less due to the amount of work involved.

2.2 Measuring instrument selection

Fishing and aquaculture activities consist of catching and raising fish, crustaceans, mollusks and other saltwater and freshwater organisms to take advantage of some of nature's resources without transforming them. These activities, in addition to providing food, represent a source of income for many families (INEGI, 2020). Puerto Peñasco, in the State of Sonora, is a municipality dedicated to a greater extent to fishing and due to the importance of this activity in the population, it is suggested to propose practices that help improve the conditions for its realization.

In 2004, the World Health Organization defined musculoskeletal disorders (also called Locomotor System disorders) as those alterations that affect the muscles, tendons, nerves, skeletal and vascular system, impacting health with the probability of generating injuries ranging from mild to irreversible and incapacitating (Cedeño, 2021).

The Mexican Official Standard NOM-036-1-STPS-2018, Ergonomic Risk Factors at Work - Identification, analysis, prevention, and control, recommends the use of the Kuorinka Nordic questionnaire, since its purpose is to detect the existence of initial symptoms that have not yet been constituted as a disease, helping to collect information on pain, fatigue or body discomfort (DOF, 2020).

Article 132 of the Federal Labor Law establishes that it is the employer's obligation to comply with the regulations and official Mexican standards on safety, health and the working environment. And it is precisely in the Article 42 of the Federal Regulations on Occupational Safety and Health where establishes that employers must perform medical examinations of personnel occupationally exposed to ergonomic risk factors in the work center (IMSS, 2020).

Due to the above, it is necessary to obtain reliable information to identify whether there is a relationship between musculoskeletal disorders and fishing activities. These disorders are some of the most important pathologies in labor activities in many countries, significantly diminishing the quality of life of active workers, which causes great absenteeism and high costs not only due to the number of incapacities and treatments of these ailments, but also in the health of workers, thus reducing their performance and capacity.

In this sense, it was proposed to analyze if there is a relationship between fishing activity and disorders of the musculoskeletal system, carrying out a series of interviews with those involved in this activity. The study includes and relates the conditions and affectations of this system, due to the work carried out in this activity, in which variables such as age, years of experience in this activity, chronic ailments, medications used, among other variables added to the applied instrument.

The instrument validated by several studies, and which was used is the Kuorinka Nordic questionnaire for the analysis of musculoskeletal disorders (Kuorinka I, 1987) created by the Nordic Council of Ministers, and arises from the need to detect musculoskeletal disorders (MSD), highlighting the areas of the neck, shoulders and lumbar back, as well as to a lesser extent: wrist, knees and ankles. This consists of the application of a questionnaire with multiple choice items, dedicated to collect information about the condition of the musculoskeletal system, which can be filled out by the respondent or by means of an interview, which must be anonymous, and due to the simplicity of the language used, it is confirmed that it is valid to highlight the detection of discomfort in the case of the research study presented here, the way to carry it out was to travel to their work centers (loading and unloading dock) and conduct the interviews, in which it was possible to detect some of the working conditions to which fishermen are exposed.

This questionnaire consists of 10 general items, which are answered YES or NO. If the answer is YES, a couple of additional questions are asked in more detail. If the answer is NO, the questionnaire is continued. Immediately afterwards, if in any of the general questions there are affirmative answers (in reference to neck, shoulder and lumbar back), we proceed to an in-depth analysis involving items such as the fact of having suffered accidents, hospitalizations, incapacity in the last 12 months, discomfort in the last few days, among others.

This measurement instrument has proved to be very useful in the identification of disorders of the musculoskeletal system, yielding reliable information that can be translated into the search for alternatives for ergonomic improvements to working conditions. This questionnaire originated in the Scandinavian region and is applied in the field of occupational health, especially in research on ergonomics, with the aim of detecting symptoms that could anticipate the disease and seek alternatives for timely treatment to the same. As can be seen in the Mexican Official Standard NOM-036-1-STPS-2018, published in the Official Journal of the Federation, it is not considered a diagnostic tool, so it should only be used for the collection and analysis of information, which does not replace specialized clinical tests.

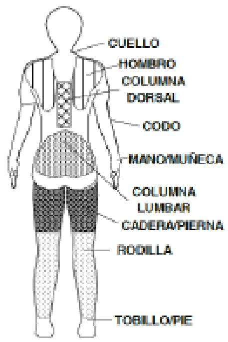
Figures 1 to 4 below show this instrument:

2.3 Measurement instrument application

The Nordic questionnaire was applied on a voluntary basis to a group of twenty active fishermen from different shipyards. It began with a brief introduction by the interviewer explaining what the research consisted of, presenting the instrument to be used and explaining the origin and objectives of the analysis. The sample was collected using the technique known as convenience or chance sampling, which is characterized by being non-probabilistic, since it selects the observations according to their access, and therefore there is no possibility of statistical inference in the results. In this case, conducting the interviews was complicated due to the place of work, available schedules, as well as the unwillingness of some of the employers. Since the objectives of this research are exploratory, it is considered that this data collection technique, as well as the sample size chosen, are sufficient to fulfill this purpose.

3. 3. RESULTS ANALYSIS

The results obtained from the application of the Nordic questionnaire to 20 active fishermen from different shipyards in the city of Puerto Peñasco Sonora, were processed in the statistical program SPSS, in which various simulations were performed between variables that indicated that the musculoskeletal organs most affected in them due to the activities related to their work were: shoulders, indicating that 65% of the sample had suffered from some pain or discomfort in this part of the body; likewise 50% of the workers agreed to have had some problem in the wrists/hands, same percentage found in knees.



CUESTIONARIO NÓRDICO ESTANDARIZADO DE KUORINKA

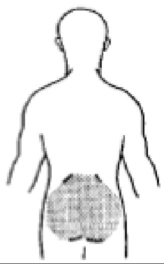
Cómo responder el cuestionario:

Responda poniendo una cruz en el cuadro apropiado: una cruz para cada pregunta. Puede tener dudas sobre cómo responder, pero por favor haga lo mejor de todos modos. Responda todas las preguntas, incluso si nunca tuvo problemas en cualquier parte de su cuerpo.

En esta imagen puede ver la posición aproximada de las partes del organismo al que se hace referencia en el cuestionario. Los límites no están bien definidos, y ciertas partes se superponen. Debes decidir por ti mismo en qué parte tiene o ha tenido su problema (si lo tiene).

Problemas con los órganos locomotores		
¿Alguna vez en los últimos 12 meses tuvo problemas (dolor, malestar) en:	Para ser respondido solo por aquellos que han tenido problemas	
	¿Se le ha impedido, en algún momento durante los últimos 12 meses, hacer su trabajo normal (en casa o fuera de casa) debido a los problemas?	¿Has tenido problemas en algún momento durante los últimos 7 días?
Cuello ( ) NO ( ) SI	( ) NO ( ) SI	( ) NO ( ) SI
Hombro ( ) NO ( ) Sí, en el hombro derecho ( ) Sí, en el hombro izquierdo ( ) Sí, en ambos hombros	( ) NO ( ) SI	( ) NO ( ) SI
Codos ( ) NO ( ) Sí, en el codo derecho ( ) Sí, en el codo izquierdo ( ) Sí, en ambos codos	( ) NO ( ) SI	( ) NO ( ) SI
Muñecas / manos ( ) NO ( ) Sí, en la muñeca/mano derecha ( ) Sí, en la muñeca/mano izquierda ( ) Sí, en ambas muñecas/manos	( ) NO ( ) SI	( ) NO ( ) SI
Columna Dorsal ( ) NO ( ) SI	( ) NO ( ) SI	( ) NO ( ) SI
Columna Lumbar ( ) NO ( ) SI	( ) NO ( ) SI	( ) NO ( ) SI
Una o ambas Caderas/Piernas ( ) NO ( ) SI	( ) NO ( ) SI	( ) NO ( ) SI
Una o ambas rodillas ( ) NO ( ) SI	( ) NO ( ) SI	( ) NO ( ) SI
Uno o ambos tobillos / pies ( ) NO ( )SI	( ) NO ( ) SI	( ) NO ( ) SI

Figure 1. Nordic questionnaire, page 1 of 4



CUESTIONARIO NÓRDICO ESTANDARIZADO ESPALDA LUMBAR

Cómo responder el cuestionario: Para problemas a nivel de la espalda lumbar, tome en cuenta las molestias, dolores y disconfort sufridos en la zona punteada que se muestra en la imagen. Limítese a esta zona y no cuente los dolores o molestias de las zonas adyacentes del cuerpo. Existe un cuestionario específico para cada zona.
Responda con una cruz en la respuesta más apropiada (una sola respuesta por pregunta). En caso de duda, elija la respuesta que más se acerque a su caso.

1	¿Alguna vez has tenido problemas en la espalda lumbar (molestia, dolor o disconfort)? ( ) NO ( ) SI

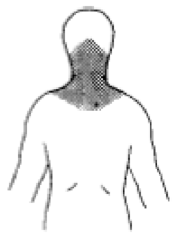
Si usted respondió NO a la Pregunta 1, NO responda las preguntas 2 a la 8

2	¿Alguna vez ha sido hospitalizado debido a problemas de espalda lumbar? ( ) NO ( ) SI
3	¿Alguna vez tuvo que cambiar de trabajo o tarea debido a problemas de la espalda lumbar? ( ) NO ( ) SI
4	¿Cuál es el tiempo total que usted ha tenido problemas de espalda lumbar durante los últimos 12 meses? ( ) 0 días ( ) 1 a 7 días ( ) 8 a 30 días ( ) Más de 30 días, pero no todos los días ( ) Todos los días

Si usted respondió 0 días a la pregunta 4, NO responda las preguntas 5 a la 8

5	¿Tiene un dolor de espalda lumbar que le hizo reducir su actividad durante los últimos 12 meses? a. ¿En actividades de trabajo (en la casa o fuera de la casa)? ( ) NO ( ) SI b. ¿En su tiempo libre? ( ) NO ( ) SI
6	¿Cuál es el tiempo total que los problemas de espalda lumbar le han impedido realizar su trabajo normal (en la casa o fuera de la casa) durante los últimos 12 meses? ( ) 0 días ( ) 1 a 7 días ( ) 8 a 30 días ( ) Más de 30 días
7	¿Ha sido consultado por un médico, fisioterapeuta, quiropráctico u otra persona debido a problemas de espalda lumbar durante los últimos 12 meses? ( ) NO ( ) SI
8	¿Ha tenido problemas de espalda lumbar en cualquier momento durante los últimos 7 días? ( ) NO ( ) SI

Figure 2. Nordic questionnaire, page 2 of 4



CUESTIONARIO NÓRDICO ESTANDARIZADO CUELLO

Cómo responder el cuestionario: Para problemas a nivel del cuello, tome en cuenta las molestias, dolores y disconfort sufridos en la zona punteada que se muestra en la imagen. Limítese a esta zona y no cuente los dolores o molestias de las zonas adyacentes del cuerpo. Existe un cuestionario específico para cada zona.
Responda con una cruz en la respuesta más apropiada (una sola respuesta por pregunta). En caso de duda, elija la respuesta que más se acerque a su caso.

1 ¿Alguna vez has tenido problemas en el cuello (molestia, dolor o disconfort)?
( ) NO ( ) SI

Si respondió NO a la Pregunta 1, no responda las preguntas 2—8

2 ¿Alguna vez te has lastimado el cuello en un accidente?
( ) NO ( ) SI

3 ¿Alguna vez tuvo que cambiar de trabajo o tareas debido a problemas del cuello?
( ) NO ( ) SI

4 ¿Cuál es el tiempo total que usted ha tenido problemas del cuello durante los últimos 12 meses?
( ) 0 días
( ) 1 a 7 días
( ) 8 a 30 días
( ) Más de 30 días, pero no todos los días
( ) Todos los días

Si respondió 0 días a la pregunta 4, no responda las preguntas 5—8

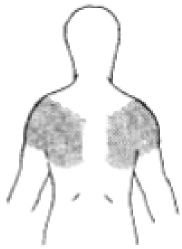
5 ¿Tiene un dolor del cuello que le hizo reducir su actividad durante los últimos 12 meses?
a. ¿En actividades de trabajo (en la casa o fuera de la casa)?
( ) NO ( ) SI
b. ¿En su tiempo libre?
( ) NO ( ) SI

6 ¿Cuál es el tiempo total que los problemas del cuello le han impedido realizar su trabajo normal (en la casa o fuera de la casa) durante los últimos 12 meses?
( ) 0 días
( ) 1 a 7 días
( ) 8 a 30 días
( ) Más de 30 días

7 ¿Ha sido consultado por un médico, fisioterapeuta, quiropráctico u otra persona debido a problemas del cuello durante los últimos 12 meses?
( ) NO ( ) SI

8 ¿Ha tenido problemas de espalda lumbar en cualquier momento durante los últimos 7 días?
( ) NO ( ) SI

Figure 3. Nordic questionnaire, page 3 of 4



CUESTIONARIO NÓRDICO ESTANDARIZADO HOMBRO

Cómo responder el cuestionario: Para problemas a nivel del hombro, tome en cuenta las molestias, dolores y disconfort sufridos en la zona punteada que se muestra en la imagen. Limítese a esta zona y no cuente los dolores o molestias de las zonas adyacentes del cuerpo. Existe un cuestionario específico para cada zona.
Responda con una cruz en la respuesta más apropiada (una sola respuesta por pregunta). En caso de duda, elija la respuesta que más se acerque a su caso.

1 ¿Alguna vez has tenido problemas en el hombro (molestia, dolor o disconfort)?
( ) NO ( ) SI

Si respondió NO a la Pregunta 1, no responda las preguntas 2 a la 9

2 ¿Alguna vez te has lastimado el hombro en un accidente?
( ) NO
( ) SI, mi hombro derecho
( ) SI, mi hombro izquierdo
( ) SI, ambos hombros

3 ¿Alguna vez tuvo que cambiar de trabajo o tareas debido a problemas del hombro?
( ) NO ( ) SI

4 ¿Has tenido problemas en el hombro durante los últimos 12 meses?
( ) No
( ) SI, en mi hombro derecho
( ) SI, en mi hombro izquierdo
( ) SI, en ambos hombros

Si respondió No en la pregunta 12, no responda las preguntas 5 a la 9

5 ¿Cuál es el tiempo total que ha tenido problemas en el hombro durante los últimos 12 meses?
( ) 1-7 días
( ) 8-30 días
( ) Mas de 30 días, pero no todos los días
( ) Todos los días

6 ¿Tiene un dolor del hombro que le hizo reducir su actividad durante los últimos 12 meses?
a. ¿En actividades de trabajo (en la casa o fuera de la casa)?
( ) NO ( ) SI
b. ¿En su tiempo libre?
( ) NO ( ) SI

7 ¿Cuál es el tiempo total que los problemas del hombro le han impedido realizar su trabajo normal (en la casa o fuera de la casa) durante los últimos 12 meses?
( ) 0 días
( ) 1 a 7 días
( ) 8 a 30 días
( ) Más de 30 días

8 ¿Ha sido consultado por un médico, fisioterapeuta, quiropráctico u otra persona debido a problemas de hombro durante los últimos 12 meses?
( ) NO ( ) SI

9 ¿Ha tenido problemas de hombro en cualquier momento durante los últimos 7 días?
( ) NO ( ) SI

Figure 4. Nordic questionnaire, page 4 of 4

Graphical representation of the above results is shown below (Figures 5, 6 and 7):

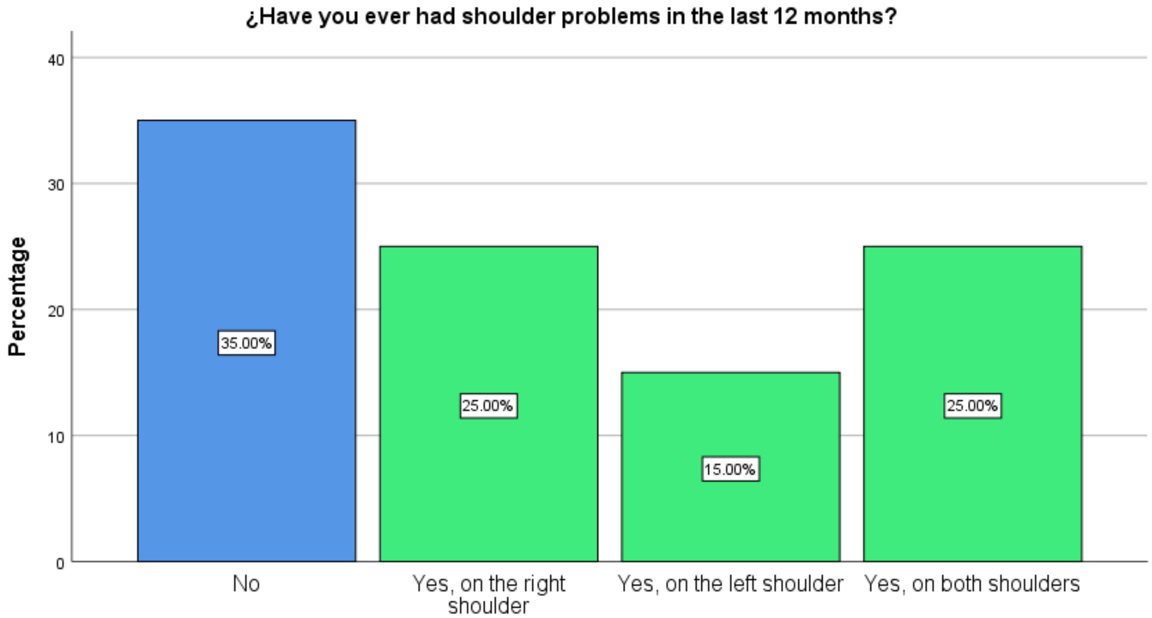


Figure 5. Shoulder problem.

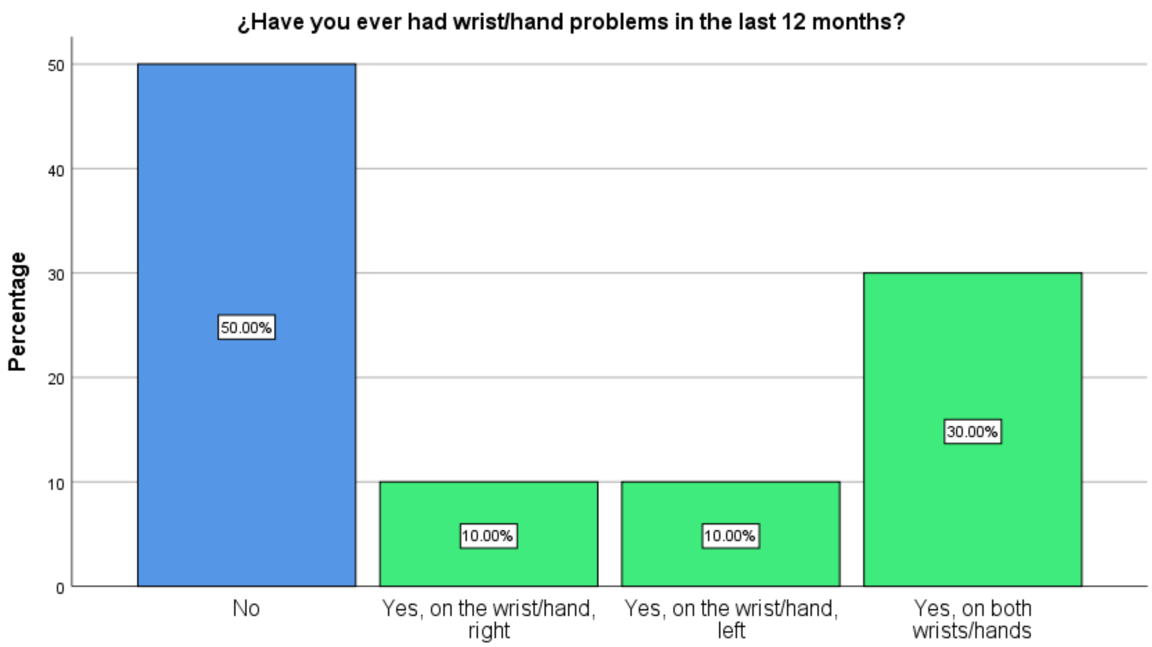


Figure 6. Wrist/ hand problem.

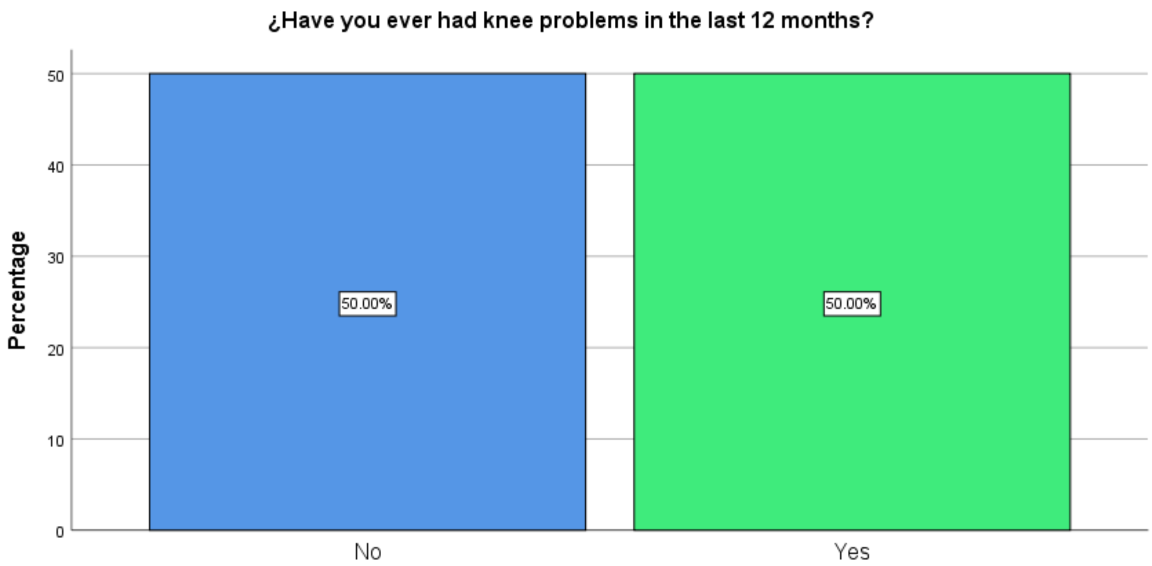


Figure 7. Knee problem.

Another of the results obtained in the research, which is considered highly relevant, is that the average age of the fishers is approximately 50 years with a standard deviation of 14 years; in other words, the ages of most of those surveyed are between 36 and 64 years old. On the other hand, the average time of work experience in fishing is 29 years with a deviation of 14 years, indicating that most of the fishermen have at least 15 years of experience in this activity.

4. CONCLUSIONS AND RECOMMENDATIONS

Based on the results obtained, it is concluded that the problems or damage to the musculoskeletal system of fishermen in the city of Puerto Peñasco, Sonora, are not only related to the age and working time dedicated to this activity, but also to the conditions of the work area, the repetitive processes and the execution times of the activities. In view of this, it is important to deepen the analysis of these aspects and propose measures for attention and prevention in order to promote a better quality of working life in companies dedicated to fishing extraction.

Likewise, it is recommended that the measurement instrument be adapted, since it does not generate timely information on some aspects that were outstanding in discomfort, as is the case of the wrists/hands and knees.

On the other hand, as was seen in the methodology, the type of exploratory sampling, in spite of the small number of elements, generated base information to investigate that there is a significant problem in the musculoskeletal system affectation in the fishermen of Puerto Peñasco, giving rise to the development of future research; It is recommended that a formal registry of active fishermen, as well as the type of ship in which they work, be made before the corresponding agency in order to have a consolidated database that will serve as a statistical basis for research in the sector.

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PHYSICAL CONDITION AND FATIGUE ASSESSMENT OF A FRUIT STAND

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Resumen: El empleo informal se refiere a la actividad laboral de los trabajadores independientes, los vendedores ambulantes, las trabajadoras de servicio doméstico, los limpiavidrios, entre otros. Este tipo de empleos, por lo general, son mal remunerados y ofrecen condiciones laborales deficientes. Además, debido a que no cuentan con la debida protección legal para las relaciones laborales, son empleos sin protección social, que no brindan estabilidad económica para los trabajadores.

Según la Organización Internacional del Trabajo (OIT), el empleo informal representa entre 50% y 75% del empleo en sectores no agrícolas en los países en desarrollo. No obstante, el empleo informal no solo causa grandes pérdidas a la economía de un país en materia tributaria, sino que también perjudica a todos aquellas personas que se ven obligadas a aceptar empleos informales, donde sus derechos laborales no son respetados.

Este estudio se realizó con el fin de determinar las condiciones de trabajo en las que labora una persona comerciante de snacks, poder encontrar qué condiciones afectan de manera negativa al trabajador y los problemas que puede causar y así poder tomar medidas de control que conlleva a mejorar aquellas condiciones de trabajo que hacen que disminuya el rendimiento de la trabajadora.

La fatiga laboral se define como una sensación de agotamiento que se experimenta después de un trabajo físico o intelectual asociado al puesto de trabajo, prolongado o intenso y que consiste en un cansancio extremo tanto a nivel físico como mental. Cuando esta persiste en el tiempo puede llegar a transformarse en fatiga crónica. Es una falta de energía y de motivación. Puede ser una respuesta normal e importante al esfuerzo físico, al estrés emocional, al aburrimiento o a la falta de sueño. La fatiga es un síntoma común y por lo regular no se debe a una enfermedad seria. Pero puede ser un signo de un trastorno físico o mental más grave. Cuando la fatiga no se alivia con dormir bien, nutrirse bien o tener un ambiente de bajo estrés debe ser evaluada por su proveedor de atención médica.

Cabe señalar que el óptimo desempeño de los trabajadores depende básicamente de las condiciones de trabajo en que éste se desempeña.

El medio ambiente de trabajo es uno de los elementos fundamentales de clara importancia en el comportamiento, rendimiento y motivación del trabajador, afectando directamente la salud, su desempeño y su comodidad. Es el resultado del clima laboral, de la tecnología, de los medios y procedimientos del trabajo y del entorno del puesto, en el cual confluye una serie de condiciones visibles que el trabajador no ve, pero percibe, siente y asimila o rechaza.

Palabras claves: Salud, ergonomía, fatiga.

Relevancia para la ergonomía: Se busca que en los trabajos informales también se cuenten con investigaciones que aporten a la corrección de las condiciones laborales y la fatiga que puedan presentarse en el trabajo, de una manera correcta para que el trabajador se encuentre en un área de trabajo favorable

Abstract: Informal employment refers to the labor activity of self-employed workers, street vendors, domestic service workers, and window cleaners, among others. These types of jobs are generally poorly paid and offer poor working conditions. In addition, because they do not have due legal protection for labor relations, they are jobs without social protection, which do not provide economic stability for workers.

According to the International Labor Organization (ILO), informal employment accounts for between 50% and 75% of employment in non-agricultural sectors in developing countries. However, informal employment not only causes great losses to a country's economy in terms of taxes, but also harms all those who are forced to accept informal jobs, where their labor rights are not respected.

This study was conducted in order to determine the working conditions in which a snack merchant works, to find out what conditions negatively affect the worker and the problems that can cause and thus be able to take control measures that lead to improve those working conditions that cause the worker's performance to decrease.

Work fatigue is defined as a feeling of exhaustion experienced after physical or intellectual work associated with the job, prolonged or intense and consisting of extreme fatigue both physically and mentally. When this persists over time, it can become chronic fatigue. It is a lack of energy and motivation. It can be a normal and important response to physical exertion, emotional stress, boredom or lack of sleep. Fatigue is a common symptom and is usually not due to a serious illness. But it may be a sign of a more serious physical or mental disorder. When fatigue is not relieved by good sleep, good nutrition, or a low-stress environment, it should be evaluated by your health care provider.

It should be noted that optimal worker performance depends primarily on the working conditions in which the worker performs.

The work environment is one of the fundamental elements of clear importan0ce in the behavior, performance and motivation of the worker, directly affecting health, performance and comfort. It is the result of the work climate, technology, work means and procedures and the work environment, in which a series of visible conditions that the worker does not see, but perceives, feels and assimilates or rejects, converge.

Key words: Health, ergonomics, fatigue.

Relevance for ergonomics: It is sought that in informal jobs there are also investigations that contribute to the correction of working conditions and fatigue that may occur at work, in a correct way so that the worker is in a favorable work area.

1. INTRODUCTION

Safety and health at work is of great concern to most workers. Every work activity takes place in a work space and workstation, where the characteristics of the environment, the design of the workstations and the general physical conditions of the workers coincide.

The jobs on public roads do not usually have a regulation regarding compliance with safety standards, as they are usually informal jobs, these types of work also require attention and the application of ergonomics, as reported by (INEGI, 2021), "The informal employed population, which includes those employed who are labor vulnerable by the nature of the economic unit for which they work, such as those whose labor link or dependence is not recognized by their work source." The environmental evaluation of the workplace makes it possible to determine the appropriate structure and configuration of such jobs, which is essential to prevent health alterations and promote worker productivity.

2. OBJECTIVES

General Objective:
To know, measure the sources of lighting, temperature, vibration, noise and ventilation in the work environment, to know the physical conditions of the worker, in order to safeguard their health and welfare to know what measures can improve efficiency and safety at work.

Specific objectives:

- Analyze and assess the appropriate levels of: Lighting, temperature, vibration, vibration, noise and ventilation.
- Analyze and evaluate the principles of occupational ergonomics.
- Analyze the different forms of fatigue presentation and the contributing factors arising from the environment, work and work organization.
- Measuring fatigue by Yoshitake questionnaire.
- Measure physical conditions to determine if they are in compliance with NOM-025,
- Measure psychosocial factors to determine compliance with NOM-035.

3. METHODOLOGY

The work area is a 2.50 * 2.50 m. space, the worker performs the activities of chopping fruit, preparing chamoy and sauces, as well as preparing peanut/fruit cups, these activities are performed standing up.

Image 1. Work area.

3.1 Evaluation of physical conditions

3.1.1 Lighting

The light levels were measured with an application called "Luxometer" in the 3 places where the workers work the most in the booth.

Table 1. Illumination level by work areas

NIVEL DE ILUMINACIÓN (LUX) POR PUESTOS DE TRABAJO				
Punto de medición	Ubucación	Nivel de iluminación encontrado	Nivel mínimo de luminación NOM-025-STPS-2008	Cumple con la norma
1	Mesa de preparado	252	200	SI
2	Mesa de corte de frutas	227	200	SI
3	Esquina, llenado de clamato	146	200	NO

3.1.2 Temperature

The temperature level was measured using an application called "thermometer".

Table 2. Temperature level by work areas.

NIVEL DE TEMPERATURA (°C) POR PUESTOS DE TRABAJO				
Punto de medición	Ubucación	Nivel de temperatura encontrado	Nivel máximo termico abatidas NOM-015-STPS-2001	Cumple con la norma
1	Mesa de preparado	31	30	NO
2	Mesa de corte de frutas	31	30	NO
3	Esquina, llenado de clamato	31	30	NO

3.1.3 Noise

The noise level was measured using an application called "sonometer" and taking a maximum permissible exposure level of 90 dB, as established by NOM-011-STPS-2001, as the exposure limit for an 8-hour work shift.

Table 3. Noise level by work areas.

NIVEL DE RUIDO(dB) POR PUESTOS DE TRABAJO				
Punto de medición	Ubucación	Nivel de ruido encontrado	Nivel máximo premisible de exposición NOM-011-STPS-2001	Cumple con la norma
1	Mesa de preparado	68	90dB(A)	SI
2	Mesa de corte de frutas	58	90dB(A)	SI
3	Esquina, llenado de clamato	56	90dB(A)	SI

3.1.4 Vibration

The vibration level was measured, using an application called "vibrometer" and taking a maximum permissible exposure level of 8 m/s².

Table 4. Vibration level by work areas.

NIVEL DE VIBRACIÓN() POR PUESTOS DE TRABAJO				
Punto de medición	Ubucación	Nivel de vibración encontrado	Nivel máximo de vibración NOM-024-STPS-2001	Cumple con la norma
1	Mesa de preparado	1.01 m/s^2	8 m/s^2	SI
2	Mesa de corte de frutas	2.5 m/s^2	8 m/s^2	SI
3	Esquina, llenado de clamato	0.98/s^2	8 m/s^2	SI

3.1.5 Ventilation

The level of ventilation was measured visually, to perceive if there was good air circulation.

Table 5. Ventilation level by work areas.

NIVEL DE VENTILACIÓN POR PUESTOS DE TRABAJO				
Punto de medición	Ubucación	Nivel de ventilación encontrado	Nivel mínimo de ventilación	Cumple con la norma
1	Mesa de preparado	Bueno	Espacio cerrado sin paso de aire, o sin algún mecanismo de ventilación	SI
2	Mesa de corte de frutas	Bueno	Espacio cerrado sin paso de aire, o sin algún mecanismo de ventilación	SI
3	Esquina, llenado de clamato	Bueno	Espacio cerrado sin paso de aire, o sin algún mecanismo de ventilación	SI

3.2 Fatigue evaluation

To evaluate work-related fatigue, two tests were performed on the worker during the course of the week to find out how he/she was at the beginning and end of the workday.

3.2.1 YOSHITAKE

The Yoshitake questionnaire consists of 30 questions which are divided into three important groups to analyze the worker during the workday to identify if the worker develops fatigue during the workday or if at the beginning of the workday he/she suffers from this problem, which could be caused by problems external to the work. The items to be evaluated were: group A; symptoms of drowsiness and monotony (Image 1), group B symptoms of difficulty concentrating (Image 2), and group C bodily symptoms or projection of damage (Image 3), with these three groups the worker had to answer these questions with "yes or "no" to examine whether the worker is in a state of fatigue.

The following weightings were taken into account to determine the level of worker fatigue.

10 – 20 FATIGA
30 – 40 MODERATE FATIGUE
50 EXCESSIVE FATIGUE

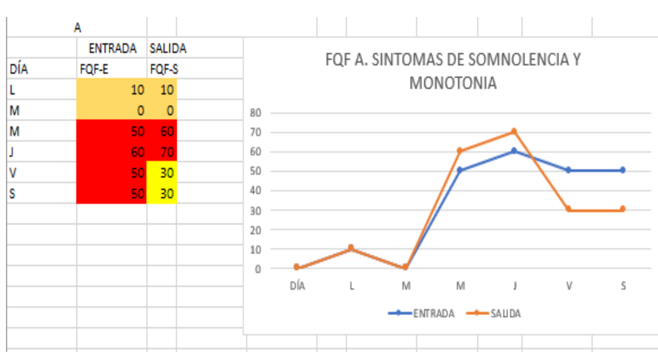
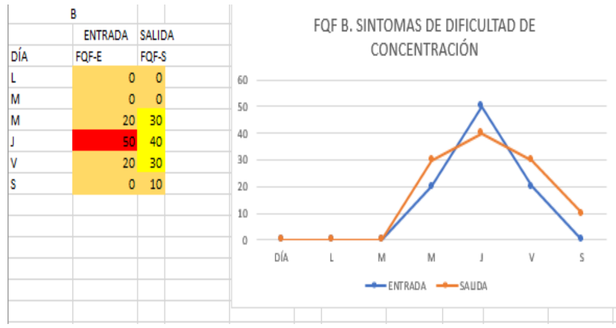


Figure 1. Symptoms of drowsiness and monotony.

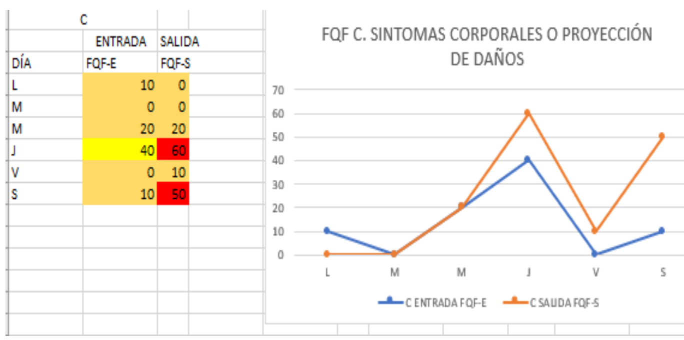
In the graph it can be seen that there is an increase in general terms, both in the output and in the input, and it is shown at different levels.



B		
	ENTRADA	SALIDA
DÍA	FQF-E	FQF-S
L	0	0
M	0	0
M	20	30
J	50	40
V	20	30
S	0	10

Figure 2. Symptoms of concentration difficulties

It is observed in the graph that the worker presents excessive fatigue on Thursday at the entrance, that this can be generated by external factors of the work, since when leaving he has a moderate level of fatigue, which means that in the course of his working day was able to recover.



C		
	ENTRADA	SALIDA
DÍA	FQF-E	FQF-S
L	10	0
M	0	0
M	20	20
J	40	60
V	0	10
S	10	50

Figure 3. Bodily symptoms or projection of damage

It can be seen that in two days there is a level of excessive fatigue, at the end of the working day, so that the rest of the days is relatively moderate.

3.2.2.4 LUKE POINTS

Luke's 4-point test catalogs fatigue levels after a normal workday, where the measurement scale is as follows: "not tired at all" which has a value of 1 point, "tired" 2 points, "very tired" 3 points and "extremely tired" 4 points.

	LUNES	MARTES	MIERCOLES	JUEVES	VIERNES	SABADO
AL INICIAR JORNADA	1	1	2	1	2	2
AL TERMINAR JORNADA	2	2	2	1	2	2

1. NADA CANSADO
2. CANSADO
3. MUY CANSADO
4. EXTREMADAMENTE CANSADO

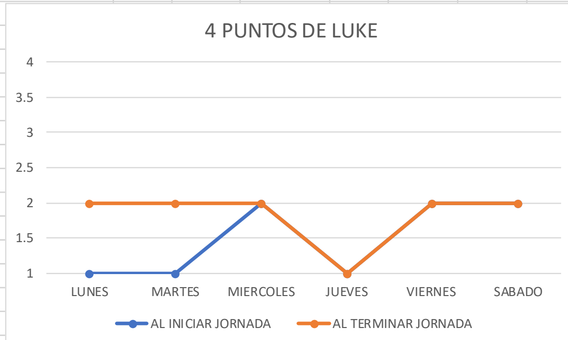


Figure 4. Results of Luke's 4-point test.

In the graph it can be seen that the worker regularly shows fatigue at the exit, and the last days of the week the fatigue is also present at the entrance, so the work carried out by the worker presents a practically constant fatigue.

3.2.3 Evaluation of Musculoskeletal Disorders (MSD) or Cumulative Trauma Disorders (CTD) by Corlett & Bishop Mapping.

For the Corlett and Bishop evaluation, the discomfort or pain presented by the worker in different parts of the body were taken into account, using the Corlett and Bishop body map, in which the parts of the body where the worker feels discomfort or pain must be marked.

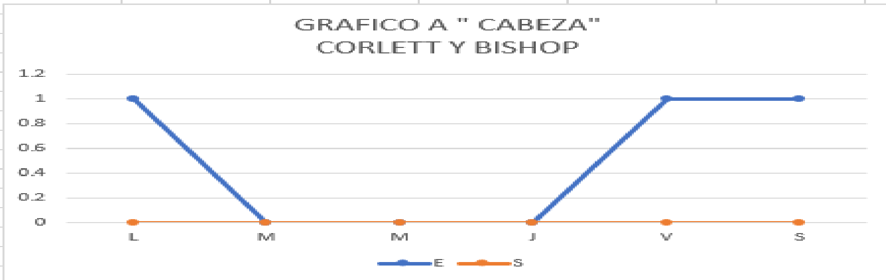
Table 6. Corlett and Bishop's evaluation.

	L		M		M		J		V		S	
	E	S	E	S	E	S	E	S	E	S	E	S
A	1	0	0	0	0	0	0	0	1	0	1	0
B	0	0	0	1	0	0	1	1	0	0	0	0
C	0	1	1	0	0	0	0	0	0	0	0	0
D												
E												
F												
G	0	0	0	0	0	0	0	0	0	1	0	0
H												
I												
J												
K												
L												
M												
N												
O	0	0	0	0	1	1	0	0	0	0	0	2

1 MOLESTIA
2 DOLOR

Table 7. Evaluation of body parts (head).

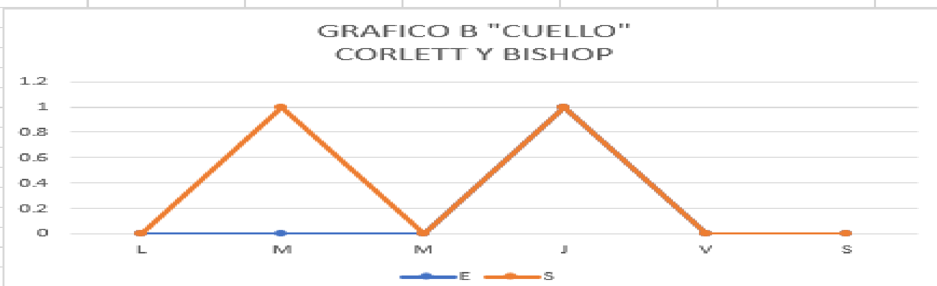
	L	M	M	J	V	S
E	1	0	0	0	1	1
S	0	0	0	0	0	0



In this graph it can be seen that the worker has headaches some days of the week, but this only at the entrance, and at the exit he no longer has these discomforts, so the work he does doesn´t cause it.

Table 8. Evaluation of body parts (neck).

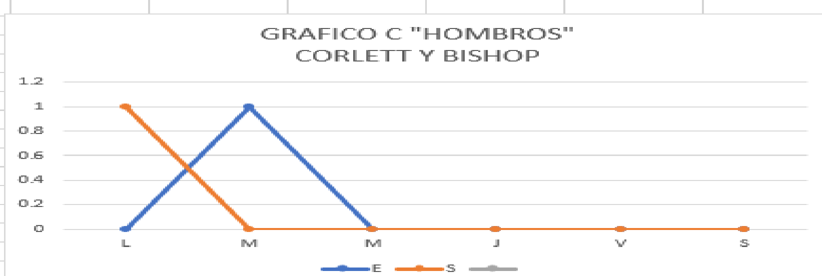
	L	M	M	J	V	S
E	0	0	0	1	0	0
S	0	1	0	1	0	0



In this graph it can be seen that the worker has neck discomfort occasionally at the exit, so it can be said that the work performed by the worker cannot be causing it.

Table 9. Evaluation of body parts (shoulders).

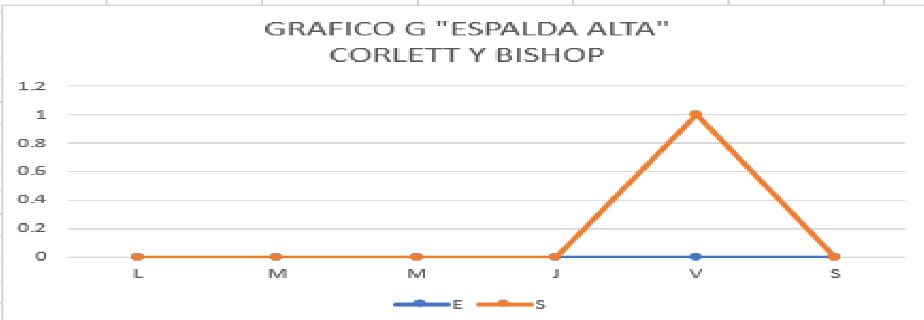
	L	M	M	J	V	S
E	0	1	0	0	0	0
S	1	0	0	0	0	0



In this graph it can be seen that the worker has occasional discomfort in the shoulders, this occurs at the exit and when he enters the next day he continues with discomfort, so the work carried out by the worker causes it.

Table 10. Evaluation of body parts (upper back),

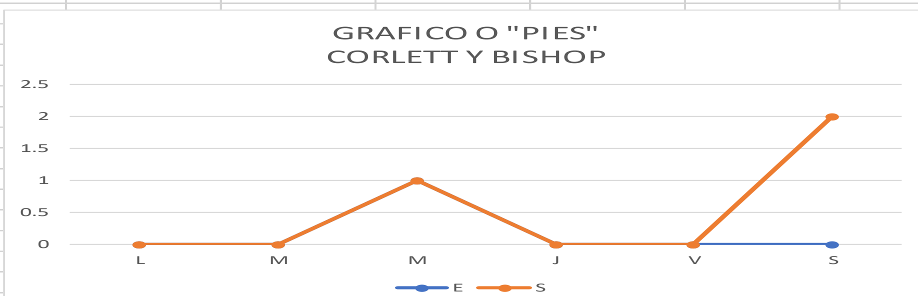
	L	M	M	J	V	S
E	0	0	0	0	0	0
S	0	0	0	0	1	0



In this graph it can be seen that the worker seldom has discomfort in the upper back at the exit, so the work performed by the worker does not cause it

Table 11. Evaluation of body parts (feet).

	L	M	M	J	V	S
E	0	0	1	0	0	0
S	0	0	1	0	0	2



In this graph it can be seen that the worker has occasional discomfort or pain in the feet when leaving, so the work performed by the worker can cause said pain.

3.3 Psychosocial Risk Assessment (NOM-035-STPS-2018)

Tables were generated according to this standard, in order to know what types of factors put the worker's physical or mental health at risk.

		Always	Almost always	Some Sometimes	Almost never	Nunca
1	My job requires me to exert a lot of physical effort				1	
	I am worried about having an accident at work					0
	I consider the activities I perform to be dangerous.					0
	Due to the amount of work I have to stay additional time after my shift.					0
5	Due to the amount of work I have, I have to work non-stop.					0
	I believe it is necessary to maintain an accelerated pace of work.					
	My job requires me to be very focused					
	My job requires me to memorize a lot of information					0
	My job requires me to attend to several issues at the same time.					

The following questions are related to the activities you perform in your job and the responsibilities you have.

		Always	Almost always	Some Sometimes	Almost never	Nunca
	In my job, I am responsible for things of great value.					
	I am accountable to my manager for the results of my entire work area.					
	I get contradictory orders at work					0
	I feel that in my job I am asked to do unnecessary things.					0

The following questions are related to your work time and family responsibilities.

		Always	Almost always	Some Sometimes	Almost never	Nunca
	I work overtime more than three times a week.					0
	My job requires me to work on days off, holidays or weekends.					
	I consider that the time spent at work is too much and detrimental to my family or personal activities.					0
	I think about family or personal activities when I am at work.					

The following questions are related to decisions you can make in your job.

		Always	Almost always	Some Sometimes	Almost never	Never
	My job allows me to develop new skills	0				
	In my job, I can aspire to a better position.					
	During my workday, I can take breaks when I need them.	0				
	I can decide the speed at which I carry out my activities in my job	0				
	I can change the order of the activities I perform at work.					

The following questions are related to the training and information you receive about your job.

		Always	Almost always	Some Sometimes	Almost never	Never
	I am clearly informed of my duties	0				
	They clearly explain to me the results that I must obtain in my work	0				
	They inform me with whom I can solve problems or work issues.	0				
	I am allowed to attend training related to my job.	0				
	I receive useful training to do my job	0				

The following questions refer to your relationships with your co-workers and your boss.

		Always	Almost always	Some Sometimes	Almost never	Never
	My boss takes my views and opinions into account	0				
	My boss helps solve problems at work.	0				
	I can trust my coworkers	0				
	When we have to carry out teamwork, our colleagues collaborate		1			
	My coworkers help me when I have difficulties	0				
	In my work I can express myself freely without interruption.	0				
	I receive constant criticism of my person and/or work.					0
	I receive mockery, slander, defamation, humiliation or ridicule.					0
	My presence is ignored or I am excluded from work meetings and decision making.					0
	Work situations are manipulated to make me appear to be a bad worker.					0
	My work successes are ignored and attributed to other workers					0
	They block or impede my opportunities for promotion or improvement in my job.					0
	I have witnessed acts of violence in my workplace.					0

The following questions are related to customer and user service.

In my job I have to provide service to customers or users:	Yes	X
	No	

If you answered "YES", answer the following questions. If your answer was "NO" go to the questions in the next section.

		Always	Almost always	Some Sometimes	Almost never	Never
	I attend to very angry customers or users				1	
42	My job requires me to take care of people in need of help or who are ill.					0
	To do my job I must demonstrate feelings other than my own.					0

I am the boss of other workers:	Yes	
	No	X

If your answer was "YES", please answer the following questions. If your answer was "NO", you have completed the questionnaire.

The following questions are related to the attitudes of the workers you supervise.

		Always	Almost always	Some Sometimes	Almost never	Never
	Late communication of work issues					

45	hinder the achievement of work results					
	They ignore suggestions to improve their work					

		Always	Almost always	Some Sometimes	Almost never	Never
1	The space where I work allows me to perform my activities in a safe and hygienic manner.	0				
	My job requires me to exert a lot of physical effort					0
	I am worried about having an accident at work					0
	I consider that in my work the occupational safety and health standards are applied.	0				
5	I consider the activities I perform to be dangerous.					0

To answer the following questions, think about the amount and pace of your work.

		Always	Almost always	Some Sometimes	Almost never	Never
	Due to the amount of work I have to stay additional time after my shift.				1	
	Due to the amount of work I have, I have to work non-stop.					0
	I believe it is necessary to maintain an accelerated pace of work.					

The following questions are related to the mental effort your work demands of you.

		Always	Almost always	Some Sometimes	Almost never	Never
	My job requires me to be very focused					
	My job requires me to memorize a lot of information				1	
	In my job, I have to make difficult decisions very quickly.					0
	My job requires me to attend to several issues at the same time.					

The following questions are related to the activities you perform in your job and the responsibilities you have.

		Always	Almost always	Some Sometimes	Almost never	Never
	In my job, I am responsible for things of great value.					
	I am accountable to my manager for the results of my entire work area.					
	I get conflicting orders at work				1	
	I feel that in my job I am asked to do unnecessary things.				1	

The following questions are related to your workday.

		Always	Almost always	Some Sometimes	Almost never	Never
	I work overtime more than three times a week.					0
	My job requires me to work on days off, holidays or weekends.					
	I consider that the time spent at work is too much and it is detrimental to my family or personal activities.					0
	I must attend to work matters when I am at home					0
	I think about family or personal activities when I am at work.					

	I feel that my family responsibilities affect my work				1	

The following questions are related to decisions you can make in your job.

		Always	Almost always	Some Sometimes	Almost never	Never
	My job allows me to develop new skills	0				
	In my job, I can aspire to a better position.					
	During my workday, I can take breaks when I need them.	0				
	I can decide how much work I do during the workday.					
	I can decide the speed at which I carry out my activities in my job	0				
	I can change the order of the activities I perform at work.					

The following questions are related to any type of change occurring in your job (consider the last changes made).

		Always	Almost always	Some Sometimes	Almost never	Never
	Changes in my job make my work more difficult.					0
	When changes are made to my work, my ideas or contributions are taken into account.	0				

The following questions are related to the training and information provided to you about your job.

		Always	Almost always	Some Sometimes	Almost never	Never
	I am clearly informed of my duties	0				
	They clearly explain to me the results that I must obtain in my work	0				
	The objectives of my work are clearly explained to me	0				
	They inform me with whom I can solve problems or work issues.	0				
	I am allowed to attend training related to my job.	0				
	I receive useful training to do my job	0				

The following questions are related to the boss(es) with whom you have contact.

		Always	Almost always	Some Sometimes	Almost never	Never
	My boss helps me organize my work better	0				
	My boss takes my views and opinions into account	0				
	My boss communicates work-related information to me in a timely manner	0				
	The guidance I get from my boss helps me to perform my job better.	0				
	My boss helps solve problems at work.	0				

The following questions refer to relationships with peers.

		Always	Almost always	Some Sometimes	Almost never	Never
42	I can trust my coworkers	0				
	Among colleagues, we solve work problems in a respectful manner.	0				
	In my job I am made to feel part of the group	0				
45	When we have to carry out teamwork, our colleagues collaborate	0				
	My coworkers help me when I have difficulties	0				

The following questions are related to the information you receive about your job performance, recognition, sense of belonging and stability offered by your job.

		Always	Almost always	Some Sometimes	Almost never	Never
	They inform me about what I do well in my job.	0				
	The way my work is evaluated at my workplace helps me to improve my performance.	0				
	I am paid my salary on time at my workplace.	0				
	The pay I receive is what I deserve for the work I do.	0				
	If I obtain the expected results in my work, I am rewarded or recognized.	0				
	People who do the job well can grow in the workplace	0				
	I consider my job to be stable	0				
	In my job there is a continuous rotation of personnel	0				
	I am proud to work in this work center.	0				
	I feel committed to my work	0				

The following questions are related to acts of workplace violence (mistreatment, harassment, bullying, psychological harassment).

		Always	Almost always	Some Sometimes	Almost never	Never
	In my work I can express myself freely without interruption.	0				
58	I receive constant criticism of my person and/or work.					0
	I receive mockery, slander, defamation, humiliation or ridicule.					0
	My presence is ignored or I am excluded from work meetings and decision making.					0
	Work situations are manipulated to make me appear to be a bad worker.					0
	My work successes are ignored and attributed to other workers					0
	They block or impede my opportunities for promotion or improvement in my job.					0
	I have witnessed acts of violence in my workplace.					0

The following questions are related to customer and user service.

In my job I have to provide service to customers or users:

Yes	X
No	

If you answered "YES", answer the following questions. If your answer was "NO" go to the questions in the next section.

		Always	Almost always	Some Sometimes	Almost never	Never
	I attend to very angry customers or users				1	
	My job requires me to take care of people in need of help or who are ill.					0
	To do my job I must demonstrate feelings other than my own.					0
	My job requires me to deal with situations of violence					0

I am the boss of other workers:

Yes	
No	X

If your answer was "YES", please answer the following questions. If your answer was "NO", you have completed the questionnaire.

The following questions are related to the attitudes of the people you supervise.

		Always	Almost always	Some Sometimes	Almost never	Never
	Late communication of work issues					
	hinder achievement of work results					
	Little cooperation when needed					
	They ignore suggestions to improve their work					

Table 12. Rubric for evaluation of general questionnaire.

Para la calificación final:

Resultado del cuestionario	Nulo o despreciable	Bajo	Medio	Alto	Muy alto
Calificación final del cuestionario C_{final}	$C_{final}<20$	$20\leq C_{final}<45$	$45\leq C_{final}<70$	$70\leq C_{final}<90$	$C_{final}\geq 90$

As a result of the questionnaire, in general it can be understood that there is a low level, which is why greater dissemination of the psychosocial risk prevention policy and programs for the prevention of psychosocial risk factors is necessary, the promotion of a reasonable operational environment and prevention of workplace violence.

Table 13. Rubric for category evaluation.

2) Para la calificación de la categoría:

Calificación de la categoría	Nulo o despreciable	Bajo	Medio	Alto	Muy alto
Ambiente de trabajo	$C_{..}<3$	$3\leq C_{..}<5$	$5\leq C_{..}<7$	$7\leq C_{..}<9$	$C_{..}\geq 9$
Factores propios de la actividad	$C_{..}<10$	$10\leq C_{..}<20$	$20\leq C_{..}<30$	$30\leq C_{..}<40$	$C_{..}\geq 40$
Organización del tiempo de trabajo	$C_{..}<4$	$4\leq C_{..}<6$	$6\leq C_{..}<9$	$9\leq C_{..}<12$	$C_{..}\geq 12$
Liderazgo y relaciones en el trabajo	$C_{..}<10$	$10\leq C_{..}<18$	$18\leq C_{..}<28$	$28\leq C_{..}<38$	$C_{..}\geq 38$

In the results obtained by category, it was reflected that they have a rating in a null or negligible standard state, which means that it is not necessary to take additional measures to make an improvement in the work.

There is an adequate work environment, since it is at a null level, which means that it is not requiring additional measures.

There are favorable factors inherent to the activity, since it is at a null level, which means that it is not requiring additional measures.

There is a very good organization of working time, since it is at a null level, which means that it is not requiring additional measures.

There is leadership and relationships at work that are adequate, since it is at a null level, which means that it is not requiring additional measures.

4. RESULTS

For the analysis conducted in this study, different tests and applications were used that helped to know the conditions of the worker as the different forms of presence of fatigue and the contributing factors that arise at work.

Once the evaluated results were obtained by applying descriptive statistics in the YOSHITAKE questionnaire, the Corlett & Bishop map with respect to the worker, the following results were obtained; a constant fatigue index is presented at the start of the workday, and as the week goes by the level of fatigue also begins to appear at the start of the workday, so that as the days go by it becomes excessive fatigue. On the other hand, the worker presents discomfort in some parts of the body, but these are not constant, they occur occasionally during the course of the week. As a result, it was found that the worker presented more fatigue problems at the beginning of the workday than at the end of it, so it was possible to determine that this could be due to problems external to the work, since it was very few times that the worker left work with fatigue.

In the symptoms of difficulty concentrating there is an increase in the middle days of the work week, and it begins to present itself in the entrance, as well as in the exit, as the week goes by the levels decrease again.

As psychosocial factors at work, in general terms, the level is low, so there is a need for greater dissemination of the psychosocial risk prevention policy and programs for: the prevention of psychosocial risk factors, the promotion of a favorable organizational environment and the prevention of workplace violence. In terms of work environment, factors specific to the activity, organization of work time, leadership and work relations, conditions in the work environment, workload, leadership, work relations and violence, a null or negligible level was found, which means that no additional measures are required to improve the work; in terms of factors of control over work and interference in the work-family relationship, a low level was found. And in terms of working hours, a medium level was found.

5. CONCLUSIONS

The application of such knowledge helps to increase the performance, safety and comfort of workers.

A workspace that has the appropriate ergonomic environmental conditions will be a pleasant place where employees will want to stay. In addition, having an adequate ergonomic environment will have a positive influence on several aspects of the organization and will contribute to increase the productivity levels of the employees and the organization in general.

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WORK CONTEXT: PERMANENCY AND WORKABILITY OF AGEING WORKERS -A LITERATURE REVIEW

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Resumen: ***Introducción:*** En la actualidad tanto países desarrollados, como aquellos en vías de desarrollo se están enfrentando a un gran cambio demográfico, lo que representa importantes desafíos para el trabajo, mismos que se deben abordar de forma integral debido a que la mayoría de las personas gastan una parte significativa de sus vidas trabajando y durante la transición hacia del envejecimiento, los trabajadores experimentan diferentes cambios en sus cuerpos, que en la interacción durante sus ocupaciones los llevan a diferentes niveles de salud y de capacidades, asociándose a otras transiciones vitales como lo es la jubilación; ***el objetivo*** de este trabajo es identificar los estudios que se han realizado en torno al contexto laboral de las personas que envejecen, la capacidad de trabajo y la permanencia de la fuerza laboral; a través de una revisión de literatura relacionada con la ergonomía. ***Delimitación:*** Los artículos de esta revisión entran dentro del área de trabajo de la salud ocupacional, ya que tratan temas de envejecimiento, de los cambios que enfrentan los trabajadores en sus ocupaciones, los factores psicosociales que influyen en su bienestar, en su salud, en su desempeño, entre otras cosas. ***Metodología:*** La revisión de literatura fue desarrollada a través de las bases de datos de Elsevier, ResearchGate and Taylor & Francis. Esta revisión de literatura fue conformada en parte por artículos de revistas de ergonomía, por artículos de revistas con un enfoque hacia el trabajo o artículos de revistas que tratan temas relacionados al envejecimiento, como lo fueron Ergonomics, Applied Ergonomics, International Journal of Occupational Safety and Ergonomics, Human Resource Management Journal, entre otras. Las palabras clave usadas para la búsqueda fueron clasificadas en cuatro tópicos: contexto de trabajo, capacidad de trabajo, permanencia en el trabajo y fuerza de trabajo que envejece. ***Resultados:*** De la revisión de literatura, 30 artículos científicos fueron identificados con aportes de información para el tema de esta revisión de literatura sobre el contexto de trabajo, la permanencia y la capacidad de trabajo de los trabajadores que envejecen. Dichos artículos se agruparon en tres áreas que fueron: 1) estudios del contexto de trabajo 2) capacidad de trabajo & envejecimiento y 3) permanencia laboral & retiro. ***Conclusiones:*** Los estudios que se han realizado han sido en contextos específicos en diversas naciones y con grupos de trabajo diversos. Es de gran importancia reconocer que en América Latina las investigaciones encontradas fueron escazas sobre los temas de interés de este trabajo, por lo que es necesario realizar más investigación con un enfoque desde la Ergonomía para reconocer los elementos del contexto laboral que tienen mayor relación con la capacidad de trabajo de las personas y su permanencia, para que eso nos lleve a generar más soluciones que se apliquen de forma integral y muestren buenos resultados.

Palabras clave: Ergonomía, Contexto Laboral, Permanencia, Capacidad de trabajo, Envejecimiento.

Relevancia para la ergonomía: Con esta revisión de literatura se puede visualizar como se ha tratado de abordar el estudio del envejecimiento de la población trabajadora en diversos países y desde hace años. Abre la posibilidad de explorar campos de aplicación de la ergonomía en relación con la permanencia en el trabajo desde diferentes enfoques que se pueden asociar con la capacidad de trabajo y nos permite reconocer parte de lo que se ha venido estudiando a lo largo del tiempo, para proponer estudios que exploren diferentes tipos de análisis de estos temas.

Abstract: ***Introduction:*** Currently, both developed and developing countries are facing a significant demographic change, which represents fundamental challenges for work, which must be addressed thoroughly since most people spend a considerable part of their lives working, and during the transition of aging, workers experience different changes in their bodies, which in the interaction during their occupations lead them to different levels of health and capabilities, associated with other life transitions such as retirement; this paper ***aims*** to identify the studies that have been conducted around the work context of aging people, workability and the permanency of the labor force; through a review of literature related to ergonomics. ***Delimitation:*** The articles in this review fall within the work area of occupational health, as they address ageing issues, changes faced by workers in their occupations, and psychosocial factors that influence their well-being, health, and performance, among other things. ***Methodology:*** The literature review was developed through Elsevier, ResearchGate and Taylor & Francis databases. This literature review was partly composed of articles from ergonomics journals, articles from journals with a focus on work or articles from journals dealing with topics related to aging, such as Ergonomics, Applied Ergonomics, International Journal of Occupational Safety and Ergonomics, Human Resource Management Journal, among others. The keywords used for the search were classified into four topics: work context, workability, permanency, and an aging workforce. ***Results:*** From the literature review, thirty scientific articles were identified with information contributions to the topic of this literature review on the work context, permanency, and workability of aging workers. These articles were grouped into three areas which were 1) work context studies, 2) workability & aging and 3) permanency & retirement.

Conclusions: The studies conducted have been in specific contexts in different nations and with diverse work groups. It is essential to recognize that in Latin America, little research has been found on the topics of interest in this literature review. Therefore, it is necessary to conduct more research on Ergonomics to recognize the elements of the work context that have a significant relationship to people´s workability and work permanency. This will lead us to generate more comprehensively applied solutions and show good results.

Keywords. Ergonomics, Work Context, Permanence, Workability, Aging.

Relevance to Ergonomics: With this literature review, it is possible to visualize how the study of the aging of the working population has been addressed in various countries and for years. It opens the possibility of exploring fields of application of ergonomics about the permanence at work from different perspectives that can be associated with workability and allows us to recognize part of what has been studied over time, in order to propose studies that explore different types of analysis of these issues.

1. INTRODUCTION

Currently, both developed and developing countries are facing a significant demographic change; society is aging gradually, as populations are living longer and longer. It is estimated that the number of people aged 60 years or older exceeds the number of children under five years of age, and this figure will increase by 34% between 2020 and 2030 (WHO, 2020).

This change is inevitable and therefore represents considerable challenges for different governments and organizations, which must be addressed thoroughly (ILO, 2010), since this increase in life expectancy can offer opportunities, not only for the elderly and their families, but also for society as a whole.

Let us remember that most people spend a significant part of their lives working and during the transition to aging, workers experience different changes in their bodies, which in the interaction during their occupations lead to different levels of health, different sensorimotor capabilities, and abilities to do certain activities; considering beyond these changes, aging is often associated with other life transitions, such as retirement.

It is important to mention that the aging of people in the context of work should not be a demarcation, it does not mean that they can no longer or should no longer work, on the contrary, they can remain, provide great benefits to the workplace and live a healthy aging experience through their work.

For this there are different aspects to take into consideration; starting from the international classification of functionality published by the World Health Organization (2001), we can understand that body functions and structures can determine the functioning of people in their activities and participation, but this will not determine their performance capacity, since this will be directly related to the physical and social environmental contextual factors (WHO, 2001); that is, when people live their aging process in a favorable environment, their well-being is promoted and their performance in their different environments, such as at work, is facilitated. Therefore, another aspect to consider based on the above is the analysis of work environments to protect people, who have different capacities and demands in their occupations, and to identify the facilitators and barriers that influence their work capacity so that they can maintain and promote health during their permanence towards retirement.

2. OBJECTIVE

This paper aims to identify the various studies conducted on the work context of aging individuals, workability, and permanency; through a review of literature related to ergonomics.

3. METHODOLOGY

The literature review was developed through Elsevier, ResearchGate and Taylor & Francis databases.

This literature review was partly composed by articles from ergonomics journals, by articles from journals with a focus on work or articles from journals dealing with aging-related topics, such as: Ergonomics, Applied Ergonomics, International Journal of Occupational Safety and Ergonomics, Human Resource Management Journal, among others.

The keywords used for the search were classified into four topics: work context, workability, permanency and aging workforce, as shown in Table 1.

This selection of articles was done by first relating the titles to the topic of this literature review, then analyzing their content and verifying that their information contributed significantly.

Part of this review focused on the approach of the studies to the issues of relevance to the aging working population with modifications in their workability within the work context during their time of permanency in the course of their retirement.

Table 1. Keywords for the search of articles.

Work context	Workability	*Ageing workforce*	*Permanency*
Work environment	Work Ability Index (WAI)	Age	Retirement
Working conditions	Health care	Aging at work	Age retaining
Social factors	Later life	Occupational Health	Work career
Facilitators and Barriers	Healthy aging	Vulnerability	Working late

Work Demands.		Needs of older workers	Extended working life
Work management			Working life
			Employment

4. RESULTS

From the literature review, thirty scientific articles were identified with contributions of information for the topic of choice on the work context, permanency, and workability of aging workers. These articles were grouped into three areas: 1) work context studies, 2) workability & aging, and 3) permanency & retirement.

The first thematic group included studies of the work context, in recent years due to different changes that affect globally, research related to this subtopic has been investigated from different approaches, such as the study of different work systems, impacting not only on performance, but also on the health and safety of workers (Peron et al., 2022). Studies on health promotion, which as Kloimüller et al. (2000) describe are an illusion for the working personnel, whose destiny should be to reduce the potential affections within this work context. For his part, Koustelios (2001) speaks of organizational factors that can serve as predictors, such as: personal achievements, working conditions, promotion, supervision, and the roles people play at work. While Moen (2017) states that the creation of a new organizational logic, valuation practices and research can be key to the challenges that companies in this century face. On the other hand, Howard (2005) highlights that there seems to be variability among the organizational factors of work, according to the different labor sectors.

Bridger, et al (2010) establish a statement of relevance regarding job demands, as well as Malińska & Bugajska (2021) who consider these demands within the psychosocial aspects to be considered when establishing occupational health preventive programs. Other authors create proposals for work improvements also considering these psychosocial factors to improve multilevel work within workplaces (Leppänen et al., 2005)(Zábrodská et al., 2014); which goes hand in hand with creating strategies not only in those categories, but also at corporate and national level (Kumashiro, 2000). Another point of view is that of López-Hernández (2016) who studies socio-labor conditions, without neglecting their association with other sociodemographic aspects that can serve to establish a project such as Haslam et al. (2018) that bring together various domains of work context, job dynamics and work system design, seeking outcomes in work practice that remove barriers in late-stage worker participation and promote health within the work context.

The second group is comprised of studies that address workability and aging of workers. As they are related, demographic change must be more widely recognized around the world to meet the challenges of the future (Knauth et al., 2005). It is essential to make workplaces age-friendly (A. F. Costa et al., 2011); being necessary to adopt flexible interventions that support and maintain this capacity of aging workers (G. Costa & Sartori, 2007) so the information that emerges regarding the workability of workers of various ages is important (Kristjuhan & Taidre, 2005) this workability can be assessed in different occupations, in conjunction with occupational or extra-occupational factors that influence it (Bugajska & Łastowiecka, 2005), also the status of work-related health, the capabilities of individuals, the absence of diseases, accidents and performance of activities can be studied (Sluiter & Frings-Dresen, 2007). The exact needs of aging workers must be known (Williams & Crumpton, 1997), as well as understanding the facilitators and barriers to implement strategies in the face of aging (Drake et al., 2017), but to break down barriers and find these new ways to develop more age-friendly environments that promote workability, the work organization requires cooperation from all involved as mentioned by Skoglund & Skoglund (2005).

Finally, the third group contains studies that analyze aspects related to job permanency, which in turn can be related to intentions to retire or retire early (Robles et al., 2019). The retention of workers in different work systems and under flexible programs for their permanence has been explored (Stirpe et al., 2018), it has been studied in relation to freedom, time and balance, choice, and control at work (Loretto & Vickerstaff, 2015). Even so, Esparza-Montes (2019) mentions that the intention to stay has decreased in recent years, creating challenges for the achievement of organizational objectives, on the contrary Hutchings et al. (2022) report that older workers have intentions to remain as long as they continue to have opportunities at work. There are resources that play a key role in people's engagement in their work and can influence the desired age of retirement (Vignoli et al., 2021), these resources can be examined following the routes marked by job enjoyment, fatigue, job control or psychosocial aspects (Stynen et al., 2017). Despite of age, during work permanency there are situations that must be reconfigured to meet the challenges that may edge people into retirement (Earl et al., 2018); factors that are studied in the context of work, such as working hours, risks, work experience, changes due to age, to mention a few, are related to these challenges, with the health and safety of workers (Bohle et al., 2010).

Table 2. Countries where research was conducted for the articles consulted in this literature review.

America	*Asia*	*Europe*			*Oceania*
United States of America (4)	Japan (1)	United Kingdom (4)	Czech Republic (1)	Norway – Italy (1)	Australia (1)
Mexico (2)		Netherlands (2)	Sweden (1)	New Zealand – United Kingdom – Australia (1)	
		Spain (2)	Finland (1)		
		Poland (2)	Estonia (1)		
		Italy (2)	Greece (1)		
		Germany (1)	Austria (1)		
		Portugal (1)			

5. CONCLUSIONS

From the point of view of ergonomics, the importance of not leaving aside all those aspects that intervene in the performance and well-being of people stands out, so within the literature review, studies were found that focused on knowing how the work context influences the different aspects of the same work. These studies help to identify the importance of research on work environments and the varied factors that are part of it, as well as the review of these articles allows to explore how workability changes during aging and what aspects contribute to the deterioration or maintenance of this.

Finally, it highlights the importance of not looking the other way and keeping an eye on demographic changes, as well as on work systems that promote the permanency of the workforce in an effective way until retirement.

The studies that have been carried out have been in specific contexts in different countries and with different working groups. It is of great importance to recognize that in Latin America not much research was found on the topics of interest of this literature review as shown in Table 2, so it is necessary to carry out more research with an approach from the perspective of Ergonomics and Human Factors to recognize the elements of the work context that have a more significant relationship with the workability of people and their permanency, so that this leads us to generate more solutions that are applied comprehensively and show good results.

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SERIOUS GAME PROTOTYPE FOR BURNOUT AWARENESS AMONG MAQUILADORA EMPLOYEES IN CIUDAD JUAREZ

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Abstract: This work aimed to develop a serious game prototype to contribute to the awareness of employees of the maquiladora industry about the effects of Burnout syndrome, and to inform them about the symptoms, consequences, treatments, dimensions, and prevention. For the development of the prototype, the iPlus and APRehab methodologies were adapted in combination with the Kmos-RE methodology to identify all the elements that comprise the Burnout syndrome and create a correct conceptualization of the problem that helps define the objectives of the project. Subsequently, the player experience and the expected gameplaying were specified. Then, all the content of the game was defined, in addition to the mechanics and gamification elements that were used. Finally, the development of the prototype was carried out, accompanied by its validation and its respective refinement in each iteration to achieve the expected solution. All this is validated by health specialists and others in serious games, to be later evaluated by employees of the maquiladora industry. The game achieved a satisfactory level of quality for the three categories evaluated, which were functionality, usability, and reliability. As conclusions, the information and gamification elements used in this project successfully contribute to the process of raising awareness of the effects of Burnout syndrome in employees with middle and high positions in the maquiladora industry.

Keywords. Digital transformation, Burnout, Serious Game, Industry.

Relevance to Ergonomics: As a contribution to Ergonomics, this work contributes to promote a technological alternative developed and evaluated according to various quality characteristics that can contribute to disseminating, understanding, and making users aware of phenomena, problems and working conditions of interest to this science and that affect the individual and/or organizations. It is considered that these alternatives are being increasingly exploited to achieve the most important objectives of Ergonomics in terms of the adaptation of work, products, systems, and environments to man for the prevention of health problems.

1. INTRODUCTION

Currently, the pillars in digital transformation are new technologies such as cloud computing and cognitive computing. While the former provides the necessary infrastructure for digital transformation processes, cognitive computing relies on the knowledge recovered from the analysis of digitized data to solve problems and make decisions (Vial, 2021). In addition, the process of digital transformation must be a tailor-made suit since it depends on the specific needs of each organization. Data acquisition is one of the most important activities for this process, because the efficiency of the analysis depends on the quality of the data, that they represent the closest information to reality. However, there are domains (areas of knowledge) that have very complex characteristics, and it is difficult to represent their knowledge. Because this knowledge is not homogeneous, it comes from various sources, it is multidisciplinary, mostly tacit, and derived from experience, these domains are called Informal Structure Domains (ISD) (Olmos-Sánchez & Rodas-Osollo, 2017). An example of this type of domain is work stress because the worker is often unaware that he or she suffers from it, in addition to the social stigma against mental illness and is not adequately cared for at the individual or organizational level. In addition, companies do not have enough health personnel or do not have them to care for their employees. Therefore, non-conventional applications that support data acquisition are required. One of these applications are serious games (Tomalá-Gonzáles et al., 2020), which are computer video games designed for teaching or to solve health, political, social, cultural problems, among others, that are not only focused on entertainment, if not to help motivate and encourage a change in the user, which is essential to combat social, cultural and health problems (Dias et al., 2018; Fleming et al., 2014, 2017).

The objective of this work is to develop a serious game to contribute to the awareness of Burnout syndrome in employees of the maquiladora industry and provide tools for its detection, prevention, and treatment. The methodology used is a combination of the iPlus and APRehab methodologies in combination with the Kmos-RE methodology to identify all the elements that comprise the Burnout syndrome.

The document is structured as follows. Section 2 presents the knowledge necessary to understand the topic of the project. Section 3 presents the objective. Meanwhile, section 4 describes the methodology used for the solution. The results and discussion are presented in section 5. Finally, in section 6 the conclusions of the project.

2. BACKGROUND

Mental health is a state of emotional, psychological, and social balance that allows the individual to carry out their activities, work productively, manage stress, relate to others, make decisions, and, in general, is the basis for the effective functioning of a community to achieve their goals ("WHO | International Classification of Diseases, 11th Revision (ICD-11)," 2019). According to the World Health Organization (WHO), mental illnesses worldwide represent a morbidity burden of 13% and in Mexico, 17% of people have at least one mental disorder. These mental disorders directly damage the nervous system, and the consequences are reflected in behavior, emotions, and cognitive processes such as memory and perception of the person, affecting productivity in organizations (Tudela et al., 2010).

In countries like Mexico, only about 2% of the health budget is allocated to mental health, while the WHO recommends an investment between 5% and 10 In countries like Mexico, only about 2% of the health budget is allocated to mental health, while the WHO recommends an investment between 5% and 10%. In addition, in Mexico, 80% of spending on mental health is allocated to the maintenance of psychiatric hospitals, so there are insufficient funds for the detection, prevention, and rehabilitation of these conditions (INCyTU, 2018). Mental disorders such as work stress are a consequence of psychosocial risk factors caused by workload, changes in schedules, shifts and even violence towards the worker (STPS | DOF, 2018). Among the vulnerable groups with the highest risk of presenting these disorders are employees with middle and high management, due to the demands and responsibilities in decision-making (Macias-Velasquez et al., 2019; STPS | DOF, 2018).

The main psychosocial risk factors are work stress and Burnout syndrome. Job stress is a set of psychological, emotional, cognitive, and behavioral reactions to certain overwhelming or demanding aspects of the workplace organization and environment (Houtman et al., 2008). On the other hand, Burnout syndrome is a psychological syndrome of exhaustion where emotional exhaustion, depersonalization or cynicism, and decreased performance or inefficiency occur (Michael P. Leiter, Christina Maslach, 2017). Burnout arises in response to stressors in the work environment and has a wide range of negative effects on the performance and personal well-being of employees.

Whenever the topic of burnout is raised, the key question is often "What can be done about it?" Although many different ideas on how to deal with burnout have been proposed, few of them have been systematically implemented or evaluated. Also, there is a cognitive bias in trying to cure people, instead of seeking to fix the employment situation in the company. In addition, there is a social stigma toward the mentally ill that can prevent them from going to the appropriate health services (Maslach, 2017). Due to the variable nature of burnout, there is no consensus to prevent, treat, or cure it.

There are instruments to identify and calculate the levels of fatigue, cynicism, and ineffectiveness of Burnout in the individual, such as the Maslach Burnout Inventory - General Survey (MBI-GS) questionnaire (Schaufeli et al., 2009). Once it is identified that the employee suffers from stress, anxiety or depression disorders, strategies must be applied to reduce their levels. Nevertheless, most of the treatments found to reduce stress focus on the individual instead of addressing the problem at the organizational level to improve the work environment (Shanafelt et al., 2012).

For this, there are traditional treatments that range from exercising the body to having a controlled diet, healthy sleep cycles and support medication (Arbués et al., 2019). Even interventions such as physical-recreational activities (Calero et al., 2016), music therapy (Izarra, 2017), behavioral activation (Coto-Lesmes et al., 2020), mindfulness sessions (Martinez-Escribano et al., 2017), and traditional games (Holgado Grajeda, 2018).

There are also modern treatments based on technological advances to treat mental health. An example of this is computer video games since they can be used for serious purposes, such as health and education (Fleming et al., 2017). These types of computer games for serious purposes are known as serious games and can go hand in hand with gamification. The latter is made up of video game elements used to attract the attention of users towards applications that are not necessarily in the field of entertainment (Fleming et al., 2014). Gamification and serious games have become a strategy to motivate and involve users of educational, business, and health applications to generate new projects. In addition, they have been shown to support several positive aspects, such as learning or training, whether in the field of education or health (Dias et al., 2018).

A project that meets the aforementioned characteristics of serious games and gamification is *Focusing Gamificada* project that deals with an application for stress management aimed at helping doctors in public hospitals in Ecuador. These doctors can set their goals for the application of the Focusing technique and, in turn, can reduce their stress levels (Tobar Lara, 2019). In addition, *Luccentus* is another video game for teaching stress assessment with the psychosocial risk battery of the Colombian Ministry of Labor. This development of a serious game was used to train desirable behavior in the cognitive-behavioral therapy of Burnout syndrome (Zielhorst et al., 2015). Another video game, that showed positively influences on learning of the subject, since, at the time of the application of the master class in conjunction with this video game, there was an increase in academic performance for the application of the stress questionnaire (Arboleda & Díaz, 2020).

Additional examples are the one proposed by (Egas-Reyes et al., 2018) in this project called *Mini-Spin-VR*, an anxiety test is carried out in virtual reality (environment of scenes or real-looking objects simulated by a computer) that, through a three-question questionnaire, helps to identify the level of anxiety in each simulated staging. Another case is the *Ubiquitous Biofeedback Serious Games* project, which consists of feedback that reflects the state of a certain physiological process based on the characteristics of the user. This allows users to have more control over their cases to achieve a higher state of well-being (Al Osman et al., 2016). There is also a serious video game called *Emotion4Down* to support the emotional education of adolescents and young adults with Down syndrome (Hernández Lara, 2019). In 2020, the serious game *Co-Op World* was developed to support the field of child psychotherapy and encourage child cooperation and reciprocity (Alkalay et al., 2020). *Stigma-Stop* is another example of a serious game created for the 2017 Video Games and Education Congress to raise awareness of mental health issues, developed in a non-immersive virtual reality environment (Cangas & Ojeda, 2017).

Other serious games have also worked as a tool for the treatment of Attention Deficit Hyperactivity Disorder (ADHD). Such is the case of the serious behavior change game Plan-it Commander (González-Calleros et al., 2019). In 2019, an interactive game prototype was presented at the IEEE international conference on Serious Games and Applications for Health (SeGAH) that helps with anxiety management (Dheda & Heymann, 2019). Another project linked to serious gaming and especially gamification is a virtual reality-based multimodal treatment for members of Canadian Armed Forces (CAF) pilots with combat-related post-traumatic stress disorder (Jetly et al., 2017).

In addition, the current world health situation due to the COVID-19 (SARS-Cov-2) pandemic have had a great influence on the increase in risk factors associated with mental disorders in humanity (Rodríguez et al., 2021) and there is also a leap in technological advances for their respective treatments (Galindo-Vazquez et al., 2020). Although research on serious games and gamification have become very important in recent years, an increase in the implementation of these tools in the field of health is required, especially for the employee and at the organizational level. This background shows projects that are the basis for research on the application of gamification and serious games in the area of education or health care. They function as a reference to identify the scope and areas of opportunity that currently exist.

3. OBJECTIVE

The general objective is to develop a serious game to help raise awareness of Burnout syndrome in workers in the manufacturing industry and provide tools for its detection, prevention, and treatment.

3. METHODOLOGY

To solve the problem defined in this project, a serious game prototype was developed, complemented with behavioral change design techniques, so that the employee identifies a possible incidence of the syndrome, and creates awareness of the repercussions that Burnout can cause in the social sphere, and health, as well as providing tools to assist in the prevention and correct treatment of this problem. To identify the dimensions of Burnout in the employee, an interactive dynamic implementation of the MBI-GS questionnaire was carried out to determine the degree of emotional exhaustion, depersonalization, and work efficiency (Rotenstein et al., 2018). To help with awareness, playful tools from serious games were used to capture the attention of the end user and make it easier to retain the message that is expected to be imparted. In addition, it is expected to instruct the employee with advice that will be collected in interviews with health specialists to attend to the syndrome, if necessary, to propose to the employee that he goes with professional help. To solve the problem defined in this degree project, it was developed a serious game prototype complemented with behavioral change design techniques, so that the employee can identify a possible incidence of the syndrome, create awareness about the repercussions that Burnout can cause in the social and health spheres, as well as provide tools to help in the prevention and correct treatment of this problem. To identify the dimensions of Burnout in the employee, dynamic and interactive implementation of the MBI-GS questionnaire was carried out to determine the degree of emotional exhaustion, depersonalization, and work efficiency (Rotenstein et al., 2018). To help with awareness, playful tools from serious games were used to capture the attention of the end user and make it easier to retain the message that is expected to be imparted. In addition, it is expected to instruct the employee with advice that will be collected in interviews with health specialists to treat the syndrome, and if necessary, propose the employee seek professional help.

In this project, a combination of the Kmos-RE methodology, the iPlus methodology, and the APRehab methodology was used, which is the result of the most important characteristics of other methodologies for the design of serious games in the field of education and health care. It is worth mentioning that the methodology was designed to solve a specific problem, so some modifications were made to adapt it to the objective of this project.

The Knowledge Management as a Strategy for Requirements Engineering (KMoS-RE) methodology is a high-level strategy based on knowledge management to elicit requirements, designed essentially to work with DEIs in which knowledge is mostly partial, non-homogeneous, implicit, tacit, and unstructured. This methodology allows for capturing, structuring, evaluating, and developing a complete and adequate solution. It consists of three phases: 1) Domain Modeling, 2) System Modeling, and 3) Specification Development. In addition to three activities that support the three main phases, 1) Identification of tacit knowledge, 2) Registration of assumptions, 3) Knowledge matrix.

Regarding the APRehab methodology, it is identified by its iterative process as a primary property, this facilitates each period to have constant progress of the interactive product and offers the opportunity to create the ideal documentation, such as the game design documents and the documents of technical design (Peñeñory et al., 2018). It also proposes an evaluation process with the support of health professionals during the development of the project, to receive constant feedback from the early stages of serious game design and thus correctly adjust the next phase of the methodology, to achieve the expected results with the final product.

On the other hand, the iPlus methodology focuses on the user's educational, interactive, and participatory experience. Considering the elementary term of history, art, and technology of a serious game, adding the pedagogical component, gameplay, and gamification resources (Carrión et al., 2019). In addition, it is identified by its verification phase of requirements validated by experts in pedagogy, experts in the main topic or problem, and experts in the development of serious games. iPlus is easy to implement in the requirements phase of any software development methodology, integrating with ease. Figure 1 shows an own edition based on (Peñeñory et al., 2018) on the integration and composition of the design process.

3.1 Identification of the problem

The *problem identification phase* was the basis of the entire methodology to identify the team of specialists with whom they collaborated and break down every detail of the project problem, this to have a broader conceptualization of the problem that would later serve to define the problem. essential elements of the solution.

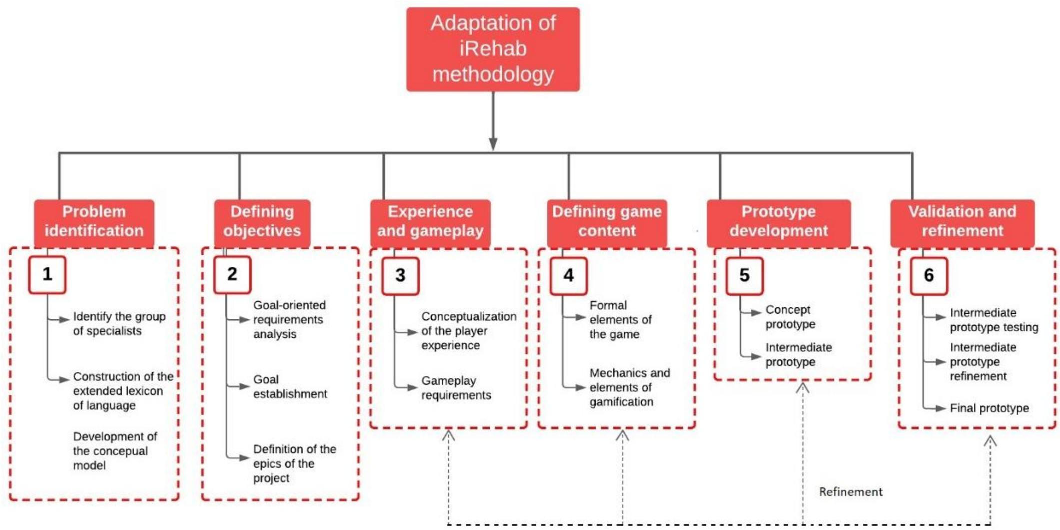


Figure 1. Modified methodology to develop the serious game proposed in this document

The *identification of the essential team of specialists* to identify and delimit the conceptualization of the problem, as well as plan its effective resolution. The iPlus methodology suggests team member profiles for the best effectiveness and efficiency throughout the project. Among those who stand out are an expert in the theme of the game, an expert in pedagogy, an expert in educational psychology, a video game designer, and a developer. The same ones that were a key point throughout the project, both in the creation of the solution, until its development, validation, and evaluation.

Construction of the extended lexicon on language model (LEL), which has its origins in requirements engineering (Hadad et al., 1997), was designed to help the bidding and representation of the language used, as well as to improve the understanding of the domain. It is a fundamental initial phase to have a better conceptualization of the problem and thus, identify, categorize, and delimit the elements that encompass it to have a better knowledge management in the development of this project. The LEL construction process consists of the following activities: identify sources of information, identify symbols, classify symbols, describe symbols, verify the LEL and validate the LEL. These activities are carried out iteratively so that they evolve in each round. Figure 2 (is shown in Spanish as it is the source language of the domain of this project) shows an example of an object type symbol with the following elements:

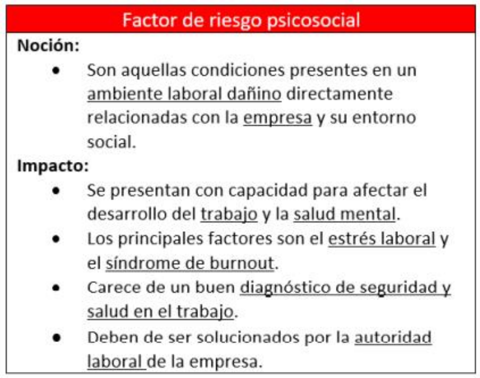
Symbol type – Object type symbols.

Notion – You must define the object and identify other symbols of the same type with that are related.

Impact – Describes the actions that can be applied to this object.

Verify, in this activity, the help of the specialists was required for the objective confirmation that the symbols were identified, classified, and described correctly, to capture the conceptualization of the problem in a clear and detailed way.

After building the LEL, the *conceptual model* of the application domain was developed using a class diagram of the Unified Modeling Language (UML) from a specification perspective to graphically represent the relationship between the



Factor de riesgo psicosocial

Noción:

- Son aquellas condiciones presentes en un ambiente laboral dañino directamente relacionadas con la empresa y su entorno social.

Impacto:

- Se presentan con capacidad para afectar el desarrollo del trabajo y la salud mental.
- Los principales factores son el estrés laboral y el síndrome de burnout.
- Carece de un buen diagnóstico de seguridad y salud en el trabajo.
- Deben de ser solucionados por la autoridad laboral de la empresa.

Figure 2. LEL psychosocial risk factor symbol in Spanish language

symbols resulting from the LEL on the problem of real world, show in Figure 3. This image is shown in Spanish as it is the source language of the domain of this project.

3.2 Definition of objectives of the serious game

In this phase, an analysis was carried out to identify the goals that had to be covered to solve the problems addressed in this project. We worked with the specialists to define where we wanted to go with this project and the activities that would make it possible to achieve these objectives. Resources such as the SMART methodology were used to establish the necessary requirements and define the epics necessary for the development of the game. This phase is made up of the following activities: goal-oriented requirements' analysis, goal setting, and defining project epics.

Goal-oriented requirements analysis, in this activity, the resources collected from the LEL model, and the conceptual model were used to correctly conceptualize the problem and, with the support of the specialists, identify the necessary functional requirements in the serious game to solve the problem and the goals to achieve said requirements.

Goal setting, this activity takes place after analyzing the requirements and identifying the solutions to achieve them, the formal definition of the goals that the serious game will address was carried out. For this, the SMART methodology was used, where (Tondello et al., 2018) proposes that goals are more motivating for high performance when they are specific, measurable, achievable, realistic and of a determined duration.

Defining project epics. The last step in defining the goals of the serious game was to develop the project epics, using the conclusion of the goal-oriented requirements analysis as input, to define the elements that were implemented in the game to satisfy those goals.

3.3 Experience and gameplay

Once the objectives that would solve the problems of this project were defined, an analysis was carried out to identify the experiences expected by the employee when playing the game (conceptualization of the player experience), as well as the definition of the *gameplay requirements* that complement that experience.

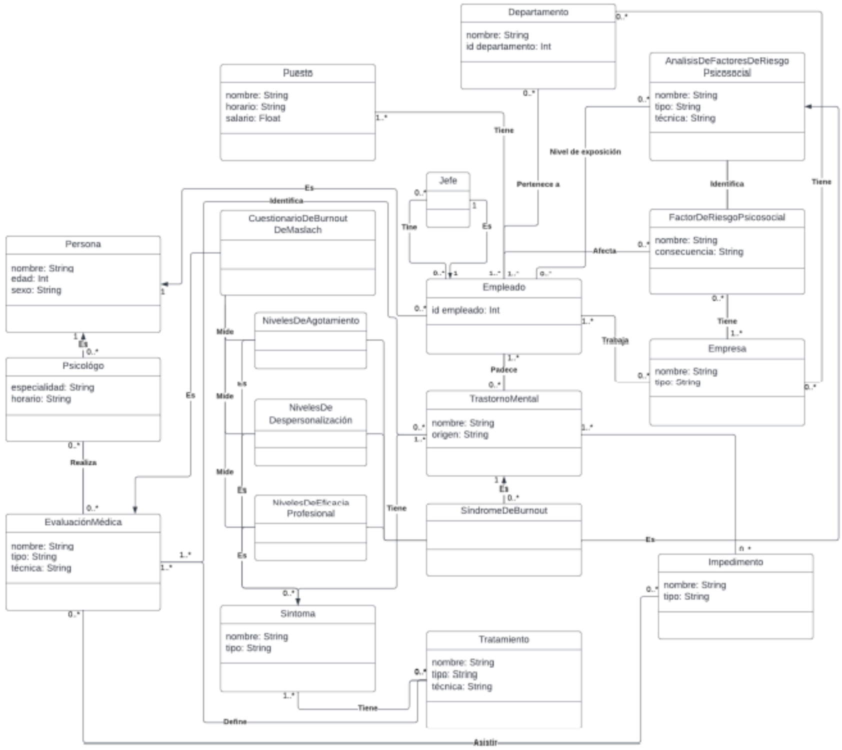


Figure 3. The conceptual model of the LEL is shown in Spanish language

Conceptualization of the player experience. The peculiarity that makes video games special is the enjoyment and fun of the user or group of users who use them, which is the purpose for which they are designed. And that goal is harder to measure than functional goals. Therefore, it is necessary to locate a series of qualities that allow us to determine the experiences of the player (Gonzalez Sánchez et al., 2008). For this, four dimensions were considered to identify: physical, cognitive, emotional, and social dimensions.

Gameplay requirements. The set of experiences in the serious game is called gameplay. According to (Gonzalez Sánchez et al., 2008), gameplay is the set of properties that describe the player's experience with a given game system, whose main objective is to amuse and entertain in a satisfactory and believable way, either alone or in the company. To finish the analysis of the serious game, it is necessary to decompose it based on different points of view, so the decomposition based on gameplay facets was used to identify the different attributes that make it up: Intrinsic gameplay, mechanical gameplay, interactive gameplay, artistic gameplay, and intrapersonal gameplay.

3.4 Definition of game content

In this phase, all the formal elements that make up the solution of this project are presented, based on the objectives and goals defined in the previous phases. Resources were used to organize the video game design structure and the main gamification elements for the serious games were defined. This phase is made up of the following activities: formal elements of the game and mechanics and gamification elements.

Formal elements of the game. To organize all the content information, a game design document was prepared, this document describes the characteristics that a video game will have, such as the name of the game (the name of the game is BAMI, an acronym for Burnout Awareness Maquiladora Industry), summary, and unique characteristics that are not found in another game.

Mechanics and gamification elements. The serious game was divided into four main elements: the topics to be reported, the questions, the tips, and the rewards.

3.5 Prototype development

Once the content and elements of the game were identified, the prototype development phase was carried out where a concept prototype was made, it was validated with the health specialists and the specialist in projects related to serious games, to make refinement and create an intermediate prototype with a level closer to the final solution proposed in this project. Once the player finishes answering the questions, the Burnout degrees are calculated, the total score of each dimension and the classification is based on the weights proposed by Maslach in (Schaufeli et al., 2009).

3.6 Validation and refinement

This phase of the methodology served for the specialists to test and validate the game. As well as making the necessary changes after each revision of the prototype to reach the final product defined in this project. The activities carried out in this phase were the tests of the intermediate prototype, refinement of the intermediate prototype and final prototype.

Intermediate prototype testing. In this activity, meetings were held with the specialists to test the game and validate its structure and content, making the changes requested by the specialists.

Intermediate prototype refinement. Meetings were held with specialists in syndromes to validate the information presented in the game and the content of the topics and tips. These tests focused on finding out if the objectives defined in the previous phases were met satisfactorily. The tests were divided into three sections: the game demo, the response to a survey to evaluate the game, and the corresponding analysis of the responses to identify changes or continue testing for end users.

Final prototype. This activity consisted of testing with the specialists and adding some changes for the final part of the game.

4. RESULTS

Regarding the results obtained from this project to validate the level of quality of the serious game, the systemic model of quality (MOSCA) proposed in (Mendoza, Luis E, Pérez, 2005) was used, with the categories of functionality, usability, and reliability, recommended by the model. Table 1 shows the results of these categories.

Table 1: Satisfaction of the level of quality of the serious game with respect to the satisfied categories.

Percentaje of BAMI	Funcionality	Usability	Reliability	Leve lof quality obtained
PBAMI < 25%	Not satisfied	–	–	null
PBAMI >= 25%	Satisfied	Not satisfice	Not satisfice	basic
PBAMI >= 50%	Satisfied	Satisfied	Not satisfied	Intermediate
PBAMI >= 50%	Satisfied	Not satisfied	Satisfied	Intermediate
PBAMI >= 75%	Satisfied	Satisfied	Satisfied	Advanced

5. DISCUSSION

At the end of the evaluations, satisfactory results were obtained for the three categories evaluated and a total of 85.3% for the entire serious game. According to Table 1, the game meets an advanced total quality level. The results show that the evaluated users showed interest in continuing to use the game and that more levels will be implemented to learn more about the syndrome. However, in the difficulty metrics there were separate answers, since having employees who had no previous knowledge about the syndrome, they had complications at the beginning of answering the questionnaires to advance in the game, but thanks to the topics and the help, the advance was more constant.

What could be improved in future refinements is the way of presenting the texts, adding animations or even other mini-games, as well as changing the size, color and font of the paragraphs. It is also proposed to improve the game installation method. Being just a prototype, the game was shared with the specific people who reviewed it via email, sharing the download link and installation guide, but to improve the experience and installation process, the game could be uploaded to a store of online applications to be downloaded and installed with a single click.

Although the game has obtained a satisfactory level of quality, it has been shown that it can be used as a support tool to publicize the effects of Burnout syndrome. The results obtained open the way to implement improvements to the game and cover other elements related to the problem addressed, to reach more people, even from other countries, and create other degree projects for careers related to computer systems.

6. CONCLUSION

The general objective of this project was to develop a serious game that helps raise awareness about Burnout syndrome in workers in the maquiladora industry and provide tools for its detection, prevention, and treatment. To achieve this goal, we work hand in hand with specialists in mental health issues and psychosocial risk factors in the manufacturing industry. As well as the implementation of methods to achieve specific objectives.

With the tests carried out, it is concluded that the game fulfills the purpose of helping to create awareness among employees, informing about the concept of the syndrome, its dimensions, symptoms, and consequences. As well as helping to recognize the worker's own condition, that is, their degrees of exhaustion, depersonalization, and professional efficiency, so that they can recognize that Burnout could be affecting their health and work and go to a specialist for a qualified analysis and treatments if necessary. The game reached a satisfactory level of quality in functionality, usability, and reliability. In conclusion, the techniques used in this project successfully contribute to the process of awareness of the effects of Burnout syndrome in employees with middle and high management in the maquiladora industry.

In addition, the potential of the use of serious games in the educational and mental health field was demonstrated in this case and in the literature thanks to the several tests suggested and answered by the specialists, showing the metrics that were used and their respective results to increase reliability.

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PILOT TEST OF AN INSTRUMENT FOR THE ASSESSMENT OF MOBBING, BURNOUT, JOB PERFORMANCE AND OCCUPATIONAL PERFORMANCE IN ADMINISTRATIVE PERSONNEL OF THE MAQUILADORA INDUSTRY

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Resumen: Los cambios globales económicos y competitividad en México han modificado el modelo organizacional de las empresas incrementando el nivel de estrés y fatiga debido a la alta carga mental de trabajo, teniendo efectos importantes en el desempeño de los trabajadores. Adicionalmente, los factores estrés y mobing han sido relevantes en investigaciones recientes donde se ha reportado su influencia en la carga mental y de igual manera en el desempeño. Los objetivos de este estudio son integrar una encuesta para valorar los factores mobbing, estrés y desempeño en trabajadores administrativos de la industria maquiladora, así como realizar una prueba piloto para conocer la consistencia interna de los instrumentos seleccionados en la encuesta. Se integraron los instrumentos Maslach burnout inventory, El IVAPT-PANDO (Inventario de Violencia y Acoso Psicológico en el Trabajo), Para la valoración del desempeño laboral y ocupacional se diseñó un constructo. La aplicación de la prueba piloto del instrumento se llevó a cabo en una empresa maquiladora de Ciudad Juárez encuestando se encuestaron cuarenta y cuatro empleados administrativos de la empresa. El valor del Alfa de Cronbach para todos los datos fue de 0.7671. Para el mobbing y el burnout el Alfa de Cronbach fue de 0.922 y 0.818, respectivamente. Mientras que para los dos instrumentos de desempeño ocupacional el Alpha de Cronbach fue de 0.844 y 0.946, respectivamente. Los valores obtenidos de Alfa de Cronbach se consideran buenos, por lo tanto, el instrumento cuenta con consistencia interna.

Palabras clave: Mobbing, burnout, estrés,

Relevancia para la ergonomía: La aplicación del instrumento nos permite, en esta fase de la investigación, determinar la confiabilidad del mismo antes de ser aplicado a un tamaño de muestra más amplia.

Abstract: Global economic changes and competitiveness in Mexico have modified the organizational model of companies, increasing the level of stress and fatigue due to the high mental workload, having important effects on the performance of workers. Additionally, stress and mobbing factors have been relevant in recent research where their influence on mental workload and performance has been reported. The objectives of this study are to integrate a survey to assess the factors mobbing, stress and performance in administrative workers of the maquiladora industry, as well as to perform a pilot test to know the internal consistency of the instruments selected in the survey. The Maslach burnout inventory, the IVAPT-PANDO (Inventory of Violence and Psychological Harassment at Work), and a construct was designed for the assessment of work and occupational performance. The application of the pilot test of the instrument was carried out in a maquiladora company in Ciudad Juarez and forty-four administrative employees of the company were surveyed. The Cronbach's alpha value for all data was 0.7671. For mobbing and burnout Cronbach's Alpha was 0.922 and 0.818, respectively. While for the two occupational performance instruments Cronbach's Alpha was 0.844 and 0.946.
respectively. The values obtained for Cronbach's Alpha are considered good, therefore, the instrument has internal consistency.

Keywords: Mobbing, burnout, stress,

Relevance to Ergonomics: The application of the instrument allows us, at this stage of the research, to determine the reliability of the instrument before it is applied to a larger sample.

1. INTRODUCTION

In Mexico, NOM-035-STPS-2018 was implemented which seeks to identify and prevent psychosocial risk factors in work spaces. This standard proposes responsibilities and challenges for the social security system (Pérez, 2020). Information and communication technologies may impose greater demands for information processing in administrative work tasks. The working conditions of millions of people in Mexico were modified due to the pandemic caused by COVID 19 (declared by the World Health Organization (WHO) on March 11, 2020 (Cucinotta and Vanelli, 2020), performing their work activities from their homes when teleworking was implemented. This new normal increased the use of information and communication technologies, increasing the mental workload of the worker (Pinto and Muñoz, 2020).

1.1 Background

Nowadays, the relevance of information in production and administrative processes requires a mental effort. Because the pace of work has been increasing, better results must be achieved with a smaller number of workers, and technological innovation is a determining factor in the socioeconomic evolution of our society and business competitiveness. The International Labor Organization (ILO) reported that psychological problems caused by work have increased, due to the growing technological development and skills (Capmany, 2016). Working conditions demand high levels of attention, high responsibility, mental workload, work overload and long working hours. All these working conditions can deteriorate the work climate affect the physical and psychological well-being of the worker.

The work environment, work organization and work management are factors that, if deficient, will have negative consequences for workers' health in the form of work stress, burnout and mobbing. European data indicate that 9% of workers have reported feeling affected by mobbing, 20% of Europeans suffer from burnout and 22% suffer from some type of work-related stress (Uribe, 2020). According to the ILO, one in ten workers suffers from depression, anxiety, stress or fatigue, which in some cases lead to unemployment or hospitalization. Work-related stress is the second most frequent work-related health problem in Europe, after musculoskeletal disorders (León, Topa, & García, 2019).

In the Report on Mexico's Mental Health System (IESM) "public spending on health is equivalent to approximately 6.5% of GDP. Per capita social security spending varies in the states of the republic: the highest is $3,816 pesos and the lowest is $1,409. The budget allocated to mental health corresponds to 2% of total health spending (Villagómez, Salazar, & Franco, 2018). Mexico is experiencing an epidemiological transition, whose most notorious features are the decrease in infectious and contagious diseases and the increase in chronic degenerative conditions, a category that includes accidents, injuries, and mental disorders. Mental disorders are a major public health problem; depressive disorder ranks first in women and fifth in men. The Ministry of Health allocates 2% of its total allocated budget for mental health and of this percentage 80% is used for psychiatric hospital expenses (Villagómez, Salazar, & Franco, 2018). Recent estimates by WHO (2018) warn that in the world there are 264 million people suffering from depression, which is one of the leading causes of disability. The study entitled "Mental health in the workplace", points out that people present symptoms of anxiety (Perez, 2020).

The importance of this research work is to make known the Burnout syndrome, mobbing, occupational performance, work performance and how it is related to the work environment, these variables significantly affect the worker's performance and quality of life. They produce prolonged stressful situations, physical, emotional, and psychological damage. The reason for this study is that in our country there is little research on this line of ergonomics in business activities. The study offers a contribution to scientific research on how the variables of burnout syndrome, mobbing, occupational performance, and work performance affect work performance.

1.2 Main concepts of this research and instrument integration

Burnout syndrome: inadequate response to chronic work stress characterized by emotional exhaustion, depersonalization, and low personal fulfillment, which manifests itself in service professions involving intense and prolonged attention (Maslach & Jackson, 1981). There is a recognized instrument designed by Maslach called Maslach burnout inventory, which helps us to measure three aspects of burnout syndrome: emotional exhaustion, depersonalization, and personal fulfillment. The scale of the questionnaire indicates that a number from 0 to 6 must be placed as answers in each of the 22 items. It is necessary to meet the criteria in the three items so that, according to Maslach, it can be recognized that a burnout situation exists in the organization. The Maslach burnout inventory has a reliability close to 90% (INSP, 2017).

Mobbing: a phenomenon that occurs in the workplace, and in which an individual or several individuals exert psychological violence systematically and repeatedly on another individual or individuals, over a prolonged period (Nava, Reyes, Nava, & Cobos, 2020). The IVAPT-PANDO (Inventory of Violence and Psychological Harassment at Work), created by Manuel Pando Moreno, which measures the frequency and intensity of psychological violence and the presence of psychological harassment-mobbing, was used to measure mobbing. This instrument consists of 22 items, double likert scale response (Sotomayor and Pando, 2014).

Laboral performance. This is conceptually described as those actions and behaviors executed by workers that help to achieve the objectives proposed for the success of companies (Bautista, Cienfuegos, & Aquilar, Panduro, 2020).

Occupational performance: a process during which people are motivated and perform occupations, according to their trajectory in which their capabilities, occupational demands, environmental stimuli, and life meanings are contributed. This term refers to the person's ability to choose, organize and develop meaningful and culturally adapted occupations in a satisfactory manner (Trujillo, Sanabria, Carrizosa and Parra, 2011). For the assessment of work and occupational performance, a new construct was designed with the contribution of the Universidad del Rosario of Bogota, Colombia. This instrument consists of 54 items using a Likert scale response. The constructs and variables that will be analyzed and that make up the hypothetical model in this research are shown in Figure 1.1

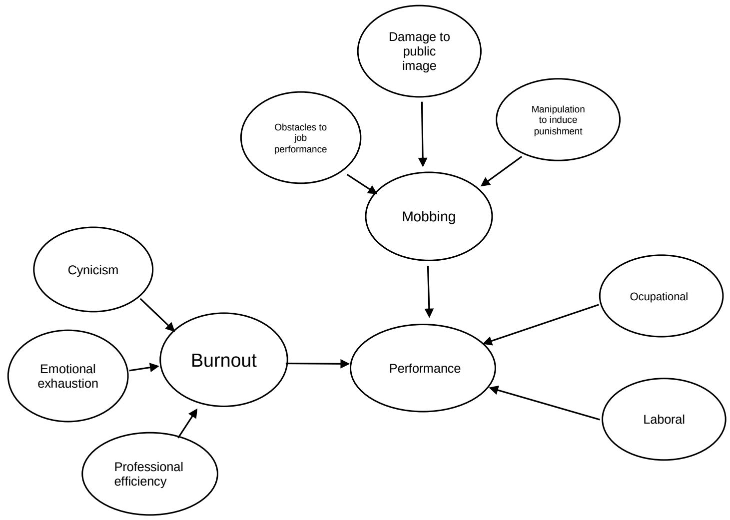

Figure 1.1 Hypothetical model

1.3 Objectives

- To design an instrument for the assessment of mobbing, burnout, and laboral and occupational performance in the administrative personnel of the maquiladora industry in Ciudad Juarez.
- To conduct a pilot test of the instrument.
- To validate the instrument through a pilot test.

1.4 Limitations

a) Space: exclusively in the maquiladora industry of Cd. Juarez.
b) Resources: this research will be carried out with the support of the administrative personnel of these companies.

2. METHODOLOGY

In the first instance, it was necessary to contact the human resources manager by sending a letter of presentation of the research project and the request for participation, in addition to some meetings were scheduled in which the acceptance and planning of the project were reviewed. Once permission was obtained, a date was set for the survey to be carried out in two plants.

This research is divided into two stages: the first stage explains the integration of the instruments and in the second stage the analysis of the results, as well as their validation.

2.1 Stages of the investigation and its elements

2.1.1 Phase 1. Survey design and validation

2.1.1.1 Design of the performance evaluation instrument

The performance evaluation instrument was designed in collaboration with students who stayed at the UACJ and their advisor from the Universidad Del Rosario in Bogotá, Colombia.

2.1.1.2 Integration of the burnout and mobing instruments to the performance questionnaire

The following instruments were integrated to the performance evaluation questionnaire:

- Questionnaire to assess burnout is the Maslach Burnout Inventory (Maslach & Jackson, 1981).
- Questionnaire to assess mobing IVAPT Pando Inventory of Violence and Psychological Harassment at Work (Franco et al, 2006).

2.1.1.3 Annex to general information and consent section

Information sheet to collect general information with demographic data, information such as: age, gender, schooling, department where they work and seniority in the company, in this part the consent of the employees to participate in the research is requested and the privacy notice is mentioned.

2.1.2 Phase 2. Survey application and analysis

2.1.2.1 Study Design

In this research a relational, prospective, and explanatory cross-sectional.

2.1.2.3 Sample

The sample of this study is composed of administrative personnel of the maquiladora industry of Cd. Juarez, the total number of administrative personnel working in the company was considered. The total for this phase of the project is forty-four people. By means of non-probabilistic sampling, the inclusion criterion is the administrative personnel of the company, and the exclusion criterion is the operative personnel and administrative personnel who do not want to participate in this research.

2.1.2.4 Field work

The questionnaires were applied in the maquiladora industry in Ciudad Juarez, duly reviewed in due time and form with the company's human resources.

2.1.2.5 Data analysis

A) Statistical validation of the information

A database was created in Microsoft Excel with the results of the forty-four surveys applied. The descriptive analysis of the sample of maquiladora industry administrative personnel will be performed using SPPS® v.20. In this phase, the percentages of sociodemographic information (sex, schooling, marital status, work seniority, current position, and department) of the sample will be described using descriptive statistics.

B) Data validation

For the reliability analysis and data validation, the Cronbach Alpha index was used, and all the information obtained was captured in the SPSS® v20 program, the results of the 44 surveys to each administrative employee of the company.

3. RESULTS

The most relevant characteristics of the sample are as follows:

a) Gender: 81.81% are men and 18.19% are women.

b) Marital status: 50% are married, 36.36% are single, 2.27% are divorced and 9.09% are in a consensual union.

c) Education: 70.45% with undergraduate studies, 2.27% high school, 11.36% with technical level and 13.63% with graduate studies.

d) Position held: 18.18% are managers, 34.09% are supervisors, 29.54% are engineers, 2.27% are buyers, 6.81% are technicians, 4.54% are assistants and 2.77% are nurses.

e) Age: 25% are between 21-30 years old, 27.27% are between 31-40 years old, 27.27% are between 41-50 years old and 18.18% are between 51-60 years old.

f) Children: 65.09% have children and 34.04% do not have children.

The results of the analysis of internal consistency were favorable, obtaining a general value for the whole instrument of 0.7871. For the five constructs used, values ranging from 0.844 to 0.946 were obtained, which are considered very good. The complete results are show in Table 1.

Table 1. Cronbach's alpha values obtained in the pilot test.

Instrument	Dimension	α	
Mobbing α:0.922	Manipulation to induce punishment	0.821	
	Damage to public image	0.758	
	Obstacles to job performance	0.578	

Burnout α:0.818	Emotional exhaustion	0.876	Global values 0.7871
	Cynicism	0.344	
Occupational performance		0.844	
Laboral performance		0.914	
Laboral performance (2)		0.946	

4. CONCLUSIONS

The first group of instruments considering mobbing and burnout presents internal consistency values of 0.922 and 0.818 which are considered as good. The second group of instruments in which occupational performance, occupational performance (2) and job performance are considered shows a good reliability index with a Cronbach's alpha of .844, .914 and .946. The total scale presents an acceptable reliability index with a Cronbach's alpha of .7671 with values ranging from .818 to .946. The results of the internal consistency analysis for each subconstruct were favorable, obtaining a value for manipulation to induce punishment of 0.821, damage to public image of 0.758 and for obstacles to work performance of 0.578, emotional exhaustion of 0.876 and cynicism of 0.344. The subconstructs have an acceptable reliability index. In conclusion, the scale presents an acceptable reliability index.

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EXPOSURE TO PSYCHOSOCIAL RISK FACTORS OF SECURITY GUARDS: A COMPARATIVE STUDY AMONG YOUNG ADULT AND OLDER ADULT PEOPLE

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Resumen: Actualmente los sistemas de trabajo están determinados por nuevas formas de organización que implican la exposición a riesgos de diferente naturaleza, entre ellos los factores de riesgo psicosocial. A la par de los cambios mencionados y como resultado de la transición demográfica, existe una mayor proporción de personas de 60 años y más que se desenvuelven en el mercado laboral. El propósito del presente estudio es investigar si existen diferencias en la percepción de los factores de riesgo psicosocial en el trabajo entre personas adultas jóvenes y adultas mayores que se desempeñan como guardias de seguridad en distintos establecimientos de la Zona Metropolitana de Guadalajara. El estudio incluyó 50 participantes, como instrumento para identificar la exposición a los factores de riesgo psicosocial se utilizó la versión corta del cuestionario CoPsoQ ISTAS 21 y se realizó la prueba estadística U de Mann-Whitney para comparar los resultados. Al comparar los resultados obtenidos en cada una de las dimensiones entre las personas del grupo de edad igual o mayor a 60 años y el grupo de menores de 60 años no se obtuvieron diferencias estadísticamente significativas. Cabe señalar, que de las 15 dimensiones de riesgo psicosocial que evalúa el instrumento, las dimensiones más afectadas fueron el ritmo de trabajo, inseguridad sobre las condiciones de trabajo, justicia e influencia en el trabajo.

Palabras clave: adulto mayor, factores psicosociales, ergonomía.

Relevancia para la ergonomía: Este trabajo pretende concientizar y motivar a otros profesionales de la ergonomía para que se realicen más investigaciones al respecto que permitan comprender el impacto y comportamiento de los factores psicosociales en este grupo etario y se logren diseñar ambientes y

esquemas de trabajo que se adapten a las necesidades de las personas trabajadoras adultas mayores con el objetivo de generar bienestar en las personas y mejorar eldesempeño del sistema.

Abstract: Currently, work systems are determined by new forms of organization that involve exposure to risks of a different nature, including psychosocial risk factors. In addition to the aforementioned changes, and as a result of the demographic transition, there is a greater proportion of people aged 60 years and older who are active in the labour market. The purpose of this study is to investigate whether there are differences in the perception of psychosocial risk factors at work between young adults and older adults who labour as security guards in diverse establishments in Guadalajara’s Metropolitan Area. The short version of the CoPsoQ ISTAS 21 questionnaire was used as an instrument to identify exposure risk factors, and the Mann-Whitney U statistics test was applied to compare the results. When comparing the results obtained in each of the dimensions between people in the group aged 60 years or older and the group under 60 years of age, no statistically significant differences were obtained. It should be noted that of the 15 psychosocial risk dimensions evaluated by the instrument, the most affected dimensions were work pace, insecurity about working conditions, fairness and influence at work.

Keywords: older adult, psychosocial factors, ergonomics

Relevance to Ergonomics: This work aims to raise awareness and motivate other ergonomics professionals to carry out more research on the subject to understand the impact and behavior of psychosocial factors in this age group and to design work environments and schemes that are adapted to the needs of older adult workers with the objective of generating well-being in people and improving the performance of the system.

1. INTRODUCTION

Currently, work systems are determined by various social situations such as economic globalization, competitiveness, technological innovations and diversification of demands, which means that these new forms of work organization involve exposure to risks of different kinds, among them psychosocial risks, derived from a greater demand on mental capacities at work.

The concept of psychosocial factors was originally defined in 1984 by the joint committee of the International Labor Organization/World Health Organization (ILO/WHO) as "those conditions present in a work situation, related to the organization, content and performance of work, which are likely to affect both the well-being and health of workers and the development of work"; this definition has been modified over time by various authors in different parts of the world (WHO/ILO, 1984).

In Mexico, the official Mexican standard 035 of the Secretariat of Labor and Social Welfare defines psychosocial risk factors as those that can cause anxiety disorders, non-organic sleep-wake cycle disorders and severe stress and adaptation, derived from the nature of the job functions, the type of workday and exposure to severe traumatic events or acts of workplace violence (Secretaria del Trabajo y Previsión Social, 2018).

In conjunction with the aforementioned changes in the dynamics of work systems and as a result of the demographic transition, a greater proportion of older adults are involved in various work systems and are susceptible to exposure to different psychosocial risk factors.

Currently, older adults with formal employment can access a severance pension at an advanced age as long as they meet the requirement of having recognized before the IMSS (Instituto Mexicano del Seguro Social) an established minimum of weekly contributions and are deprived of paid work, in the year in 2021, the necessary contribution weeks were 750, each year weeks will be added until reaching 1,000 weeks by the year 2031 (Cámara D, 2022).

Unfortunately, not all older adults can meet the weekly contribution requirement since some cases worked in their youth in informal jobs without social security, began their working life at an advanced age, or meet the weekly contribution requirements buts the amount of the pension is not enough to cover their needs, so these adults find it necessary to continue working in the job systems. In Mexico, the older adult population continues to increase and is expected to represent 21.5% of the national population by 2050 (Gonzalez, 2015).

In summary in our environment, there are no previous studies that analyze the behaviour of psychosocial risk factors at work between the young adult and older adult population, in other countries studies have been conducted in various contexts to evaluate the effect of age on psychosocial risk factors obtaining heterogeneous results (Bos et al., 2013; Burr et al., 2017; Götz et al., 2018; Mauno et al., 2013; Ng & Feldman, 2010; Zacher & Schmitt, 2016), so it is not known exactly whether or not there are age-related changes in perception and coping mechanisms to psychosocial risk factors at work.

2. OBJECTIVE

This study aims to investigate whether there are differences in the perception of psychosocial risk factors at work among young adults and older adults who labour as security guards in diverse establishments in Guadalajara's Metropolitan Area, being this job environment one of the most common and accessible formal employment for older adults.

3. METHODOLOGY

The study included fifty participants, as an instrument to identify exposure to psychosocial risk factors the short version of the CoPsoQ ISTAS 21 questionnaire was used, which addresses psychosocial risk from a multidimensional perspective integrating the theoretical models of "demand-control-support" and "effort-reward", it has a Cronbach's alpha of between 0.66 and 0.92 and a kappa index of between

0.69 and 0.77 (García et al., 2013). Based on the score obtained, for each of the 15 dimensions, the degree of health risk expressed in the type of health exposure is obtained, which has three possible categories: favorable, intermediate, or unfavorable exposure.

The questionnaire was applied personally to each of the participants after obtaining their informed consent. Some questionnaires were answered on paper and others by portable electronic devices according to the participants' preferences.

For the statistical analysis, the SPSS version 25 was used, where the mean and standard deviation were obtained for the quantitative variables, frequencies and percentages for the categorical variables. The Mann-Whitney U test was used to compare the ordinal categorical variables of exposure to psychosocial risk factors among the different age groups.

4. RESULTS

The analyzed data showed that 22% of the participants were female and 78% were male. The mean age was 46.5 years, ranging from 20 to 65 years. The work shifts were distributed as follows: 76% shifts of 24 hours work by 24 hours rest; 14% shifts of 12 hours work by 12 hours rest and 10% rotating shifts of 8 hours per day.

The results of the type of exposure for each of the 15 dimensions of psychosocial risk are shown in Figure 1. It should be noted that the main dimensions affected are work rhythm, insecurity about working conditions, fairness and influence at work.

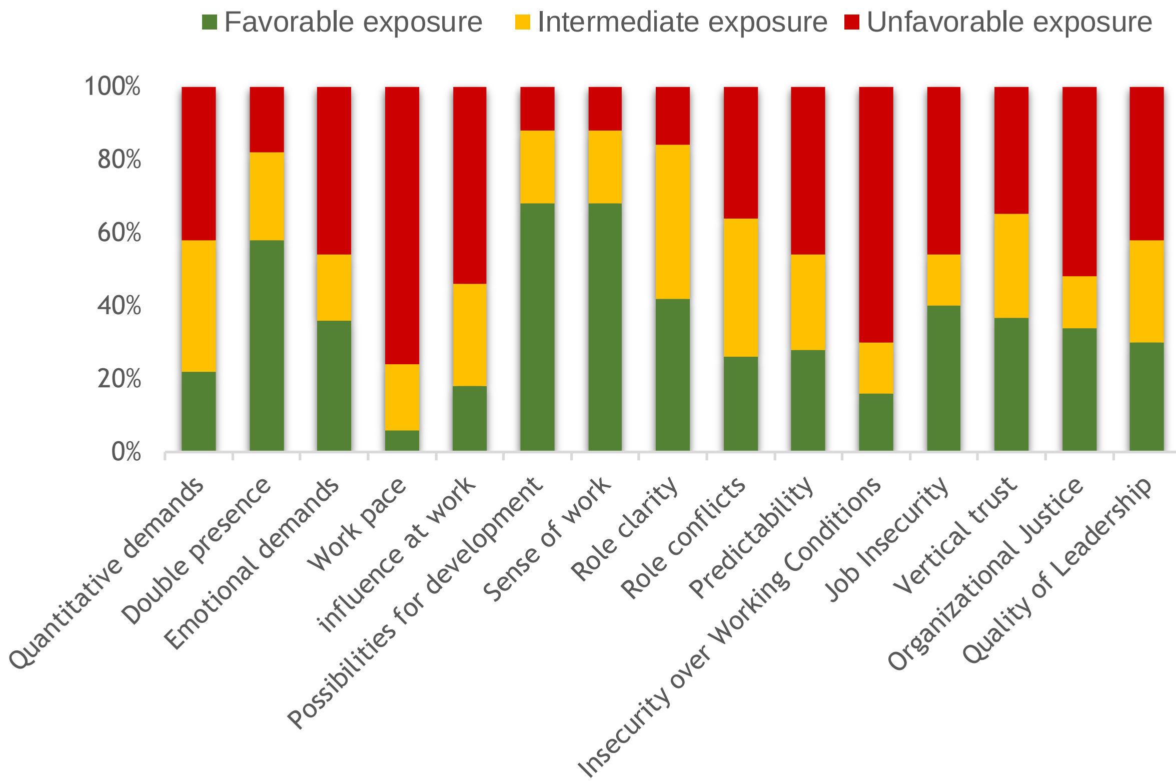

Figure 1. Results of the type of exposure for health in the 15 dimensions of psychosocial risks

Table 1 shows the results obtained by applying the Mann-Whitney U statistics test to compare the level of exposure in each of the dimensions between people in the age group equal to or older than 60 years and the age group younger than 60 years. The statistical analysis showed that no statistically significant differences were obtained between the two groups in any of the dimensions because no P value es less than 0.05.

Table 1. Statistical test of Mann-Whitney U for the types of exposure for health in the dimensions of psychosocial risk in security guards.

Dimension	P Values
Quantitative demands	**0.990**
Double presence	**0.125**
Emotional demands	**0.729**
Work pace	**0.344**

Influence at work	**0.821**
Possibilities for development	**0.896**
Sense of work	**0.971**
Role clarity	**0.542**
Role conflicts	**0.198**
Predictability	**0.676**
Insecurity over working conditions	**0.693**
Job insecurity	**0.896**
Vertical trust	**0.760**
Organizational justice	**0.451**
Quality of leadership	**0.747**

5. CONCLUSIONS

The present study found that there are no differences in the perception of psychosocial risk factors between young and older adults working as security guards. It is noteworthy that one of the most affected dimensions was the pace of work, a worrisome situation considering that most of the participants are exposed to long working hours of up to 24 consecutive hours.

On the other hand, it is important to point out that the limitations of this study were that the instrument used is not validated in the older Mexican population, in addition to the proportion of older adults who participated in the study considering that only 20% of the total number of participants were over 60 years of age.

Therefore, it is necessary to carry out more research in the future, since there is not enough research in the literature that evaluates the behavior of psychosocial risk factors in older adults, so it is not known exactly if there are changes or not related to age in the perception and coping mechanisms of people facing the various cognitive demands of work.

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IDENTIFICATION AND ANALYSIS OF PSYCHOSOCIAL RISK FACTORS ACCORDING TO NOM-035-STPS-2018 IN A HIGHER EDUCATION INSTITUTION IN MEXICO

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Resumen: Las actividades laborales pueden generar riesgos para la salud física, mental y emocional, lo cual se refleja directamente en la productividad y la satisfacción laboral. En México se publicó la Norma Oficial Mexicana NOM-035-STPS-2018, que establece que la identificación, análisis y prevención de los factores de riesgo psicosocial debe realizarse en todos los centros de trabajo, incluidas las Universidades.

En el presente estudio, la implementación de la NOM-035-STPS-2018 en un Instituto Tecnológico con 105 trabajadores permitió determinar las estrategias de acción potencialmente efectivas para reducir el riesgo psicosocial de acuerdo con las necesidades del lugar de trabajo, evocando las estrategias basadas en los criterios de toma de acciones enfocadas en los niveles medio y alto. En general, los instrumentos muestran consistencia, pero algunos factores no se ajustan a lo esperado, por lo que se sugiere corroborar su factibilidad en poblaciones similares.

Palabras clave: Legislación Laboral, Rendimiento Laboral, Política de Salud Ocupacional, Programa de Salud Laboral, Estrés Laboral.

Relevancia para la ergonomía: Resulta muy conveniente que la satisfacción laboral de los empleados siempre se encuentre en condiciones óptimas, ya que ésta es la culpable de diversos aspectos vinculados con los empleados y las organizaciones, desde el desempeño laboral hasta la salud y la calidad de vida. Todos están expuestos a ser víctimas de dolores de espalda baja, síndrome del carpo en las muñecas, etc., lo cual se transforma en ausentismo, rotación y hasta discapacidad, por lo que se busca la optimización de los recursos, como lo son el elemento humano, las herramientas y el ambiente laboral, para lo cual se deben diseñar lugares de trabajo que coincidan con las características fisiológicas, anatómicas y psicológicas.

Esta alta correlación entre los factores ergonómicos y los efectos en la salud física, mental y emocional de la plantilla laboral conlleva la imperante necesidad de gestar cambios en los centros de trabajo acondicionando, evaluando e incluso rediseñando los procesos conforme a la normatividad vigente, además de la obligación de identificar los riesgos psicosociales internos y externos en que se desempeñan los trabajadores..

Abstract: Work activities can generate risks to physical, mental, and emotional health, reflected in productivity and job satisfaction. In Mexico, the Official Mexican Standard NOM-035-STPS-2018 was published, establishing that the identification, analysis, and prevention of psychosocial risk factors must be carried out in all workplaces, including Universities.

In the present study, the implementation of the NOM-035-STPS-2018 in a Technological Institute with 105 workers allowed us to determine the potentially effective action strategies to reduce psychosocial risk according to the needs of the workplace, evoking the strategies based on the criteria for taking actions focused on the medium and high levels. Generally, the instruments show consistency, but some factors do not conform to what is expected, so it is suggested to corroborate their feasibility in similar populations.

Keywords. Ergonomic evaluation, OWAS, BRIEF, REBA, LEST.

Relevance to Ergonomics: Conveniently, employees' job satisfaction is always in optimal conditions since this is the culprit of various aspects related to employees and organizations, from work performance to health and quality of life. All are exposed to be victims of lower back pain, carpal syndrome in the wrists, etc., which is transformed into absenteeism, rotation, and even disability, so the optimization of resources is sought, such as the human element, tools, and the work environment, for which workplaces that coincide with physiological characteristics must be designed, anatomical and psychological.

This high correlation between ergonomic factors and the effects on the physical, mental, and emotional health of the workforce entails the imperative need to develop changes in the workplaces by conditioning, evaluating, and even redesigning the processes by current regulations, in addition to the obligation to identify the internal and external psychosocial risks in which workers perform.

1. INTRODUCTION

Work activities can generate risks to physical, mental, and emotional health, reflected in productivity and job satisfaction. In Mexico, the Official Mexican Standard NOM-035-STPS-2018 (Secretaria de Trabajo y Previsión Social, 2018) was published, establishing the identification, analysis, and prevention of psychosocial risk factors in all workplaces, including higher-level institutions.

Working is an activity that characterizes the human being since he has been able to organize, positioning himself as the primary agent to carry out activities and tasks necessary to achieve objectives together. At the same time, it becomes a beneficiary of this process by generating the goods and services that will be made available to them (Marrau et al., 2007).

However, in addition to the benefits, there are factors associated with labor activities that put their integrity at risk, conditioning their health due to accidents or other types of diseases derived from the tasks carried out; which highlights the labor field as a fundamental aspect in the study and understanding of the health-disease process of people.

Thus arises the discipline of ergonomics dedicated to studying and generating knowledge for preventing injuries and diseases derived from work activities.

The inclusion of psychological aspects as an essential component in Management Systems for the promotion of safety and health at work is of great importance to impact the well-being of workers since the health-disease-care process cannot be understood without considering all the dimensions that make up the human being.

Data from the World Health Organization (WHO) show that 1.9 million men and women die annually from work-related accidents, illnesses, or injuries. It should also be noted that non-fatal work accidents cause, on average, at least three days of absenteeism due to disability and 160 million new cases due to occupational disease. Likewise, it has been detected that 8% of the global rate of depressive disorders at present is related to occupational risks (OMS,2021).

Also, according to the World Health Organization, the stress generated by work activities is potentially harmful to the health of the worker while violating the functioning and achievement of organizational objectives, as associations are found between the presence of stress symptoms with the rates of absenteeism, deterioration of health, and low productivity.

According to Cotonieto-Martínez (2019), "To carry out effective prevention and adequate intervention in the face of trends and new orientations that direct aspects related to psychosocial risks, there must be a total and absolute commitment from the top management of organizations, as well as specific and sufficient resources. Only in this way will it be possible to identify, analyze and assess the probable causes. According to these analyses, effective solutions for the control and elimination of risks will emerge according to the risk and with each case" (Cotonieto-Martínez, 2019).

Thus, as the importance of working conditions on mental health and the impact that this, in turn, had on the functioning of organizations became more evident, the study of psychosocial risks became more relevant in the area of ergonomics at work;

looking for the most appropriate mechanisms for its anticipation, recognition, evaluation, and control. So, it is evident that this law is a paradigm shift in which the value of the integral health of the worker is claimed. However, it is necessary to have the disposition and skills to comply with this mandate that the new generations are demanding (Saldaña et al., 2019).

In Mexico, some documents currently provide regulatory support for actions to improve safety at work and prevent psychosocial risk factors. Among the most important we can mention the Political Constitution of the United Mexican States in article 123 (Constitución Política de Los Estados Unidos Mexicanos, 2021), Federal Labor Law in article 2 (Ley Federal del Trabajo, 2022), Federal Regulation of Safety and Health at Work in article 3 (STPS, 2014), as well as the Official Mexican Standard NOM-035-STPS-2018, Psychosocial risk factors at work- Identification, analysis, and prevention (STPS, 2018).

This last norm was issued in 2018 and defines that psychosocial risk factors are: "those that can cause anxiety disorders, non-organic sleep-wake cycle, and severe stress and adaptation, derived from the nature of the functions of the workplace, the type of working day and exposure to severe traumatic events or acts of labor violence to the worker, for the work carried out" (STPS, 2018); including:

- Dangerous and unsafe conditions in the work environment.
- Excessive workloads concerning the workers' capacity.
- Limitations influence how to organize and develop your work when possible.
- Working hours longer than those established in the Federal Labor Law.
- Rotation of night shifts that do not allow recovery and rest.
- Interference in the work-family relationship.
- Negative leadership practices and labor relations.

In addition, this Standard establishes a series of guidelines for its evaluation, analysis, and prevention, indicates the obligations of both the employer and the workers, specifies some procedures, and provides guidelines for their application. Also, it suggests that it applies in all workplaces in the national territory, although the type of obligations changes depending on the number of workers. Hence, as of October 23, 2020, its implementation is mandatory in higher education centers.

This is especially relevant since, in the educational field, the burden and nature of associated work activities usually generate absenteeism due to illness, nonconformity, irritability, emotional neglect, deficient generation of satisfactory labor products; stress, workplace harassment, and burn syndrome are the psychosocial risk factors most often in both managers and teachers of educational centers (Unda et al., 2016).

2. OBJECTIVE

Evaluate the level of psychosocial risk in a higher education institution in Mexico according to guidelines established in NOM-035-STPS-2018 and explore the organizational social climate scale and the psychosocial risk scale for higher-level teachers for a complimentary assessment.

3. DELIMITATION

It takes place in a Technological Institute that offers nine undergraduate and two graduate programs in which 105 workers from a total of 153 answered the survey.

4. METHODOLOGY

The diagnosis of psychosocial risk was carried out with the provisions of NOM-035-STPS-2018, so the Questionnaire "Reference Guide III- Identification and analysis of psychosocial risk factors and Evaluation of Organizational Environment in The Workplace" was used; the mentioned questionnaire evaluates the risk of developing anxiety disorders, non-organic of the sleep-wake cycle and severe stress and adaptation, as a result of the functions performed in the workplace and has a section to assess the symptoms related to extreme traumatic events on occasion or associated with work and that require a clinical assessment.

It is composed of 72 questions with five answer options on the Likert Scale: Always (4), Almost always (3), Sometimes (2), Almost never (1), and Never (0), of which four must be answered only by personnel who provide services to customers or users and another four only by the high administration staff. The questions are divided into five categories: Work environment, Factors specific to the activity, Organization of working time, Leadership and relationships at work, and Organizational environment. For the qualification, it must be considered that a higher score represents a greater psychosocial risk; In addition, there are reagents in which the values obtained initially must be invested. The scores are grouped into levels: Null or negligible, Low, Medium, High, and Very High.

5. RESULTS

First, figure 1 shows the way gender was distributed among the one hundred and five employees who answered the survey.

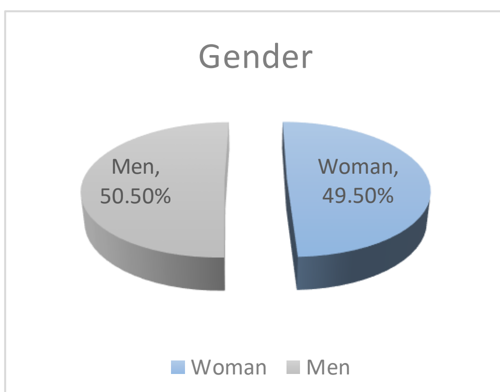

Figure 1. Gender

The results will have to be interpreted based on Reference Guide III of Nom-035-2018, Table 1. (STPS, 2018).

Table 1. Item Groups by Dimension, Domain, and Category

Work Environment	Conditions in the working environment	Dangerous and unsafe conditions	1, 3
		Poor and unsanitary conditions	2,4
		Hazardous work	5
Factors specific to the activity	Workload	Quantitative loads	6, 12
		Accelerated work rhythms	7,8
		Mental load	9, 10. 11
		Emotional and psychological burdens	65,66,67,68
		High responsibility loads	13, 14
		Contradictory or inconsistent charges	15, 16
	Lack of control over work	Lack of control and autonomy over work	25,26,27,28
		Limited or no possibility of development	23,24
		Insufficient participation and change management	29,30
		Limited or no training	35,36
Organization of working time	Interference in the work-family relationship	Extensive working days	17, 18
		Influence of work outside the workplace	19,20
		Influence of family responsibilities	21,22
Leadership and relationships at work	Leadership	Poor clarity of functions	31,32,33,34
		Characteristics of leadership	37, 38, 39, 40,41
	Relationships at work	Social relationships at work	42, 43, 44, 45, 46
		Poor relationship with the collaborators he supervises	69, 70, 71, 72
	Violence	Workplace violence	57, 58, 59, 60,61,62,63,64
Organizational environment	Performance recognition	Little or no performance feedback	47,48
		Little or no recognition and compensation	49,50,51,52
	Insufficient sense of belonging and instability	Limited sense of belonging	55,56
		Limited sense of belonging	53,54

Where the responses applied to the configuration presented in Table 2 allows us to obtain the level of psychosocial risk, which in the case of our study was 51%, with medium to high psychosocial risk level.

Table 2. Reference Guide Table III of Nom-035-2018 (STPS, 2018)

Questionnaire Results	Null or despicable	Low	Medium	High	Very High
Questionnaire final grade. C_{final}	$C_{final}<50$	$50\leq C_{final}<75$	$75\leq C_{final}<99$	$99\leq C_{final}<140$	$C_{final}\geq 140$

The domains with the most workers at risk considering the three highest criteria for taking actions (medium, high, and very high), are shown in Table 3.

Table 3. Reference Guide Table III of Nom-035-2018 (STPS, 2018)

Domain Results.	Null or despicable	Low	Medium	High	Very High
Conditions in the working environment	$C_{dom}<5$	$5\leq C_{dom}<9$	$9\leq C_{dom}<11$	$11\leq C_{dom}<14$	$C_{dom}\geq 14$
Workload	$C_{dom}<15$	$15\leq C_{dom}<21$	$21\leq C_{dom}<27$	$27\leq C_{dom}<37$	$C_{dom}\geq 37$
Lack of control over work	$C_{dom}<11$	$11\leq C_{dom}<16$	$16\leq C_{dom}<21$	$21\leq C_{dom}<25$	$C_{dom}\geq 25$
Working day	$C_{dom}<1$	$1\leq C_{dom}<2$	$2\leq C_{dom}<4$	$4\leq C_{dom}<6$	$C_{dom}\geq 6$
Interference in the work-family relationship	$C_{dom}<4$	$4\leq C_{dom}<6$	$6\leq C_{dom}<8$	$8\leq C_{dom}<10$	$C_{dom}\geq 10$
Leadership	$C_{dom}<9$	$9\leq C_{dom}<12$	$12\leq C_{dom}<16$	$16\leq C_{dom}<20$	$C_{dom}\geq 20$
Relationships at work	$C_{dom}<10$	$10\leq C_{dom}<13$	$13\leq C_{dom}<17$	$17\leq C_{dom}<21$	$C_{dom}\geq 21$
Violence	$C_{dom}<7$	$7\leq C_{dom}<10$	$10\leq C_{dom}<13$	$13\leq C_{dom}<16$	$C_{dom}\geq 16$
Performance recognition	$C_{dom}<6$	$6\leq C_{dom}<10$	$10\leq C_{dom}<14$	$14\leq C_{dom}<18$	$C_{dom}\geq 18$
Insufficient sense of belonging and instability	$C_{dom}<4$	$4\leq C_{dom}<6$	$6\leq C_{dom}<8$	$8\leq C_{dom}<10$	$C_{dom}\geq 10$

Workload (68%) refers to the demands that work imposes on the worker that exceeds his capacity. The following figures show the results of the questions.

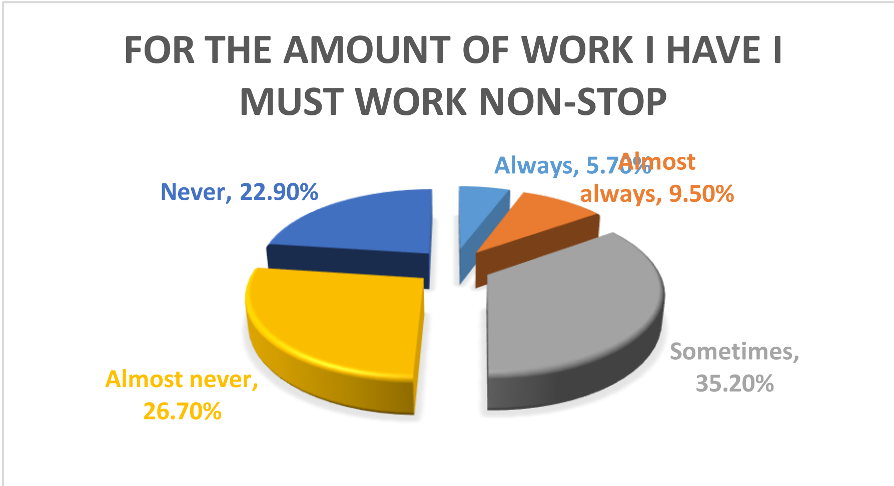

Figure 2. Question 6 results.

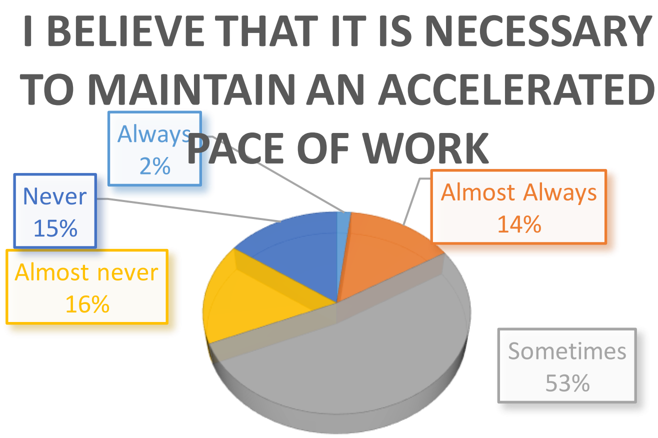

Figure 3. Question 7 results.

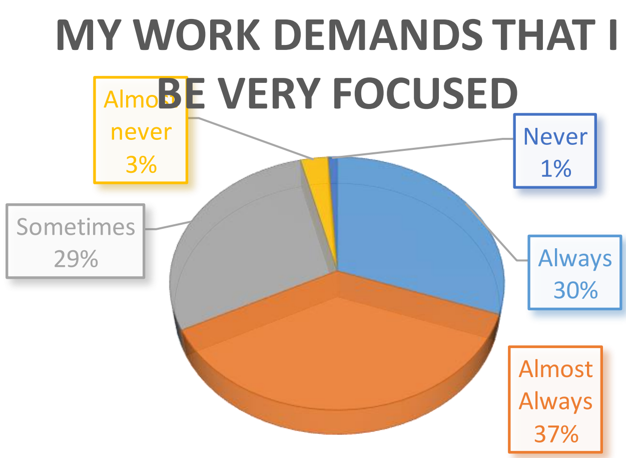

Figure 4. Question 8 results.

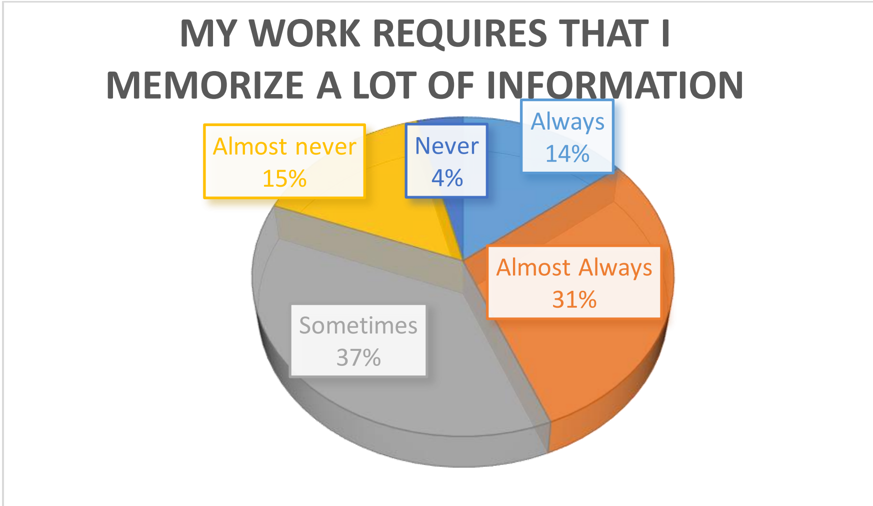

Figure 5. Question 9 results.

Figure 6. Question 10 results.

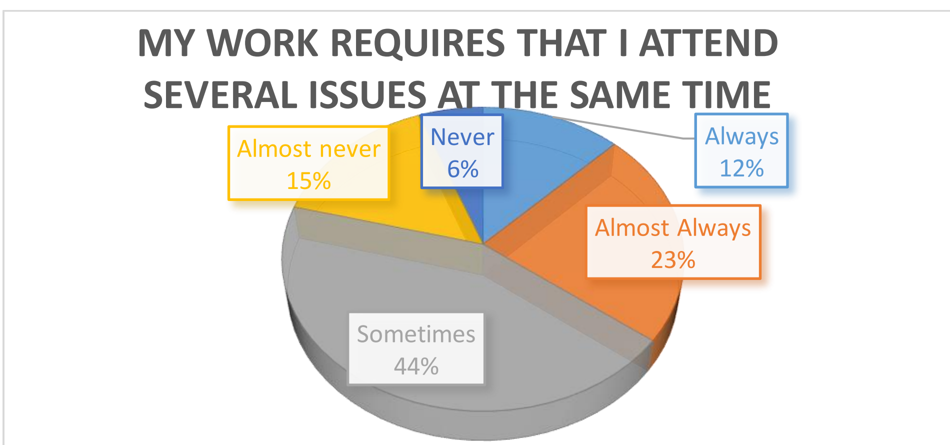

Figure 7. Question 11 results.

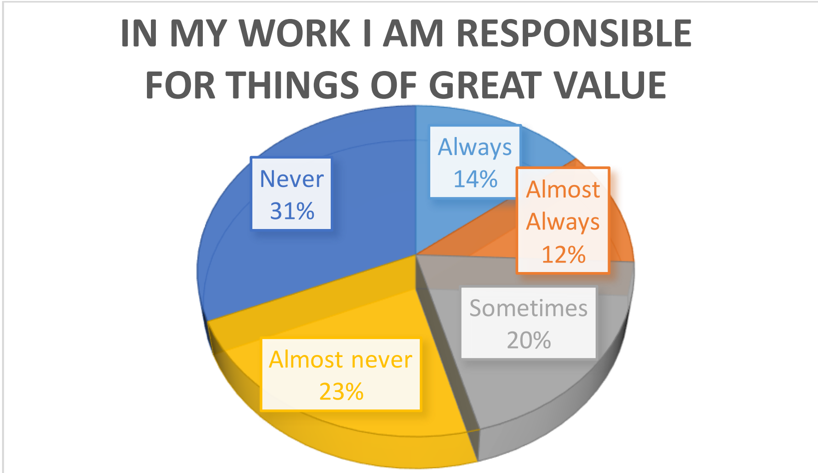

Figure 8. Question 12 results.

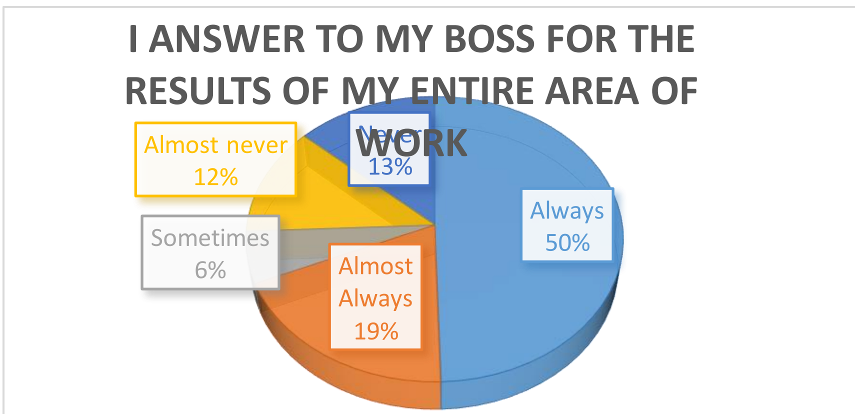

Figure 9. Question 13 results.

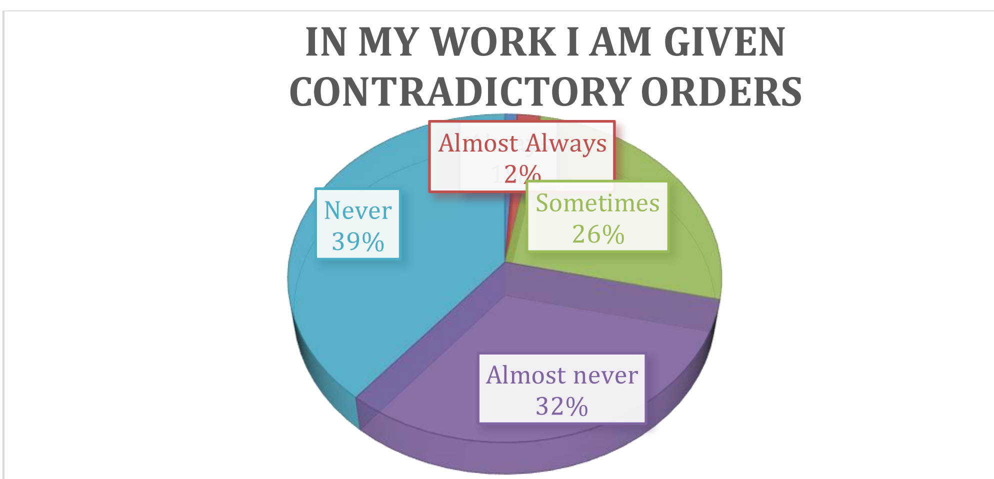

Figure 10. Question 14 results.

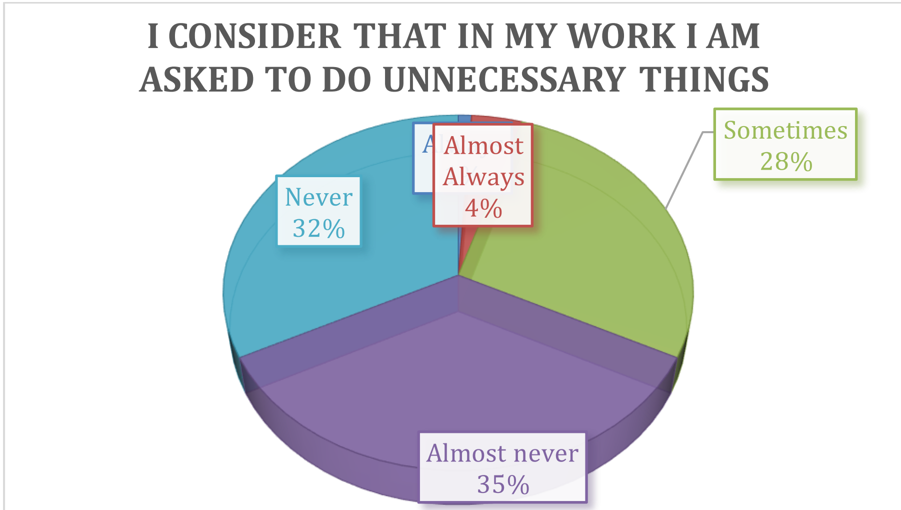

Figure 11. Question 15 results.

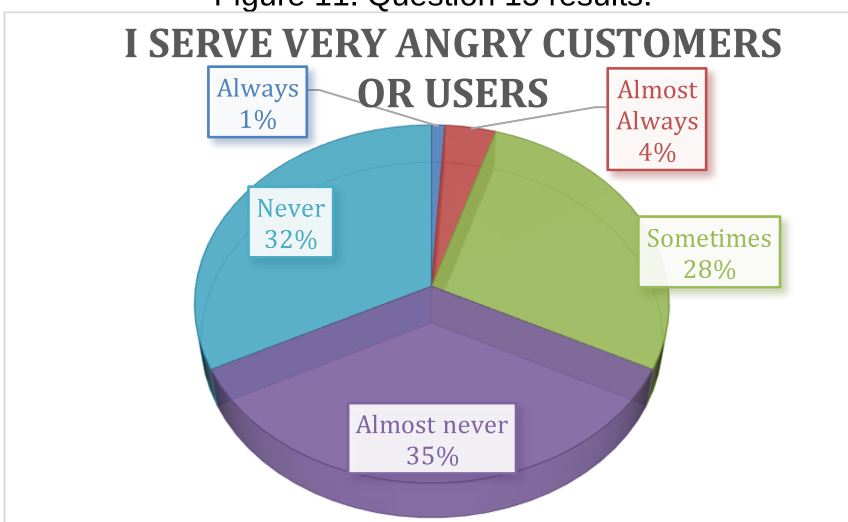

Figure 12. Question 65 results.

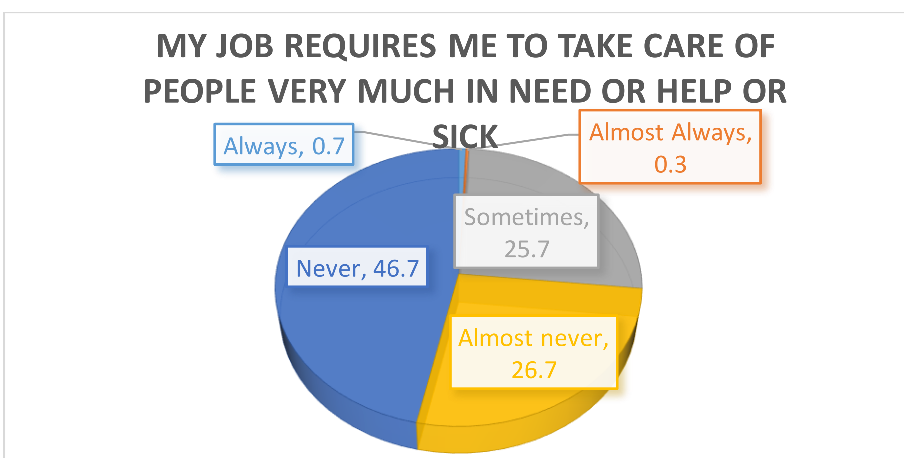

Figure 13. Question 66 results.

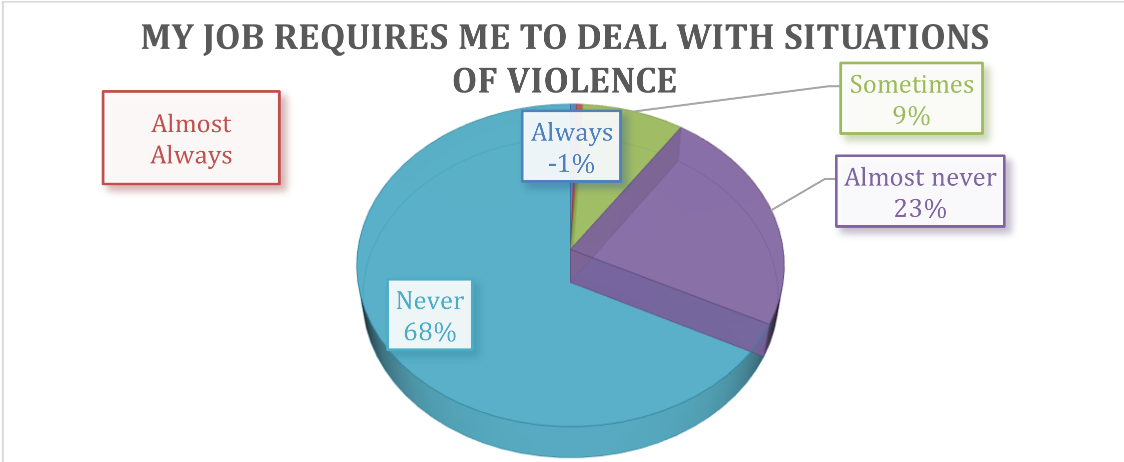

Figure 14. Question 68 results.

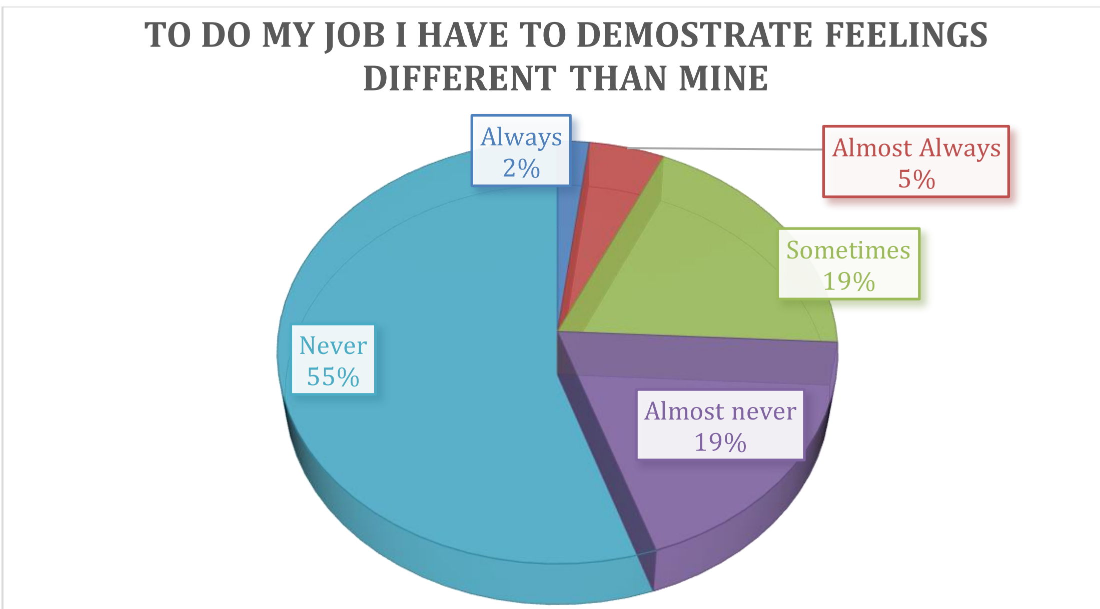

Figure 15. Question 67 results.

The Working Day (60%) represents a demand for the working time made to the worker in terms of the duration and schedule of the working day.

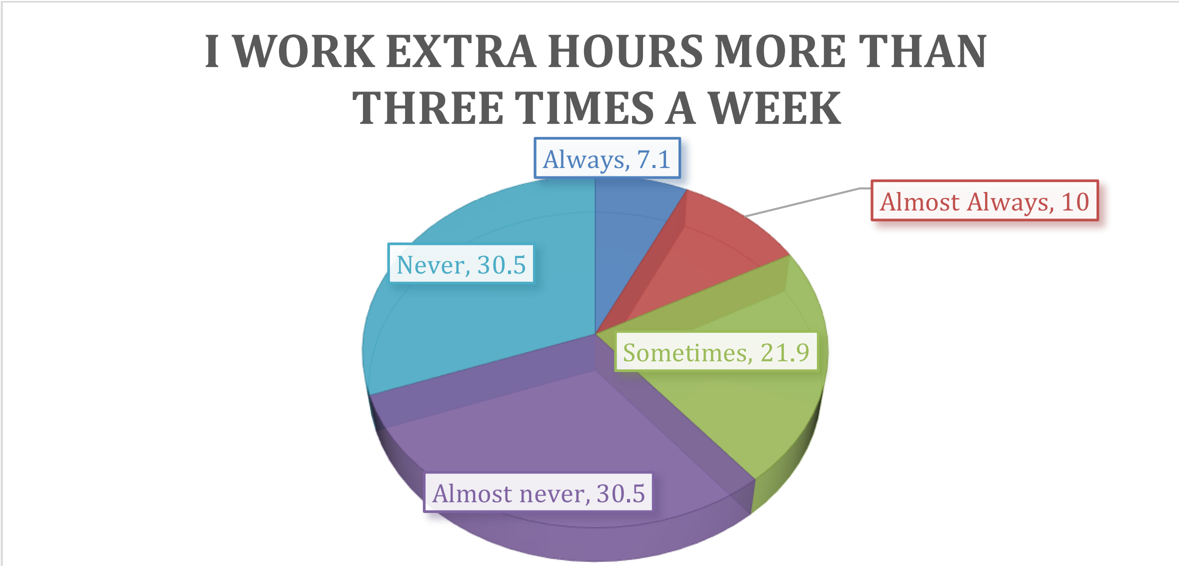

Figure 16. Question 17 results.

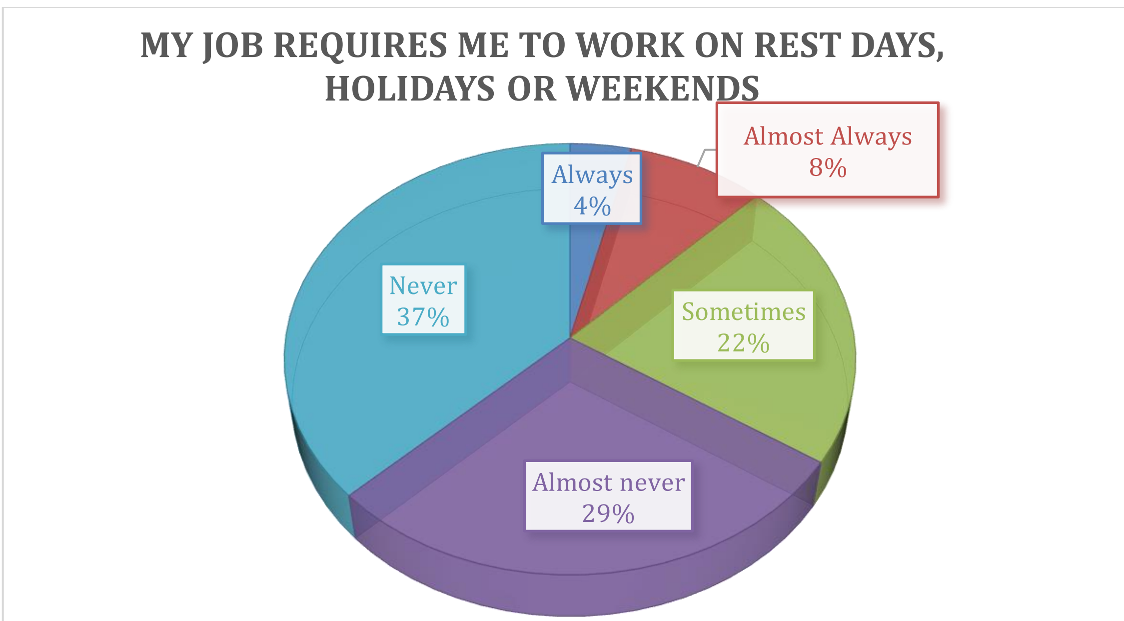

Figure 17. Question 18 results.

Finally, the lack of control over work (46%) is the scarce or non-existent possibility that the worker has to influence and make decisions.

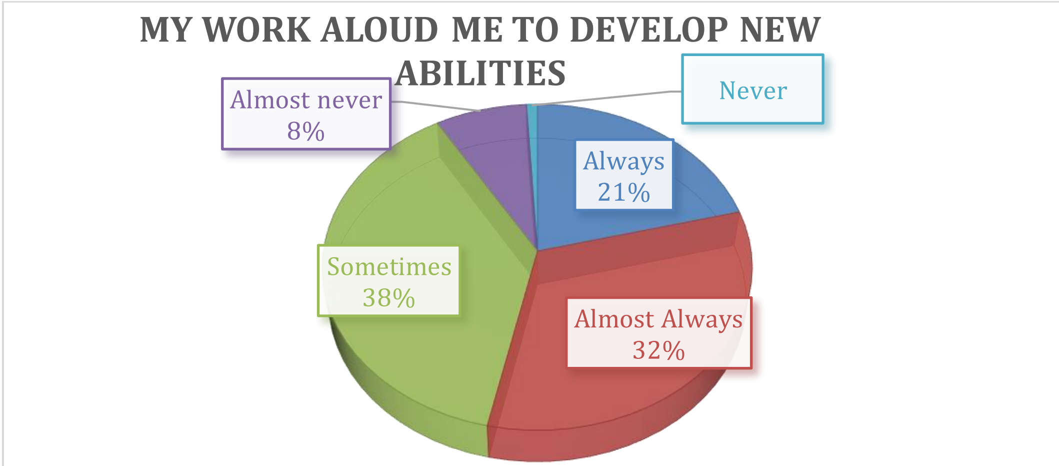

Figure 18. Question 23 results.

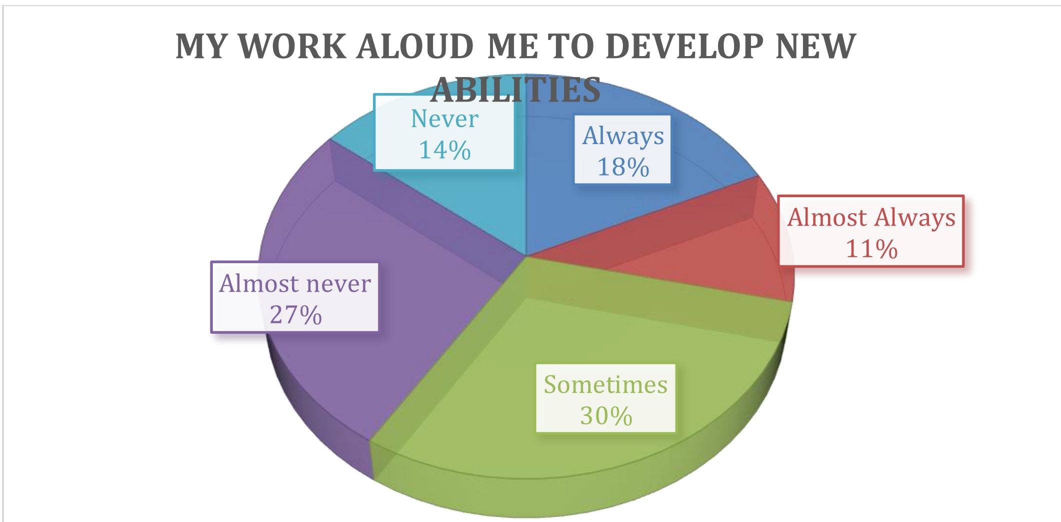

Figure 19. Question 24 results.

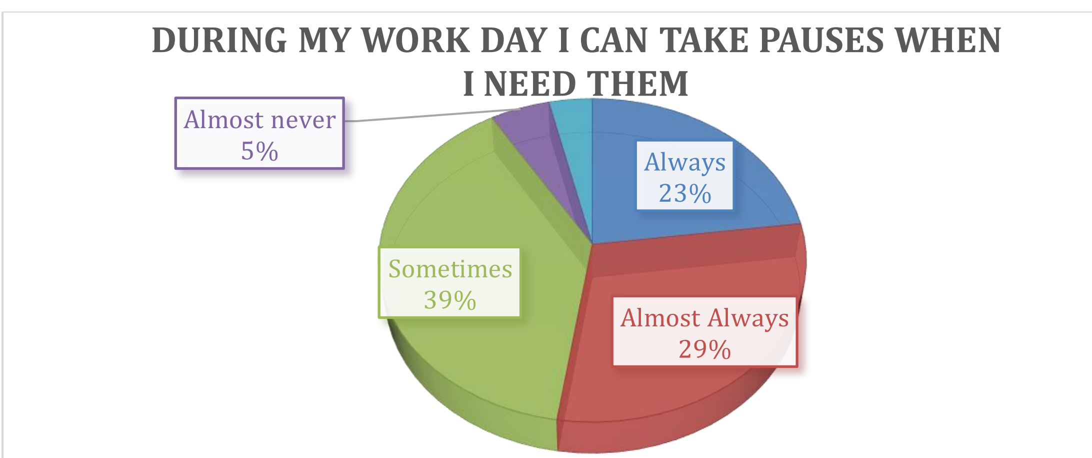

Figure 20. Question 25 results.

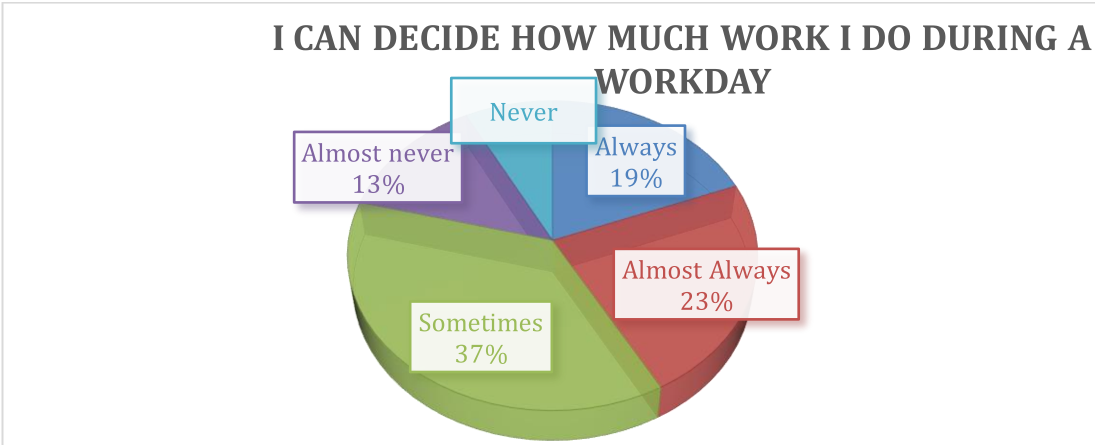

Figure 21. Question 26 results.

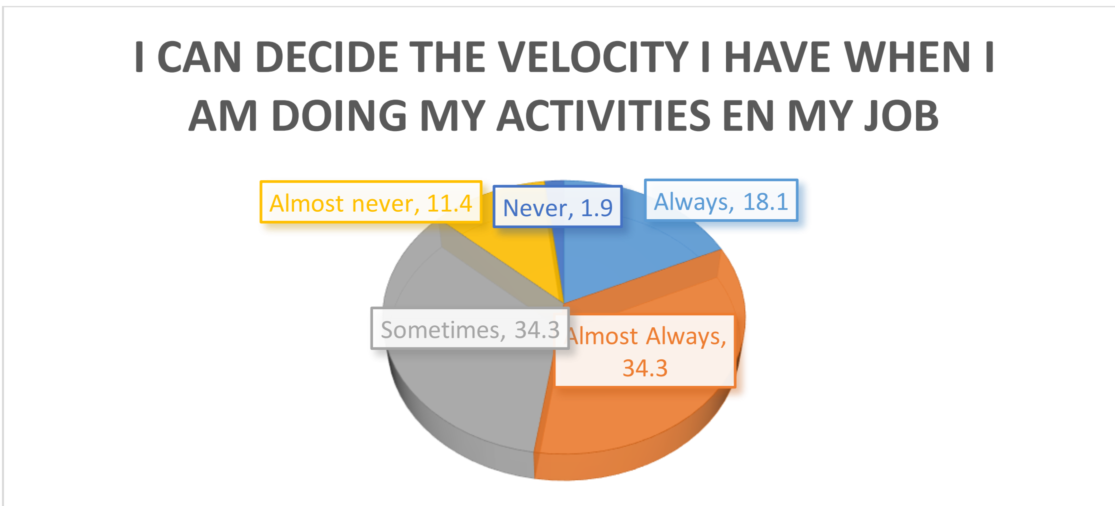

Figure 22. Question 27 results.

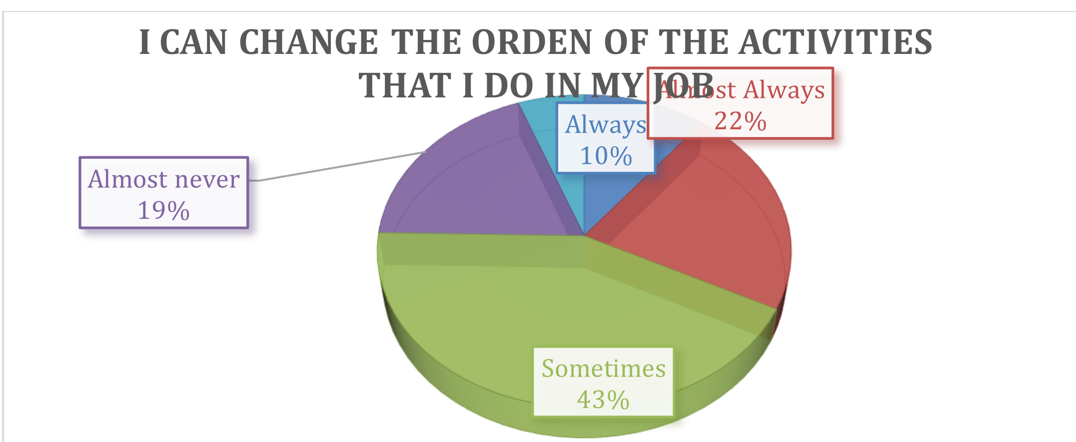

Figure 23. Question 28 results

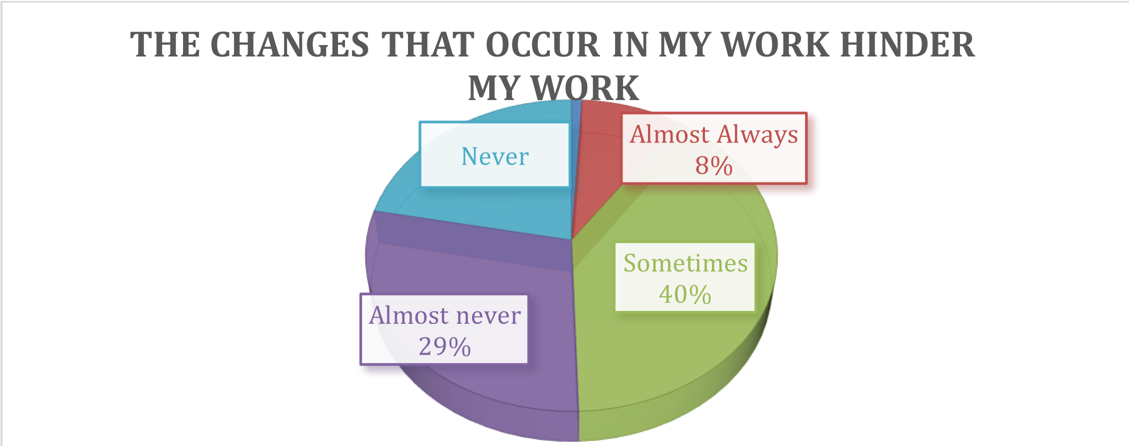

Figure 24. Question 29 results.

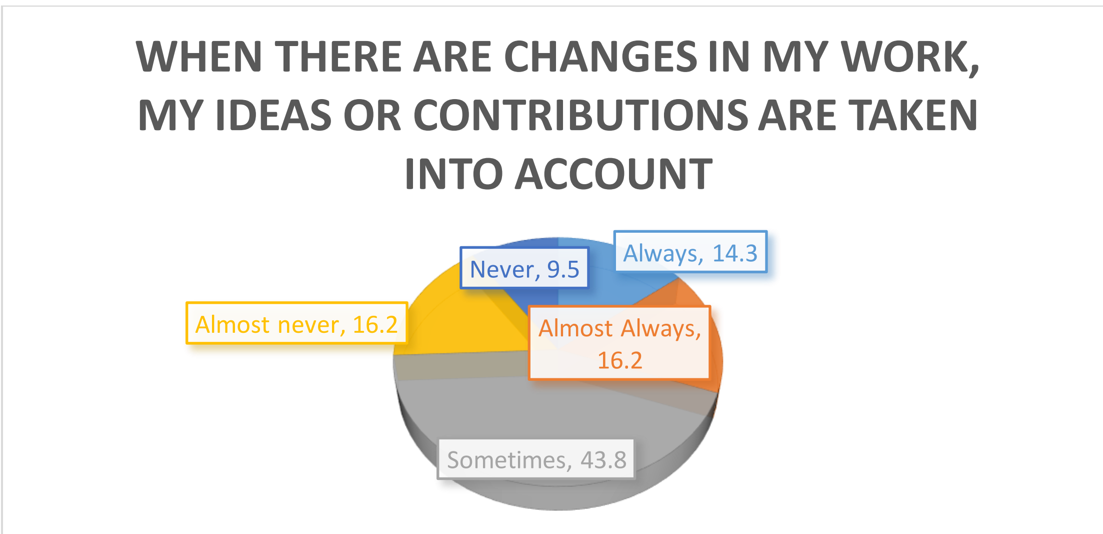

Figure 25. Question 30 results.

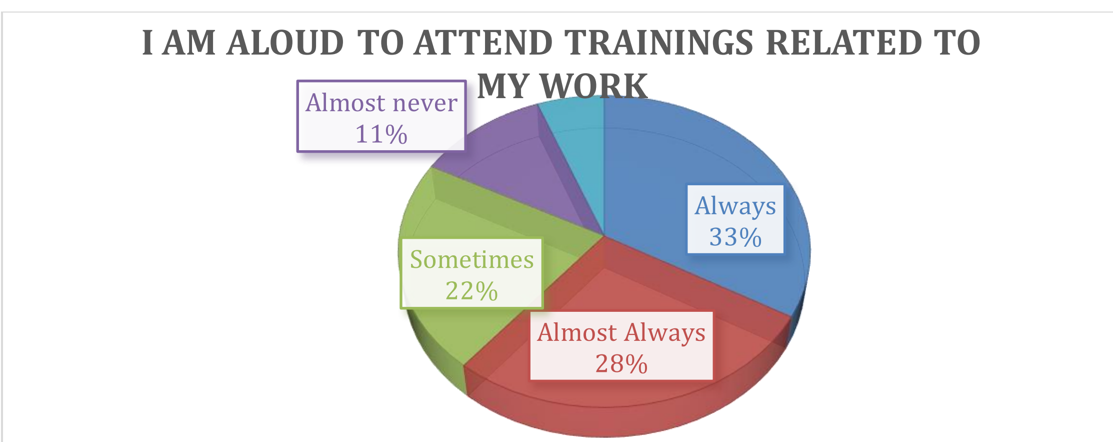

Figure 26. Question 35 results

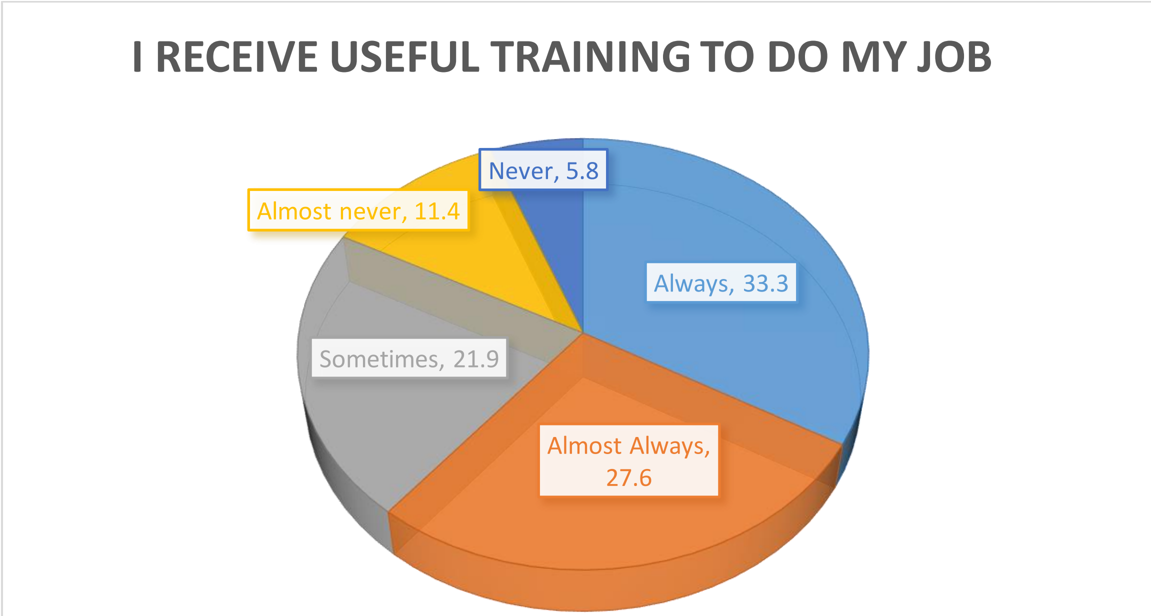

Figure 27. Question 36 results.

Correlations were found between most of the factors of the questionnaires, but not with the work environment factor of the NOM-035 questionnaire since in the analyzed factors, it was obtained that they are at the Null or negligible and low levels.

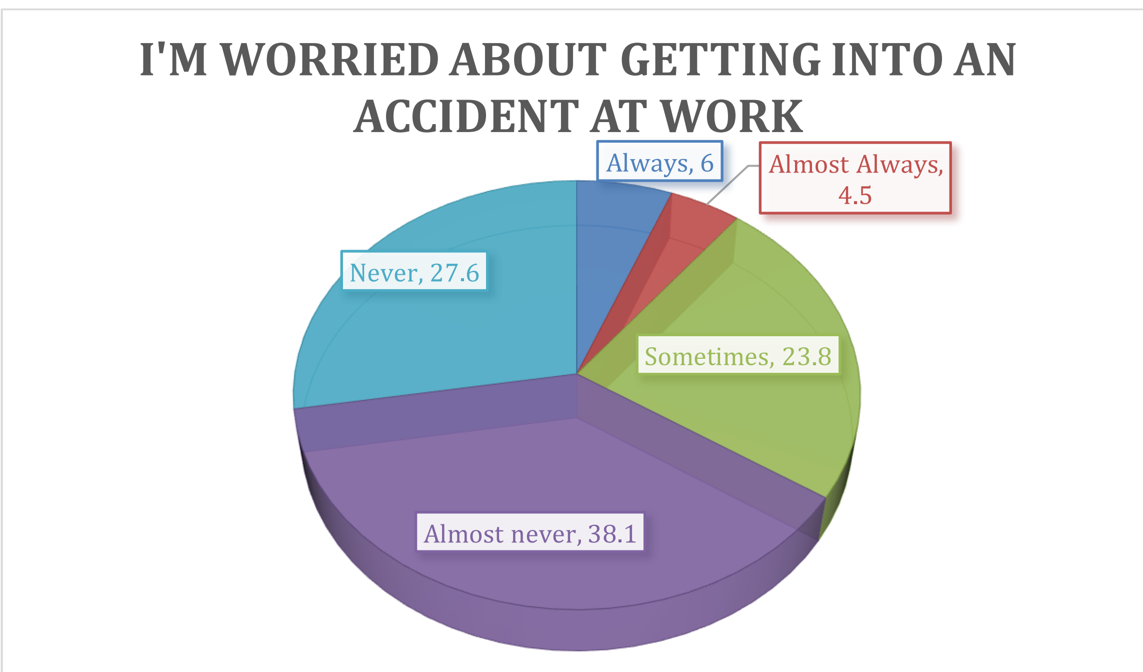

Figure 28. Question 1 results.

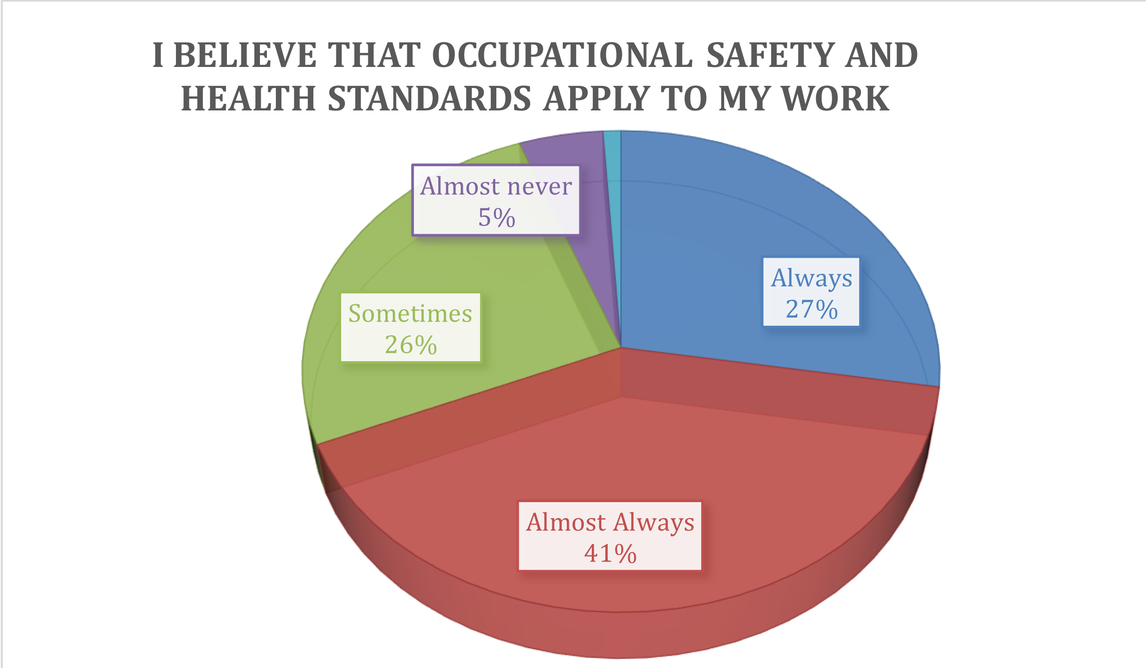

Figure 29. Question 2 results

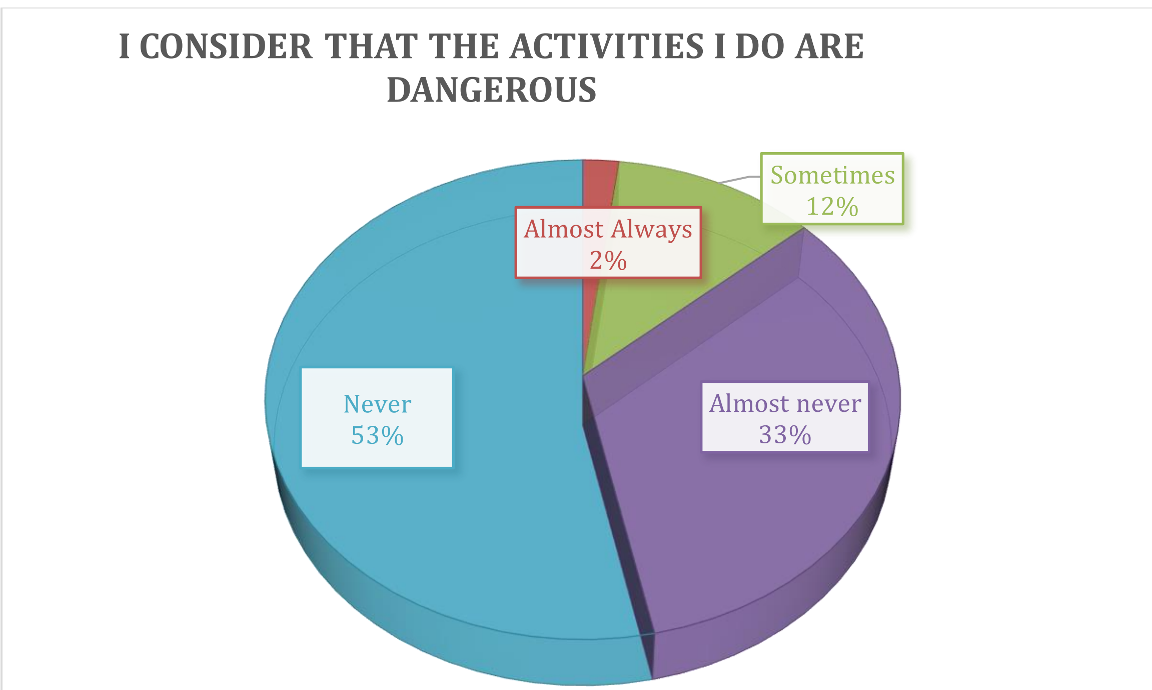

Figure 30. Question 3 results.

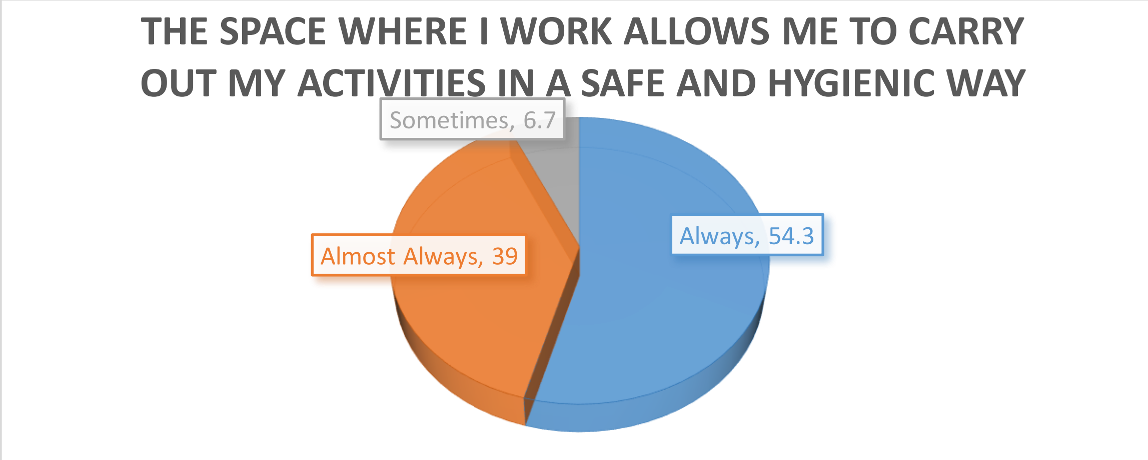

Figure 31. Question 4 results.

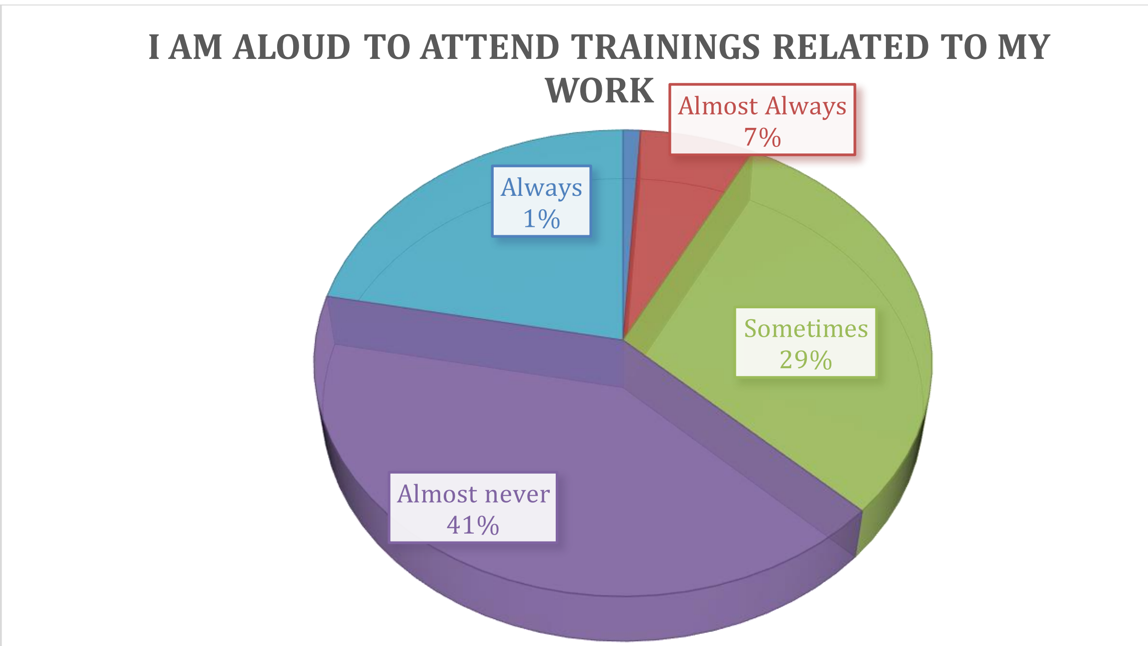

Figure 32. Question 5 results

6. DISCUSSION/CONCLUSIONS

Concerning the results obtained, it was possible to identify workers with high psychosocial risk and analyze them to carry out a strategic plan to meet the needs found, aligned with NOM-035-STPS-2018, which indicates that:

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- High: It is necessary to carry out an analysis of each category and domain so that the appropriate intervention actions can be determined through an

Intervention Program, which may include a specific evaluation and must include an awareness campaign, review of the psychosocial risk prevention policy and programs for the prevention of psychosocial risk factors, the promotion of a favorable organizational environment and the prevention of workplace violence, as well as strengthening its application and dissemination. The recommendation to support the worker with safety equipment appropriate to their functions, such as safety lenses and essential earplugs that significantly reduce exposure to environmental noise, was also met. On the other hand, it was recommended to buy an industrial type of heater which allowed the temperature to rise to 18 ° C, which is much more comfortable for workers.

- Medium: It is necessary to review the psychosocial risk prevention policy and programs for the prevention of psychosocial risk factors, the promotion of a favorable organizational environment, and the prevention of workplace violence, as well as to reinforce its application and dissemination through an Intervention Program. (1)

With the present study, the implementation of the Standard allowed determining the potentially effective action strategies to reduce psychosocial risk according to the needs of the workplace, evoking the strategies based on the criteria for taking actions focused on the medium and high levels. Generally, the instruments show consistency, but some factors do not conform to what is expected, so it is suggested to corroborate their feasibility in similar populations.

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APPLICATION OF NOM-035-STPS-2018 IN A CALL CENTER IN TIJUANA, MEXICO

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Resumen: La presente investigación tiene el objetivo de evaluar los riesgos psicosociales de la empresa ASC, específicamente en el área de atención a clientes, por reportar un mayor nivel de estrés en comparativa a otros departamentos internos. Esto para poder hacer el inicio de la norma rigente NOM-035-STPS-2018, que es el método de obligación para la evaluación, análisis y previsión de factores de riesgo psicosocial en el trabajo. El estudio involucró llevar a cabo los cuestionarios de forma física en el departamento, así como una captura concreta de los datos en el programa de Excel® y su posterior análisis, para una conclusión de recomendación en el área psicosocial, pero también el hecho de una recomendación por la categoría más referente a estudios adicionales para evaluar el entorno físico de la ergonomía en el área de trabajo.

Palabras clave: Psicosocial, ergonomía, estrés, riesgo, NOM-035-STPS-2018

Relevancia para la ergonomía: La contribución que se genera es la promoción de la ergonomía en áreas poco exploradas en empresas de centros de llamadas, permitiendo resolver problemas psicosociales, además de detectar y mejorar los niveles de riesgos a los que están expuestos los trabajadores, contribuyendo de manera positiva al ambiente laboral y el bienestar de estos.

Abstract: The objective of this research is to evaluate the psychosocial risks of the ASC company, specifically in customer service, for reporting a higher level of stress compared to other internal departments. This is to be able to start the governing norm NOM-035-STPS-2018, which is the mandatory method for the evaluation, analysis, and forecast of psychosocial risk factors at work. The study involved carrying out the physical fitness questionnaires in the department, as well as a specific capture of the data in the Excel® program and its subsequent analysis, for a conclusion of recommendations in the psychosocial area but also the fact of recommendations by the category most referring to additional studies to evaluate the physical environment of ergonomics in the work area.

Keywords: Psychosocial, ergonomics, stress, risk, NOM-035-STPS-2018.

Relevance to Ergonomics: The contribution to ergonomics is in underexplored area in call center companies, allowing to solve psychosocial problems, in addition to detecting and improving the levels of risks to which workers are exposed, contributing positively to the environment. employment and their well-being.

1. INTRODUCTION

AMERICAS SURVEY COMPANY (ASC), a call center, has been experiencing frequent understaffing problems due to stress and medical appointment rates experienced by staff. It has also filed complaints about stress-related illnesses. The company's employees are stressed by the fact that they are on the phone with problematic customers, with limited time and demanding goals, all this in addition to real-time monitoring.

The lack of personnel causes labor problems, reducing work efficiency, maintaining a highly saturated telephone line with more than 50 calls on hold, with an average time of 25 minutes per client, and an average of 10 employees with excused absences per week due to stress-related illnesses.

It is estimated that another contributor to stress is the same personnel before the contagion, since, according to the Mexican Institute of Social Security (Instituto Mexicano del Seguro Social, IMSS, 2018), stress is potentially contagious, since being close to or visualizing other people in stressful situations, can increase the observer's cortisol levels. Stress contagions fall into two categories: physical symptoms and psychological-type manifestations. Call center agents manifest both physiological and psychological symptoms that decrease their performance in work, rest and leisure activities, while the workload, accompanied by the feeling of vigilance, is assumed to be a stressor, triggering feelings of fatigue, muscle tension, and low performance.

Job stress could affect the performance of work activities or cause alterations in physical and mental health, family or economic problems, and changes in routine, among others.

ASC considers that for its employees it is important to comply with Mexican standards to increase efficiency and work quality, having a more relaxed and friendly work environment, based on NOM-035-STPS-2018.

2. OBJECTIVE

The objective of this research is to make recommendations for action for the proper management of occupational stress aimed at agents in the customer service area, through the factors governed by NOM-035-STPS-2018, with the purpose of improving the quality of work life and reducing absenteeism caused by stress.

3. DELIMITATIONS

The project takes shape in the Customer Service department at ASC, located in the International Industrial Park, Tijuana, Mexico. A psychosocial risk analysis is proposed based on NOM-035-STPS-2018. The research is limited only to the application of the questionnaire to identify psychosocial risk factors in the workplace and a Favorable Organizational Environment (Reference Guide III). The application of Reference Guide I: Questionnaire to identify workers who were subjected to severe traumatic events is not within the scope of this research. Moreover, the present study was only applied to employees who had absenteeism and the rest of the employees were excluded.

4. METHODOLOGY

The methodology used was divided into three main stages, which are presented below.

4.1 Data Collection

The data collection is based on the absence list of the Customer Service department (both shifts) with a number of active agents of 55. This list was provided by the Human Resources department, including data from October 2021 to February 2022, in a format that summarizes unjustified and justified absences, and also concentrates on personal problems, vacations, leaves, medical appointments, and incapacities, as well as common illnesses, stress, and accidents.

The format created in Excel® software helped to visualize the data more clearly with subsequent Pareto diagram analysis, applying the methodology of the Uruguayan Institute of Technical Standards (2004), which mentions that the Pareto diagram allows distinguishing between those causes that are important (vital and few) and those that are not (trivial and many), where 80% of the absences in the period evaluated are due to stress and medical appointments.

4.2 Definition of Employer's Obligations by NOM-035

The obligations of the employer in the NOM are established in numeral 5, where the employer must establish in writing, implement, maintain, and disseminate in the workplace a psychosocial risk prevention policy that contemplates:

a) The prevention of psychosocial risk factors;

b) The prevention of workplace violence, and

c) Promoting a favorable organizational environment.

Likewise, items 5.6, 5.7, and 5.8 contemplate a medical analysis, as well as the dissemination of information on the workplace and its good practices to combat psychosocial risks, keeping a complete record within the company of each collaborator.

4.3 Application of Questionnaire III of NOM-035

The questionnaire was applied with the recommendation of numeral 7.1, paragraph b), which recommends a sample for employees with a number greater than 51. Since the size of the population is 55, no sample is made, the entire population to be evaluated is contemplated. However, the Reference Guide III is used to cover the evaluation with the specific points of 7.2, 7.3 and 7.4, which are the set of approach to the psychosocial factors of the company, as well as the regulations.

For a correct direction of application of the questionnaire, the application instructions of III.2 of the standard are used, which define how to start the application of the questionnaire and how to give clear instructions during the application of the questionnaire, as well as how to foster an atmosphere of respect and trust. The structuring of the Reference Guide III is respected, as well as III.3 which corresponds to the scoring of the questionnaire, as well as its answers, and the items provided in the framework of the regulation of the psychosocial risk.

5. RESULTS

In the analysis prior to the results, the most critical causes of non-attendance were obtained as shown in Figure 1, where it was shown that incapacity, mostly due to stress, was the main cause, followed by medical appointments.

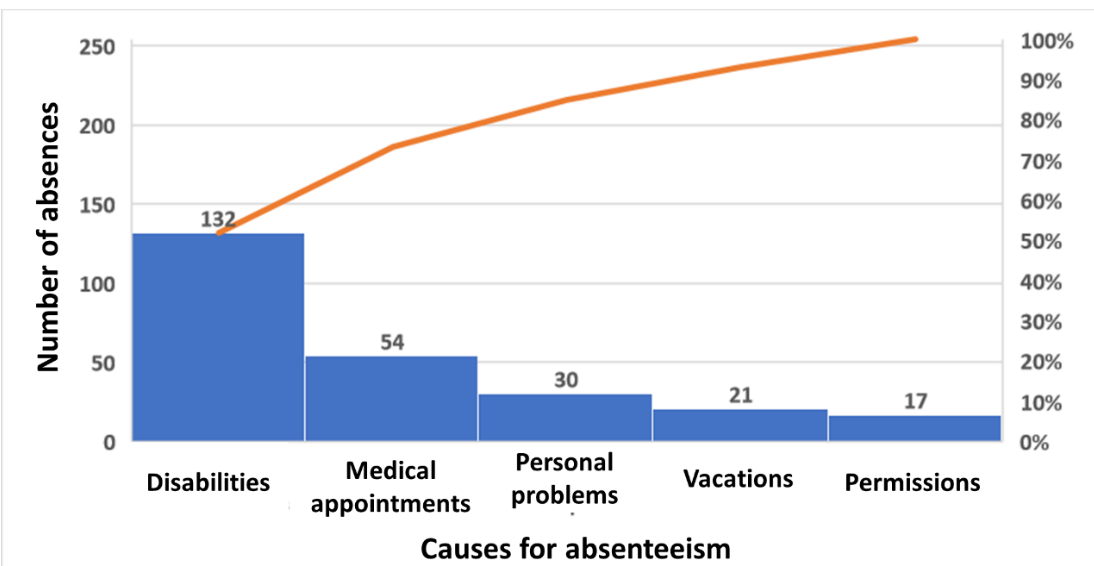

Figure 1. Pareto Diagram of Absenteeism from October 2021 to February 2022

The results obtained from the customer service department, with reference to gender, indicated that most of the workers were male, with a percentage of 64%, equivalent to 35 employees, while 20 workers were female, corresponding to 36%.

Figure 2 shows the results of the age diversity of the department's employees, highlighting that it is composed mostly of young adults, with a cumulative frequency from 18 to 34 years of age, with a total percentage of 71%, equivalent to 39 employees.

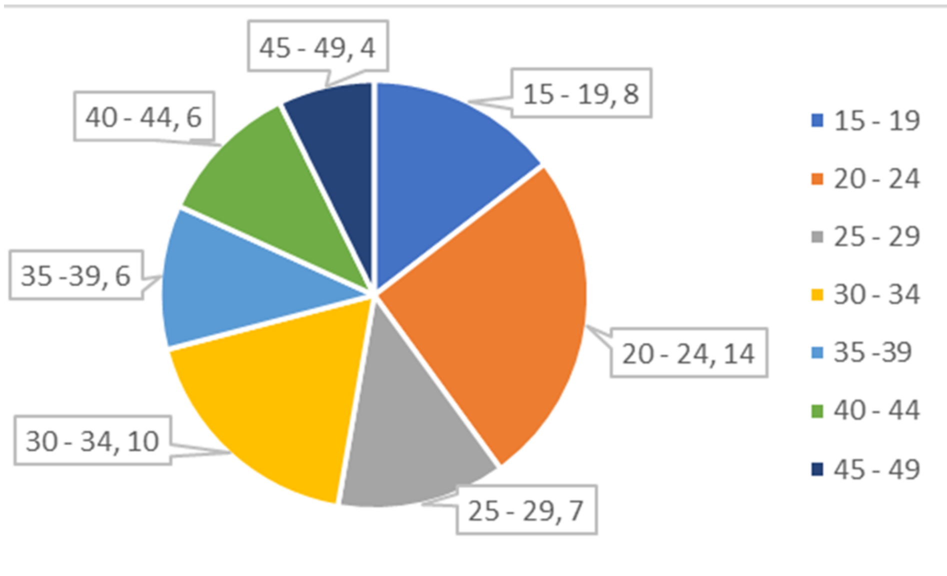

Figure 2. Ages of Customer Service Personnel

Figure 3 shows the result of personnel turnover in relation to the time that operators have been with the company. As can be seen, there was a decrease of 11% in the number of personnel that went from less than 6 months to between 6 months and 1 year, equivalent to 6 employees.

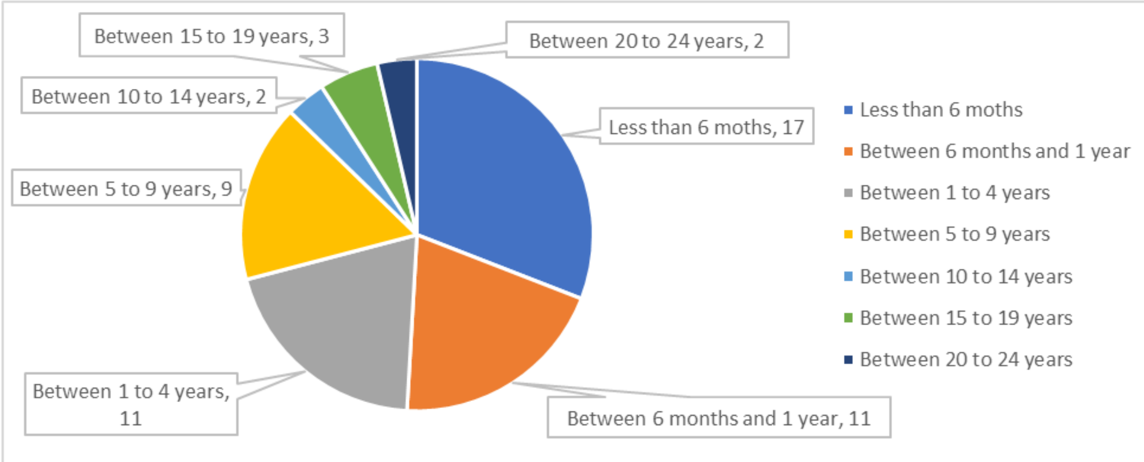

Figure 3. Personnel Time in the Company

Table 1 visualizes the results obtained from the questionnaire, through the score evaluation seen in NOM-035-2018, which generated an average score of 90 and a Medium risk level in the department, with an upward trend to High, due to the number of workers accumulated in the risk level.

Table 1. General Summary of Questionnaire Scores

Risk level	**Number of workers**
Very high	4
High	16
Medium	18
Low	11
Null	6
Grand Total	**55**

Once the general risk level of the department was obtained, we began with the generation of the recommendation with reference to Table 2, where it was taken as a High risk level, due to its upward trend.

Table 2. Recommendations Based on Risk Level

Risk level	Recommendations
High	It is required to carry out an analysis of each category and domain, so that the appropriate intervention actions can be determined through an Intervention Program, which may include a specific evaluation1 and must include an awareness campaign, review the prevention

	policy of psychosocial risks and programs for the prevention of psychosocial risk factors, the promotion of a favorable organizational environment and the prevention of workplace violence, as well as to strengthen their application and dissemination.
Medium	It is necessary to review the psychosocial risk prevention policy and programs for the prevention of psychosocial risk factors, the promotion of a favorable organizational environment and the prevention of workplace violence, as well as to reinforce its application and dissemination, through an intervention program.

The risk levels for the category are shown in Table 3, where a High-Medium risk level result was obtained, with a tendency to Very High-High for the work environment, and a High-Medium risk level for the factors inherent to the activity. The Low or Null risk levels were also taken into account in this case, which is the work organization, showing that there is an organization. In addition, a good risk level was also obtained for the category of leadership and relationships at work.

Table 3. Risk Level by Category

Category	**Risk level**					
	Very high	**High**	**Medium**	**Low**	**Null**	**Grand Total**
Work environment	7	11	14	15	8	55
Organizational environment	5	10	9	13	18	55
Factors of the activity	2	15	26	12	0	55
Leadership and relationships at work	2	5	11	15	22	55
Organization of working time	1	7	10	12	25	55

Table 4 shows the results obtained by category, where it was visualized that the domains with Low-None risk levels were insufficient, sense of belonging and instability, interference in the work-family relationship, leadership, relationship at work, and violence, generating a conclusion that the social environment is having an acceptance of well-being in most of the department.

In the opposite case, the domains with a High-Medium risk level start with the workload, working hours, and performance recognition. Others with the same High-Medium risk level, but with a rise in the Very high cases are work environment conditions and lack of control over work. This generated a conclusion that the employee may be having some indicator of Burnout due to the type of work he/she is doing and/or the fact of dealing with annoying customers, adding that they are not rewarded or recognized for their own performance.

Table 4. Risk Level by Domain

Domain	**Risk level**					
	Very High	**High**	**Medium**	**Low**	**Null**	**Grand Total**
Workload	3	12	17	14	9	55
Conditions in the work environment	7	11	14	15	8	55
Lack of control over work	11	13	12	12	7	55
Insufficient sense of belonging and instability	0	4	7	20	24	55
Interference in the work-family relationship	3	5	7	11	29	55
Working day	7	9	26	4	9	55
Leadership	8	8	7	4	28	55
Performance recognition	6	9	16	8	16	55
Relationships at work	0	3	3	8	41	55
Violence	4	6	5	8	32	55

As a result, a direct recommendation is made to ASC Tijuana call center managers to formulate psychosocial risk policies, based on the reference guide IV of NOM-035-STPS-2018 and strengthening items 1,3,4 and 7, which are the focus of attention by High-Medium risk level that are contemplated in the domain and category results.

It is also advisable to hire an external service specialized in occupational health to be able to give continuity to the standard on severe cases that represent 10% of the department and, according to NOM-035-STPS-2018, these have to be attended and a clinical history generated within the company.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The NOM-035-STPS-2018 is already an obligation for all companies, making it important to use this tool for the evaluation of the department, concluding that it is important to continue strengthening the points of psychosocial ergonomics for workload factors, conditions in the work environment, and lack on work control.

6.2 Recommendations

Once this project was finished, the following actions are recommended:

1. It is recommended to further investigate the categories of work environment and factors specific to the activity, for a second evaluation with a physical

ergonomics methodology, such as the Rapid Office Strain Assessment (ROSA) method.

2. Also, it is recommended to conduct a second investigation focused on an existing root factor, which can cause physiological and postural discomfort, linked to the stress of psychosocial factors within the Customer Service department. Moreover, it is suggested to apply the Reference Guide I: Questionnaire to identify workers who were subjected to severe traumatic events in a short-term investigation.

3. Since the call center job, due to the nature of its tasks with telephone attention to a large number of customers, involves high levels of mental workload given the cognitive processes, it is advisable to apply the National Aeronautics and Space Administration Task Load Index (NASA-TLX) method, the Yoshitake method (physical and mental fatigue), as well as the aforementioned ROSA method. The application of these three methods allows the link between biomechanical and cognitive ergonomics.

4. Evaluate the sound levels in the work environment, in case the workstations are located in a common area where workers talk simultaneously, generating background noise that can interfere with concentration and additionally generate stress.

5. Evaluate stress levels with the Questionnaire for Stress Evaluation, in its third version (31 items), which reveals levels of stress symptoms: a) physiological, b) social behavior, c) intellectual work, and d) psychoemotional.

6. Correlating the psychosocial risk factors with absenteeism to know if this is due to psychosocial risk factors derived from the nature of the job or due to external agents.

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PSYCHOSOCIAL RISKS IDENTIFICATION AND ANALYSIS OF LEVELS IN WORKERS OF INSTITUTO TECNOLÓGICO SUPERIOR DE CIUDAD CONSTITUCIÓN CONSIDERING GENDER PERSPECTIVE AS AN IDENTIFICATION FACTOR

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Resumen: El análisis de los riesgos psicosociales en el trabajo es una actividad que en México tiene un auge a partir de la entrada en vigor de la NOM-035-STPS-2018. Actualmente este tipo de riesgos representa una afectación negativa a la productividad en las empresas, por lo que su identificación y tratamiento debe de considerar una actividad primordial. En la presente investigación se identificó la presencia de estos a través de la guía de referencia III estipulada en la mencionada norma, fue así que se aplicaron 133 cuestionarios y se utilizó estadística descriptiva para identificar el nivel de presencia de riesgo psicosocial presente en los trabajadores hombres y mujeres dentro del Instituto Tecnológico Superior de Cd. Constitución. Los resultados muestran una paridad en los resultados del nivel de riesgo psicosocial entre ambos géneros, encontrándose en nivel medio, así mismo se aplicó una prueba t para muestras independientes, resultando la aceptación de la hipótesis de igualdad de medias (Sig.= 0.929). Se concluye que la identificación de los riesgos psicosociales en los participantes no difiere estadísticamente entre los géneros, por lo que su tratamiento y prevención debe de presentarse sin suponerse que el nivel es mayor en mujeres u hombres.

Palabras clave: Riesgos psicosociales, salud en el trabajo, perspectiva de género.

Relevancia para la ergonomía: La ergonomía al ser una ciencia multidisciplinar tiene diversos campos de aplicación, siendo la ergonomía ocupacional la que se puede enfocar en temas relacionados en como los riesgos psicosociales pueden afectar la productividad laboral. En este sentido la presente investigación se centró en la identificación y análisis de este tipo de riesgos, posteriormente los resultados obtenidos pueden apoyar a la identificación de la relación entre los riesgos psicosociales y la productividad. De esta manera se abren nuevas puertas dentro del Instituto Tecnológico Superior de Ciudad Constitución para que haga uso de las múltiples ciencias que integran ergonomía para mejorar la productividad y mantener un entorno laboral donde los riesgos tanto físicos como psicosociales puedan ser disminuidos.

Abstract: The analysis of psychosocial risks at work is an activity that has boomed in Mexico since the entry into force of NOM-035-STPS-2018. Currently, this type of risk represents a negative impact on productivity in companies, so its identification and treatment must be considered a primary activity. In the present investigation, the presence of these was identified through the reference guide III stipulated in the aforementioned standard, so 133 questionnaires were applied and descriptive statistics were used to identify the level of presence of psychosocial risk present in male and women workers within the Higher Technological Institute of Cd. Constitución. The results show a parity in the results of the level of psychosocial risk between both genders, being at a medium level, likewise a t-test for independent samples was applied, resulting in the acceptance of the hypothesis of equality of means (Sig.= 0.929). It is concluded that the identification of psychosocial risks in the participants does not differ statistically between genders, so their treatment and prevention must be presented without assuming that the level is higher in women or men.

Keywords: Psychosocial risks, occupational health, gender perspective.

Relevance to Ergonomics: Ergonomics, being a multidisciplinary science, has various fields of application, with occupational ergonomics being the one that can focus on issues related to how psychosocial risks can affect work productivity. In this sense, the present investigation focused on the identification and analysis of this type of risk, later the results obtained can support the identification of the relationship between psychosocial risks and productivity. In this way, new doors are opened within the Higher Technological Institute of Ciudad Constitución so that it can make use of the multiple sciences that integrate ergonomics to improve productivity and maintain a work environment where both physical and psychosocial risks can be reduced.

1. INTRODUCTION

Achieving gender equality is one of the main challenges facing the world today, gender equality is defined as the equal rights, responsibilities and opportunities of women and men, and girls and boys. Equality does not mean that women and men are the same, but rather that rights, responsibilities and opportunities do not depend on the sex they were born with.

A great challenge for Mexico is to achieve a society where there is greater equity and equality for the female sex, since it has long been under the suppression of a macho society that limits growth opportunities in different aspects. Although the UN recognizes that Mexico has made progress in terms of gender equality, inequality prevails as women continue to work more and earn less, have fewer opportunities for development and suffer multiple forms of violence at home and in workplaces (UNICEF, 2020).

Gender inequality appears in different ways, one of them can appear in the workplaces when organizations hinder the favorable development of women. Among these obstacles can be identified: the difficulty faced by women to achieve a promotion regardless of their skills or job skills, low salaries and little involvement in decision making.

Previously, occupational health focused most of its attention on attacking those problems that put the physical well-being of workers at risk. At present, mental health has become highly relevant in the workplace, proof of this is that some countries have developed guidelines, regulations and standards that help reduce and prevent psychosocial risks that may affect the mental health of the workers.

In Mexico in 2019, the official Mexican standard NOM-035-STPS-2018, Psychosocial risk factors at work-Identification, analysis and prevention, comes into force. Its main objective is to establish the elements to identify, analyze and prevent psychosocial risk factors, as well as to promote a favorable organizational environment in the workplace. The standard considers any work center as the field of application, taking into account the number of workers present in said work center.

It is important to differentiate psychosocial risk factors from psychosocial risks, the latter being defined as: "Those conditions present in a work situation directly related to the organization of work, the content of the work and the performance of the task, and which are presented with the capacity to affect the development of work and the health of the worker "(UGT, 2019).

A study published by the Mexican Association of Human Resources Management (Amedirh) revealed that stress is a factor that triggers absenteeism, a problem that in Mexico reaches costs greater than 5% of the companies' payroll (Rojas, 2016). In Mexico, women are the people who suffer the most from work stress, being 65 percent, as well as the age group between 30 and 49 years old, almost 70 percent (Chávez, 2022).

The purpose of this research is to determine if there is a difference between the levels of psychosocial risk according to the gender of the participants, that is, if women and men present a difference in their respective levels of psychosocial risk. For this, it was considered to make use of the reference guides dictated by NOM-035-STPS-2018 that indicate according to their scales at what level of psychosocial risk the respondent can be found. Once the results have been obtained, it can be affirmed that the level of psychosocial risk does not differ in terms of gender among the workers of the Higher Technological Institute of Ciudad Constitución.

2. OBJECTIVE

Identify and analyze the existence of psychosocial risks levels considering the gender perspective in workers of the Instituto Tecnologico Superior de Ciudad

Constitución, in order to establish prevention policies for this type of risk and with a gender approach if necessary.

Specific objectives:

- Apply as the main instrument for the identification of psychosocial risk factors the reference guide III identification and analysis of psychosocial risk factors of NOM-035-STPS-2018.
- Design a software database with the results obtained for subsequent descriptive statistical treatment.
- Interpret the results and check the assumption of difference in levels of psychosocial risk considering the general average of the rating according to gender to establish adequate policies for its prevention.

3. Methodology

The Instituto Tecnologico Superior de Ciudad Constitución is a higher educational institution that offers differents academic programs, currently the teaching staff is 87 who are distributed in the following educational programs: Industrial engineering, food industry engineering, systems engineering computer science, electromechanical engineering, business management engineering, architecture, administration, and gastronomy. Likewise, there are 76 non-teaching collaborators that are distributed in personal, administrative, technical and manual. The application of the instrument for the evaluation and identification of levels of psychosocial risk will be carried out in all areas of the institution that have available personnel.

The present investigation is of a non-experimental descriptive nature where an intentional sample of 133 participants was obtained, it is important to mention that the formula to calculate the sample size stipulated in NOM-035-STPS-2018 was not used since the intention is to apply the reference guide III that is stipulated for work centers with more than 50 collaborators to all the teaching and non-teaching staff that work in the institution and that was found available during the investigation, since some collaborators were commissioned or absent due to Covid-19 infections.

Table 1 shows an example of how an item is presented with its respective answer options shown in reference guide III:

Table 1. Example of question and answers.

No.	Question	Always	Almost always	Sometimes	Rarely	Never
1	My job requires me to do a lot of physical effort					

The respondent has to indicate only one option within the box of an answer with which he identifies according to the last six months in his work center. In total, each respondent answered 72 items correctly, each adding a score as shown in the following table:

Table 2. Weighting of each response per item.

Rating of answer options					
Ítems	**Always**	**Almost always**	**Sometimes**	**Rarely**	**Never**
1, 4, 23, 24, 25, 26, 27,28, 30, 31, 32, 33, 34,35, 36, 37, 38, 39,40, 41, 42, 43, 44, 45,46, 47, 48, 49, 50, 51,52, 53, 55, 56, 57	0	1	2	3	4
2, 3, 5, 6, 7, 8, 9, 10, 11,12, 13, 14,15, 16, 17, 18,19, 20, 21, 22, 29, 54,58, 59, 60, 61, 62, 63,64, 65, 66, 67, 68, 69,70, 71, 72	4	3	2	1	0

Through the sum of each item, a final rating is obtained, which will be the one that indicates the level of psychosocial risk in which the respondent is found, said level is identified according to the range in which the final rating is found, as indicated in the table 3:

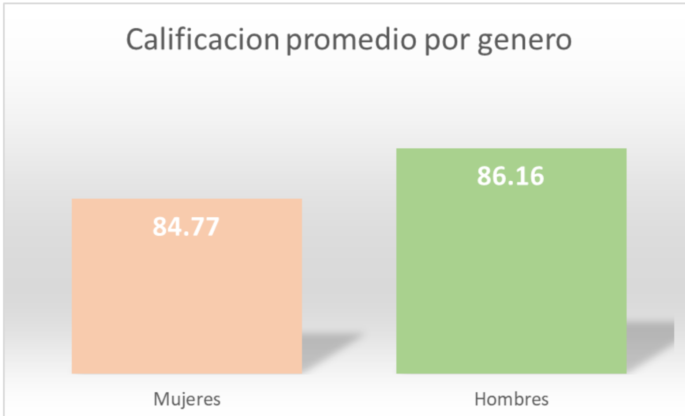
Table 3. Questionnaire result intervals.

Questionnaire result	Null or negligible	Low	Medium	High	Very high
Final questionnaire score	Cfinal≤50	50≤Cfinal<75	75≤Cfinal<99	99≤Cfinal<140	Cfinal≥140

The application of the questionnaire was carried out in paper format, the interviewer went to various areas of the institution to interview the staff, indicating the gender to which each participant belongs. During the interview, adequate time and space were provided to the participants, in addition to an explanation of the intention of the instrument and the objective of the research, questions that arose were answered and the procedure was repeated until reaching the total number of collaborators available in the institution. Once the data was collected, a database was created in Excel software for subsequent descriptive treatment, emphasizing the differences in levels between genders.

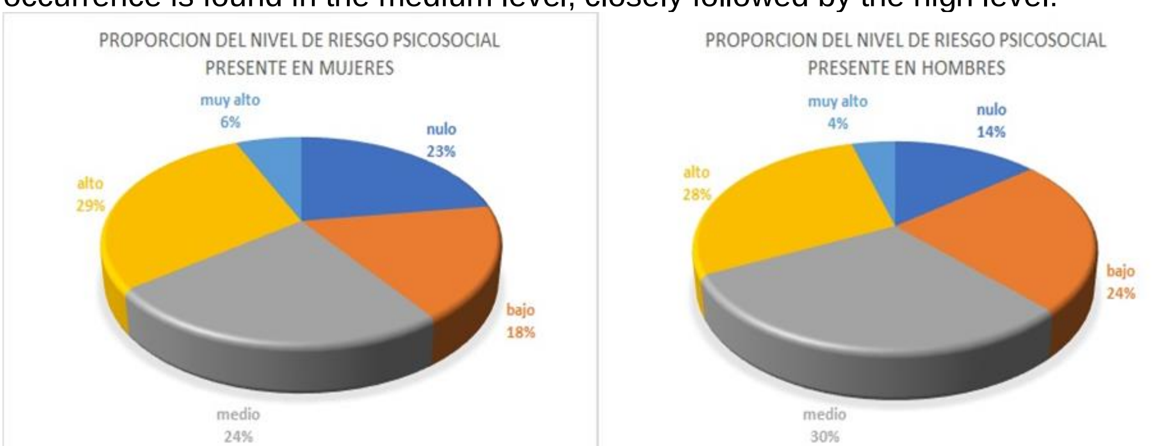
4. Results

In total 133 surveys were answered correctly, of which 62 correspond to the female gender (46%) and 71 to males (54%). The average of the responses between genders is shown in graph one, it is observed that both are within the interval of the average level of psychosocial risk, therefore, considering the average of the scores of the questionnaire, it is not possible to affirm that the level of psychosocial risk, depending on the instrument used to measure it, is greater in one of the genders.



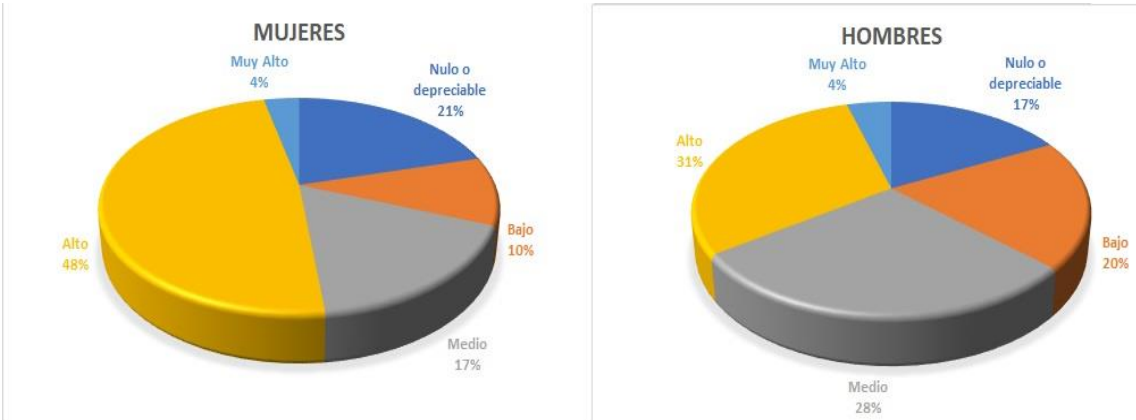
Graph 1. Average rating by gender.

The comparison between the different levels of psychosocial risk between women and men shown in graph 2 indicates that in both genders the highest occurrence is found in the medium level, closely followed by the high level:



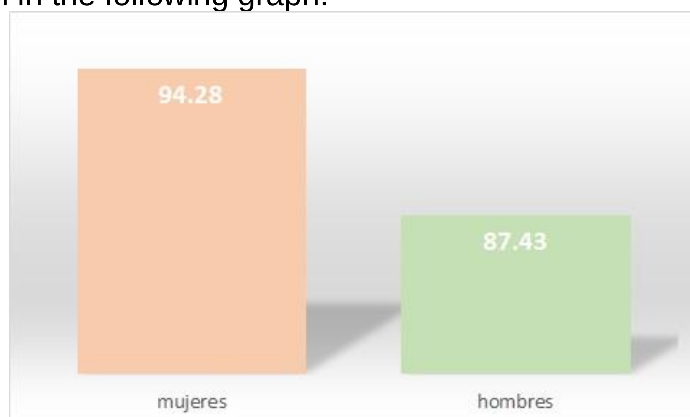
Graph 2. Comparison of levels of psychosocial risk present between women and men.

The same analysis was carried out considering one of the work activities carried out by the collaborators of the institution, as shown in the comparison of graph 3, between female and male teachers, there was a higher proportion of women who were found in the "high" level of psychosocial risk (48%), compared to men, the highest concentrations are occupied by the “medium” (28%) and “high” (31%) levels:



Graph 3. Comparison of risk levels between female and male teaching staff. Source: self-made.

The general average rating for female and male teachers indicates that both are within the average level of psychosocial risk, with the female rating being slightly higher, as shown in the following graph:



Graph 4. General average rating for female and male teachers.

To identify the presence of a significant difference between the final scores of the test made in men and women, SPSS software was used using a t-test for independent samples, the results are shown in the following table:

Table 4. t test for independent samples.

Prueba de muestras independientes

		Prueba de Levene para la igualdad de varianzas		Prueba T para la igualdad de medias						
									95% Intervalo de confianza para la diferencia	
		F	Sig.	t	gl	Sig. (bilateral)	Diferencia de medias	Error típ. de la diferencia	Inferior	Superior
puntuacion	Se han asumido varianzas iguales	1.105	.295	-.090	131	.929	-.49341	5.49296	-11.35981	10.37298
	No se han asumido varianzas iguales			-.089	124.325	.929	-.49341	5.52898	-11.43654	10.44971

As can be seen, the bilateral significance resulting from the t test (Sig.= 0.929) is greater than that established to test the null hypothesis (Sig.= 0.05), therefore it can be shown that there is no statistically significant difference between the genders in function of the score they obtained.

5. Conclusions

The analysis of psychosocial risks is an activity that is on the rise within the workplace in the Mexican territory, since as of 2019 and with the entry into force of NOM-035-STPS-2018, employers must implement strategies to identify and prevent these damages that affect labor productivity. Regarding the ITSCC, it was possible to identify that there is no difference in the level of psychosocial risk between women and men who work in the institute, this can be verified if the general averages of both sexes are considered, that of women corresponds to a average of 84.77 while in men it is 86.16, which places both at a medium level of psychosocial risk.

In any workplace that identifies the presence of levels of psychosocial risk among its collaborators, it is essential that a policy be established for its prevention and identification, in this sense, for Instituto Tecnológico Superior de Ciudad Constitución, it can be described as follows:

In the Higher Technological Institute of Ciudad Constitución, in relation to the prevention of psychosocial risks, the following commitments are assumed:

- It is the obligation of directors and special commissions to apply this policy and lead by example.
- Acts of workplace violence are not tolerated, as well as any incident that promotes psychosocial risk factors or actions against a favorable organizational environment.
- Measures aimed at preventing psychosocial risks, prevention of workplace violence and gender inequality are applied to prevent their adverse consequences.
- Awareness and training actions are carried out.
- Prevention policies and measures are effectively disseminated.
- The exercise of the rights of personnel to maintain their beliefs or practices or to satisfy their needs related to race, sex, religion, ethnicity or any other condition that may give rise to discrimination is respected.
- Spaces for participation and consultation are created, taking into account the ideas of the workers.

Considering the null inequality of levels of psychosocial risk between genders, it was not necessary to specify this situation in greater detail in the policy described above.

Likewise, the level found in the teaching staff resulted in both genders within the medium category, for which a prevention policy for this type of risk was designed so that the institution can adopt it and, where appropriate, apply the strategies that in her are mentioned, this is how in future research it can be verified if the level found in the participants could drop in at least one category.

In general, it was possible to verify the hypothesis raised at the beginning of the investigation and it is shown that considering the general average rating between both genders, the level of psychosocial risk is similar, therefore, women are not more or less affected than their peers. men, thus verifying that psychosocial risks can be present in equal conditions for all participants.

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ANALYSIS OF THE PREVALENCE OF PSYCHOSOCIAL RISK FACTORS IN THREE ECONOMIC SECTORS

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Resumen. La Organización Internacional del Trabajo (OIT), ha reconocido a los factores psicosociales como parte fundamental del desarrollo en las organizaciones considerando en ellas un componente positivo que propicia la conservación y, en ocasiones, el mejoramiento de la salud. Sin embargo, el componente negativo ha sido asociado -con cierta importancia relativa- con la aparición de enfermedades que pueden surgir en prácticamente todo el entorno donde interactúan las personas, particularmente en el ambiente de trabajo, en ciertos aspectos de la organización, en los sistemas y aspectos físicos del trabajo y en las relaciones humanas repercutiendo en el clima social de la empresa y en la salud física y mental de los trabajadores, (OIT, 1984).

Palabras clave: factores de riesgo psicosocial, agroindustrial, farmacéutico, logístico

Relevancia para la ergonomía. identificar los factores de riesgos psicosociales en el trabajo o entorno organizacional provee a la empresa el conocimiento y, por lo tanto, la toma de decisión para mitigar los efectos que estos puedan generar en la salud física y emocional del trabajador.

La psicosociología aporta a la ergonomía …entre otros….la posibilidad de identificar y reducir los riesgos laborales, adaptando el puesto y condiciones del trabajo a las características del trabajador, incrementa la motivación y satisfacción del empleado al mitigar cargas, ritmos y jornadas laborales con estudios ergonómicos derivados del análisis de FRPS.

Abstract. The International Labor Organization (ILO), has recognized psychosocial factors as a fundamental part of development in organizations, considering them a positive component that promotes the conservation and, sometimes, the improvement of health. However, the negative component has been associated - with a certain relative importance- with the appearance of diseases that can arise in practically the entire environment where people interact, particularly in the work

environment, in certain aspects of the organization, in the systems and physical aspects of work and human relations, which have repercussions on the social climate of the company and on the physical and mental health of the workers (ILO, 1984).

Keywords: psychosocial risk factors, agroindustrial, pharmaceutical, logistics

Contribution to ergonomics. Identifying psychosocial risk factors at work or in the organizational environment provides the company with knowledge and, therefore, decision-making to mitigate the effects that these may have on the worker's physical and emotional health.

Psychosociology contributes to ergonomics, among others, the possibility to identify and reduce occupational risks, adapting the position and working conditions to the characteristics of the worker, increasing the motivation and satisfaction of the employee by mitigating loads, rhythms and working hours with ergonomic studies derived from FRPS analysis.

1. INTRODUCTION

Psychosocial risk factors (PSRF) and their negative effects related to work have been extensively studied. In several countries there are regulations, decrees and regulations aimed at reducing exposure to risks and their consequences on the health of workers. FRPS have been associated in industries governed by continuous flow production systems, organized by just-in-time system concepts and that require great flexibility in their work organization structures to maintain a competitive level according to the demands of the globalized markets.

In Mexico, as of 2015, the Federal Regulation on Safety and Health at Work (RFSST, 2014) has come into force, where, as part of Article 32, the general provisions for health at work are established and include in numerals X and XI to Ergonomic Risk Factors (ERF) and Psychosocial Risk Factors (FRPS) respectively. It is also mentioned that the provisions will be complemented by the regulations that are applicable, in this case, NOM-035-STPS-2018; Psychosocial risk factors at work, Identification, analysis and prevention.

This research work addresses the issue of psychosocial risk factors based on the analysis of three companies from different economic sectors.

Psychosocial risk factors worldwide

In 2012, the ILO pointed out that, although some of the traditional risks have decreased thanks to safety, technical advances and better existing regulations, they continue to affect the health of workers, since there is an increase in new types of risk. of occupational diseases without the application of adequate prevention, protection and control measures. Psychosocial risk factors are found in the “new diseases”.

In recent decades, globalization and technological progress have transformed the world of work by introducing new forms of work organization, labor relations and employment models and contributing to the rise of work-related stress and related disorders.

Globalization has given rise to new opportunities for economic development but also to the danger posed by global competitiveness processes due to the pressure they exert on working conditions and respect for fundamental rights (ILO, 2016).

In 2017, the ILO announced that around 2 million deaths from occupational accidents or illnesses are registered annually in the world, and 160 million people suffer from work-related ailments.

As a consequence, it has an economic impact equivalent to 4% of the world's GDP, being a value 20 times higher than the resources dedicated to the prevention of these risks.

According to studies by the International Labor Office, ILO (1984), adverse factors related to health are considered to be work overload, lack of control, misuse of the worker's skills, authority problems, poor salary distribution, lack of job security, labor relations problems, shift work and physical danger.

In Brun and Milczarec (2007) of the European Agency for Safety and Health at Work, 6 organizational factors that cause psychosocial risks are identified, among others: excessive workloads; conflicting demands and lack of clarity of the functions of the position; lack of participation in making decisions that affect the worker and lack of influence in the way the work is carried out; ineffective communication, lack of support from management or colleagues; violence by third parties and psychological and sexual harassment.

Other studies of psychosocial risks (Cox et al, 2003, Velázquez, 2010) include the content, rhythm and program of work, control, environment and equipment, the culture of the organization, interpersonal relationships at work, role in the company, development professional and interrelation between the organization and the worker's home.

Although it is difficult to determine what the main psychosocial risks are, NOM-035-STPS-2018 makes it possible to identify some of the most important, namely:

Conditions in the work environment. They refer to dangerous and unsafe or poor and unhealthy conditions; that is, to the conditions of the workplace, which under certain circumstances require the worker to make an additional adaptation effort.

Workloads. They refer to the demands that the work imposes on the worker and that exceed their capacity, they can be of a diverse nature, such as quantitative, cognitive or mental, emotional, responsibility, as well as contradictory or inconsistent loads;

Lack of control over work. Control over work is the possibility that the worker has to influence and make decisions in carrying out their activities. Initiative and autonomy, the use and development of skills and knowledge, participation and management of change, as well as training are aspects that give the worker the possibility of influencing their work. These elements, when they are non-existent or scarce, become a risk factor;

Working hours and shift rotation that exceed what is established in the Federal Labor Law. They represent a requirement of working time that is made to the worker in terms of the duration and schedule of the day, it becomes a psychosocial risk factor when working with long hours, with frequent rotation of shifts or night shifts, without pauses and breaks clearly established periodicals and no prevention and protection measures for the worker to detect an early impact on their health;

Interference in the work-family relationship. It arises when there is a conflict between family or personal activities and work responsibilities; that is, when they constantly have to attend to work responsibilities during the time dedicated to family and personal life, or have to work outside of working hours;

Negative leadership at work. refers to the type of relationship established between the employer or its representatives and the workers, whose characteristics influence the way of working and the relationships in a work area and which is directly related to the aggressive and/or imposing attitude; lack of clarity of roles in activities, and little or no performance recognition and feedback;

The concept of negative relationships at work. refers to the interaction that is established in the work context and covers aspects such as the impossibility of interacting with co-workers to solve work-related problems, and unfavorable characteristics of these interactions in functional aspects such as poor or no teamwork and social support.

Favorable Organizational Environment. One in which the sense of belonging of the workers to the company is promoted; training for the proper performance of the tasks entrusted; the precise definition of responsibilities for the workers of the workplace; proactive participation and communication between workers; the adequate distribution of workloads, with regular working hours in accordance with the Federal Labor Law, and the evaluation and recognition of performance.

2. OBJECTIVE

The objective is to analyze the prevalence of psychosocial risk in three companies, limiting the study to the economic, agro-industrial, pharmaceutical and logistics sectors.

3. LITERATURE REVIEW

The International Labor Organization (1984) defines Psychosocial Factors as interactions, on the one hand, between work, environment, satisfaction and the conditions of the organization and on the other, the worker's abilities, needs, culture and the situation. personnel that prevails outside of work, considering for this the perceptions and experiences manifested by the worker in the company.

On the other hand, Moncada and Llorens (2006) identify them as the conditions present in the work environment that have their origin in the company, the content, load and performance of the tasks assigned to the position and that can affect both well-being or health. (physical, mental or social) of the worker as well as their performance in the position. In Mexico, the Ministry of Labor and Social Welfare (STPS) defines psychosocial factors as those risks capable of generating anxiety disorders, non-organic disorders of the sleep-wake cycle and severe stress and adaptation, derived from the nature of the functions of the job, type of working day and the worker's exposure to severe traumatic events or acts of workplace violence due to the work performed (NOM-035-2018).

An attempt has been made to classify the various risks that the worker may face in order to identify the most common ways in which these adverse conditions occur for both the individual and the organization. According to ILO studies (1984), adverse factors related to health are considered to be work overload, lack of control, misuse of the worker's skills, problems with authority, poor salary distribution, lack of job security. work, labor relations problems, shift work and physical danger. The European Risk Observatory (2007) indicates, among others, 6 organizational factors that cause psychosocial risks: excessive workloads; conflicting demands and lack of clarity of the functions of the position; lack of participation in making decisions that affect the worker and lack of influence in the way the work is carried out; ineffective communication, lack of support from management or colleagues; violence by third parties and psychological and sexual harassment.

Other studies of psychosocial risks (Cox et al, 2003, Velázquez, 2010) include the content, rhythm and program of work, control, environment and equipment, the culture of the organization, interpersonal relationships at work, role in the company, development professional and interrelation between the organization and the worker's home.

Although it is difficult to determine what the main psychosocial risks are, studies (ILO, 2014, Moreno and Báez, 2010) allow us to identify some of the most important:

Stress. The internal and external factors and the constant technological change in which the organization operates, demand maximum efforts to meet the demands that the environment determines, or in the opposite direction, the inefficient use of the worker's skills in their work, generates a change in behavior negatively affecting their work performance, motivation and quality of life, and decrease their capacity for creativity and stagnation of professional development, having a decisive impact on organizational effectiveness (Schabracq et al., 2000).

Stress is caused in part by the imbalance between the demands and pressures faced by the worker in the job and, on the other, by the skills and knowledge that he or she possesses (Stravoula et. al, 2004). When the needs of the environment exceed the capabilities of the worker, it can trigger adverse effects on physical and mental health such as exhaustion, depression to the detriment of their quality of life and productivity, even leading to termination of the contract.

The characteristics of the position, volume, rhythm and work schedules as well as the participation and control exercised by the company are triggering agents of stressors in the company, poorly managed administration, poorly designed processes and demanding work shifts are red lights that must be considered when establishing improvement strategies within the organization and that are aimed at developing the skills and competencies of the worker in a work environment that fosters creativity, motivation and productivity.

Burnout or professional burnout. Widely related to stress, the term burnout was used in the 1970s after the behavior presented by some policemen of that time was analyzed, according to data from the work stress portal, they were the psychologists S. Jackson and C. Maslasch who in 1981 identified burnout as a "syndrome of emotional exhaustion, depersonalization and less personal fulfillment, which tends to occur more frequently in jobs that require attention to third parties, wearing out the employee physically and mentally, disabling him to efficiently develop their work and increasing stress levels that in the long run can affect their behavior.

Work shifts. The hectic dynamics of organizations in industrialized countries has led to the need to incorporate a shift system that covers 24 hours to meet market demands, considering for this the fragmentation of schedules into shifts that include Sundays and holidays, causing These work rhythms generate physical and mental imbalances in the worker.

According to the Foundation for the Prevention of Occupational Risks, sleeping during the day does not allow the body to adapt easily as when sleeping at night, sleep provides a state of uniform rest for the body characterized by low levels of physiological activity which includes Two phases; one of slow sleep allowing the physical recovery of the organism and the other of fast sleep that helps the psychic recovery. It is necessary to sleep at night for about 7 hours to be able to go through all the phases of sleep and obtain physical and mental recovery.

4. METHODOLOGY

For the identification and evaluation of psychosocial risks in companies, five stages are considered:

1. Planning and carrying out field work.
2. Application of the Reference Guide III Questionnaire established by the STPS to detect FRPS and favorable organizational environments.
3. Analysis of the results.
4. Preparation of a map of psychosocial risks.

5. Comparative analysis between the 3 companies studied.

To carry out the research, a review was carried out considering the psychosocial risk factors and organizational environments, as well as references on addictions and their impact on the work environment, for which sources such as books by recognized authors, articles published in magazines were used. of prestige, information issued by government institutions.

A first approach towards determining the FRPS that prevail in the analyzed companies was carried out through the information collection instruments suggested by the STPS in NOM-035-2018 to achieve our objective.

To obtain the sample size, the NOM-035-STPS-2018 formula was used:

$$n = \frac{.9604N}{0.0025(N-1)+.9604}$$

Which already establishes criteria to determine how many workers should apply the questionnaire depending on the number of these in the company.

For the purposes of this study, the companies were named as follows:

- Logistics: Company 1, with 240 surveys.
- Agroindustrial: Company 2, with 305 applied questionnaires and,
- Pharmacist: Company 3, 164 questionnaires,

The method used to carry out the data collection is based on the questionnaire called Reference Guide III for the identification and analysis of psychosocial risk factors and the evaluation of the organizational environment described by NOM-035-STPS, 2018 , since the three companies have more than 50 workers.

The interpretation of the risk levels of the questionnaire data is given through the Risk Level and color scale suggested by the Standard:

Table 1. Risk Levels

0 = Riesgo Nulo, el cual se identifica por el color azul
1 = Riesgo Bajo, identificado por el color verde
2 = Riesgo Medio, color amarillo
3 = Riesgo Alto, color naranja
5 = Riesgo Muy Alto. Color rojo

The questionnaire consists of 72 questions that allow knowing the perception that workers have in various aspects of the company and that are summarized in 5 categories and 10 domains. Table 1.

Table 1. Groups of items by category, domain, dimension

Categoría	Dominio	Dimensión	ítem
Ambiente de trabajo	Condiciones en el ambiente de trabajo	Condiciones peligrosas e inseguras	1, 3
		Condiciones deficientes e insalubres	2, 4
		Trabajos peligrosos	5
Factores propios de la actividad	Carga de trabajo	Cargas cuantitativas	6, 12
		Ritmos de trabajo acelerado	7, 8
		Carga mental	9, 10. 11
		Cargas psicológicas emocionales	65, 66, 67, 68
		Cargas de alta responsabilidad	13, 14
		Cargas contradictorias o inconsistentes	15, 16
	Falta de control sobre el trabajo	Falta de control y autonomía sobre el trabajo	25, 26, 27, 28
		Limitada o nula posibilidad de desarrollo	23, 24
		Insuficiente participación y manejo del cambio	29, 30
		Limitada o inexistente capacitación	35, 36
Organización del tiempo de trabajo	Jornada de trabajo	Jornadas de trabajo extensas	17, 18
	Interferencia en la relación trabajo-familia	Influencia del trabajo fuera del centro laboral	19, 20
		Influencia de las responsabilidades familiares	21, 22
Liderazgo y relaciones en el trabajo	Liderazgo	Escasa claridad de funciones	31, 32, 33, 34
		Características del liderazgo	37, 38, 39, 40, 41
	Relaciones en el trabajo	Relaciones sociales en el trabajo	42, 43, 44, 45, 46
		Deficiente relación con los colaboradores que supervisa	69, 70, 71, 72
	Violencia	Violencia laboral	57, 58, 59, 60, 61, 62, 63, 64
Entorno organizacional	Reconocimiento del desempeño	Escasa o nula retroalimentación del desempeño	47, 48
		Escaso o nulo reconocimiento y compensación	49, 50, 51, 52
	Insuficiente sentido de pertenencia e, inestabilidad	Limitado sentido de pertenencia	55, 56
		Inestabilidad laboral	53, 54

The results of the questionnaire should be evaluated according to the following ranges:

Table 2. Final grade ranges.

Resultados del cuestionario	Nulo o despreciable	Bajo	Medio	Alto	Muy alto
Calificación final del cuestionario C_{final}	$C_{final}<50$	$50\leq C_{final}<75$	$75\leq C_{final}<99$	$99\leq C_{final}<140$	$C_{final}\geq 140$

Table 3. Rating ranges for the category.

Calificación de la categoría	Nulo o despreciable	Bajo	Medio	Alto	Muy alto
Ambiente de trabajo	$C_{cat}<5$	$5\leq C_{cat}<9$	$9\leq C_{cat}<11$	$11\leq C_{cat}<14$	$C_{cat}\geq 14$
Factores propios de la actividad	$C_{cat}<15$	$15\leq C_{cat}<30$	$30\leq C_{cat}<45$	$45\leq C_{cat}<60$	$C_{cat}\geq 60$
Organización del tiempo de trabajo	$C_{cat}<5$	$5\leq C_{cat}<7$	$7\leq C_{cat}<10$	$10\leq C_{cat}<13$	$C_{cat}\geq 13$
Liderazgo y relaciones en el trabajo	$C_{cat}<14$	$14\leq C_{cat}<29$	$29\leq C_{cat}<42$	$42\leq C_{cat}<58$	$C_{cat}\geq 58$
Entorno organizacional	$C_{cat}<10$	$10\leq C_{cat}<14$	$14\leq C_{cat}<18$	$18\leq C_{cat}<23$	$C_{cat}\geq 23$

Table 4. Domain qualification ranges.

Resultado del dominio	Nulo o despreciable	Bajo	Medio	Alto	Muy Alto
Condiciones en el ambiente de trabajo	$C_{dom}<5$	$5\leq C_{dom}<9$	$9\leq C_{dom}<11$	$11\leq C_{dom}<14$	$C_{dom}\geq 14$
Carga de trabajo	$C_{dom}<15$	$15\leq C_{dom}<21$	$21\leq C_{dom}<27$	$27\leq C_{dom}<37$	$C_{dom}\geq 37$
Falta de control sobre el trabajo	$C_{dom}<11$	$11\leq C_{dom}<16$	$16\leq C_{dom}<21$	$21\leq C_{dom}<25$	$C_{dom}\geq 25$
Jornada de trabajo	$C_{dom}<1$	$1\leq C_{dom}<2$	$2\leq C_{dom}<4$	$4\leq C_{dom}<6$	$C_{dom}\geq 6$
Interferencia en la relación trabajo-familia	$C_{dom}<4$	$4\leq C_{dom}<6$	$6\leq C_{dom}<8$	$8\leq C_{dom}<10$	$C_{dom}\geq 10$
Liderazgo	$C_{dom}<9$	$9\leq C_{dom}<12$	$12\leq C_{dom}<16$	$16\leq C_{dom}<20$	$C_{dom}\geq 20$
Relaciones en el trabajo	$C_{dom}<10$	$10\leq C_{dom}<13$	$13\leq C_{dom}<17$	$17\leq C_{dom}<21$	$C_{dom}\geq 21$
Violencia	$C_{dom}<7$	$7\leq C_{dom}<10$	$10\leq C_{dom}<13$	$13\leq C_{dom}<16$	$C_{dom}\geq 16$
Reconocimiento del desempeño	$C_{dom}<6$	$6\leq C_{dom}<10$	$10\leq C_{dom}<14$	$14\leq C_{dom}<18$	$C_{dom}\geq 18$
Insuficiente sentido de pertenencia e, inestabilidad	$C_{dom}<4$	$4\leq C_{dom}<6$	$6\leq C_{dom}<8$	$8\leq C_{dom}<10$	$C_{dom}\geq 10$

Source: Official Mexican Standard NOM-035-STPS-2018

5. RESULTS

The General risk level of Company 1 and 2, as can be seen in table 1, is of a medium level since they are between the parameters of 75 to 99, and considering the criteria of NOM-035 for this level , it is necessary to review the psychosocial risk prevention policy and carry out programs to prevent these factors, as well as promote a favorable organizational environment in companies to avoid workplace violence and reinforce its application.
Company 3 presents, according to the global analysis, a high level of risk, which implies, in addition to the suggestions made to companies 1 and 2, a more detailed analysis of each category and level in order to determine intervention actions. appropriate and specific according to the level of risk detected in each of them.

Table 1. Global Results

	Empresa 1	Empresa 2	Empresa 3
RESULTADO GLOBAL	91.40	90.15	115.32

NIVELES DE RIESGO	Nulo o despreciable	Bajo	Medio	Alto	Muy alto
	$C_{final}<50$	$50\leq C_{final}<75$	$75\leq C_{final}<99$	$99\leq C_{final}<140$	$C_{final}\geq 140$

As indicated by the NOM-035 when making a more detailed analysis of the results obtained by categories, it can be seen in Table 2, how the 3 companies analyzed have an incidence of FRPS in the category of Factors typical of the activity with a medium risk in 1 and 2 and high level in Company 3.

As can be seen, the category of Leadership and relationships at work indicates a medium level of risk in companies 2 and 3.

In relation to the category of Organizational Environment, company 3 presents a medium level of risk.

Table 2. Results by Category

CATEGORIA	Empresa 1	Empresa 2	Empresa 3
AMBIENTE DE TRABAJO	7.45	7.98	7.85
FACTORES PROPIOS DE LA ACTIVIDAD	41.81	31.66	49.51
ORGANIZACIÓN DEL TIEMPO DE TRABAJO	6.66	5.18	8.51
LIDERAZGO Y RELACIONES EN EL TRABAJO	22.58	32.09	33.06
ENTORNO ORGANIZACIONAL	12.90	13.24	16.39

Continuing with the analysis of the domains, and in order to know in which risk factors are more present in each of the companies, it can be seen in Table 3 that the analysis of the category of Factors specific to the activity, in company 1 the risk is high in the lack of control over work, while in company 2 the risk is medium but due to workloads and in company 3, with a high level we see the workloads and level means the lack of control over it.

In the category of Organization of working time, company 1 risk is generated during the working day and company 3 presents a medium level.

Regarding the category of leadership and relationships at work, company 3 presents medium risk in leadership.

Company 2 in this category had a medium level as can be seen in Table 2, but when breaking down by domain to identify in which of them the risk is generated, it can be seen that the three domains in this category are at low risk. , but labor relations has a score of 12.96 and for the medium risk it is already from 13 to 17 and is rather in the lower part of the medium level.

Table 3. Results by Domain

	RESULTADO POR DOMINIO		
DOMINIO	Empresa 1	Empresa 2	Empresa 3
CONDICIONES EN EL AMBIENTE DE TRABAJO	7.45	7.98	7.85
CARGAS DE TRABAJO	20.70	24.53	30.12
FALTA DE CONTROL SOBRE SU TRABAJO	21.11	7.13	19.39
JORNADA DE TRABAJO	3.40	1.83	3.43
INTERFERENCIA EN LA RELACION TRABAJO-FAMILIA	3.26	3.35	5.08
LIDERAZGO	6.89	10.76	12.64
RELACIONES DE TRABAJO	9.68	12.96	11.93
VIOLENCA	6.01	8.36	8.49
RECONOCIMIENTO DEL DESEMPEÑO	7.75	9.64	11.41
INSUFICIENTE SENTIDO DE PERTENENCIA	5.15	3.60	4.98

In relation to the category of Organizational Environment, the employees of Company 3 perceive that there is no adequate recognition of performance.

6. CONCLUSIONS

Identifying the negative psychosocial factors that impact the worker implies an in-depth evaluation and analysis on the part of the organization to generate a map of risks inherent to the company. The difficulty lies in the perceptual factor that prevails in the behavior of the worker. The attitude, knowledge, experiences, social and family environment that are part of the context in which the worker operates can affect their work performance and what for a worker is a normal situation without any particularity that worries him, for other people it can be an emotional trigger that impacts their work and group activities.

The strategies to address the FRPS can be broken down in two ways: the first, referring to the obligations set forth in Article 43 of the RFSST and reflected in NOM-035-STPS-2018, specifically in the process of informing and training workers on the FRPS, and the second related to the results obtained with the application of the questionnaire. All the management of the process of compliance with the Standard must be done under the guidelines of NOM 030 STPS 2009.

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FACTORES DISERGONÓMICOS Y PSICOSOCIALES POR TELETRABAJO EN ÉPOCA DE COVID 19: CASO PRÁCTICO.

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Resumen La presente investigación en época de Covid 19 y teletrabajo como modalidad de laborar para evitar contagios provoca malestar en la salud física y mental. El objetivo es determinar la fatiga visual en servidores universitarios y evaluar el uso de pantallas de visualización digital (PVD) en estudiantes de la asignatura de Ergonomía de Ingeniería de la Universidad Nacional de Chimborazo para diseñar un puesto de trabajo basado en medidas antropométricas. La metodología aplicada es el uso del test CVSS 17 para la fatiga visual con una escala de lickers tabulada en el SPSS V24 para obtener resultados y la evaluación de ergonomía en PVD mediante el método ROSA en un antes y un después, es correlacional y longitudinal el trabajo, se analiza las variables sociodemográficas para establecer por medio del V de Cramer su relación con las dimensiones de estudio. El test CVSS 17 se sometió al análisis de fiabilidad y confiabilidad con resultados de bueno a muy bueno que puede ser aplicable a este entorno. Referente a los resultados de fatiga 39.1 % sintomáticos y 60.9 % asintomáticos, con casos del síndrome de fatiga visual 6.4 % leve nivel 2, 45.9 % medio nivel 3, 46.5 % media nivel 4 y 1.2 % severo nivel 5. La evaluación ROSA establece un nivel muy alto de riesgo con valor de 8 que luego de la intervención con la implementación de mobiliario ergonómico basado en medidas antropométricas se reduce a 2. Se concluye la presencia de fatiga visual y trastornos musculoesqueléticos por factores de riesgo ergonómicos que afectan a la salud del personal, se debe implementar medidas como es pausas activas, rotación de turnos, organización del trabajo, ejercicios para la vista como el 20 - 20 – 20, mobiliario ergonómico, entre otros factores.

Palabras clave: Disergonomía, fatiga visual, trastornos músculo esqueléticos, teletrabajo

Relevancia para la ergonomía: La disergonomía ante la presencia del Covid 19 ha traído muerte, desempleo, pobreza y una nueva modalidad de trabajo vinculada a las Tics que debe ser analizada, puesto que por el exceso de exposición al mismo genera fatiga visual, molestias musculoesqueléticas entre otra sintomatología que debe ser evaluada y se debe plantear mejoras en los puestos basados en la antropometría y la organización del trabajo.

Abstract This research at the time of Covid 19 and teleworking as a modality of working to avoid contagion causes discomfort in physical and mental health. The objective is to determine visual fatigue in university servers and to evaluate the use of digital display screens (DVP) in students of the Engineering Ergonomics course at the National University of Chimborazo to design a job based on anthropometric measurements. The applied methodology is the use of the CVSS 17 test for visual fatigue with a scale of lickers tabulated in SPSS V24 to obtain results and the evaluation of ergonomics in PVD by means of the ROSA method in a before and after, it is correlational and longitudinal. In this work, the sociodemographic variables are analyzed to establish, through Cramer's V, their relationship with the study dimensions. The CVSS 17 test underwent reliability and reliability analysis with good to very good results that may be applicable to this environment. Regarding the results of fatigue 39.1% symptomatic and 60.9% asymptomatic, with cases of visual fatigue syndrome 6.4% mild level 2, 45.9% medium level 3, 46.5% medium level 4 and 1.2% severe level 5. The ROSA evaluation establishes a very high level of risk with a value of 8 that after the intervention with the implementation of ergonomic furniture based on anthropometric measurements is reduced to 2. The presence of visual fatigue and musculoskeletal disorders is concluded due to ergonomic risk factors that affect the health of the patient. personnel, measures such as active breaks, shift rotation, work organization, eye exercises such as 20 - 20 - 20, ergonomic furniture, among other factors, must be implemented.

Keywords. Dysergonomy, visual fatigue, musculoskeletal disorders, teleworking

Relevance to Ergonomics: The dysergonomy in the presence of Covid 19 attracted death, unemployment, poverty and a new work modality linked to Tics that must be analyzed, since due to excess exposure to it generates visual fatigue, musculoskeletal discomfort among other symptoms that must be evaluated and improvements should be proposed in the positions based on anthropometry and work organization.

1. INTRODUCCIÓN

El COVID-19 y sus consecuencias ha impulsado al teletrabajo y uso de las Tics (Human Rights Watch, 2020), estas actividades rutinarias generan factores de riesgo debido al uso elevado de ordenadores, la falta de iluminación entre otros aspectos agravan la situación del usuario. (Expósito C. & Marsollie R., 2020).

La Organización Mundial de la Salud (OMS), en 2021 establece que la pérdida de visión entre 1990 y 2020 a nivel mundial aproximadamente 2200 millones de personas con disminución en la vista de cerca o lejos: refracción no corregida, cataratas, glaucoma, retinopatía diabética, opacidad de la córnea, etc. Existe cerca de 1000 millones de esos casos, que pueden ser evitados con prevención y tratamiento. (OMS, 2020) y (Bourne et al., 2020).

Los trastornos musculo esqueléticos (TME) afectan a diferentes partes del cuerpo principalmente a los miembros superiores con sintomatología como: cervicalgia, manguito rotador, epicondilitis media y lateral, atrapamiento del nervio cubital, radial, tendinitis, enfermedad de Quervain, túnel carpiano, fenómeno de Raynaud, vibracion de mano-brazo, etc. (Aptel, Aublet & Cnockaert, 2002).

El teletrabajo no vulnera los derechos del trabajador, ni terminación laboral, el empleador puede optar por la modalidad de acuerdo a la necesidad empresarial y tareas asignadas al trabajador. (Ministerio del Trabajo, 2020).

El teletrabajo alrededor del mundo, los constantes cambios, el alto uso de Tics y pantallas de visualización digital (PVD) en las empresas. Una encuesta aplicada en Europa referente a las condiciones de trabajo en el 2015 establece que: el 37 % de los trabajadores usa PVD en su jornada diaria y el 20 % un cuarto de la jornada. (Eurofund, 2017), requiere de una evaluación para determinar las consecuencias que ellas traen.

La fatiga visual es uno de los efectos por el uso de PVD ocasionado por la frecuencia e intensidad de uso que presenta un cuadro clínico en las personas con diferente sintomatología. (Rodríguez, 2015), con consecuencias en el rendimiento laboral debido a la demanda visual en la tarea, el trabajador presenta problemas como: diplopía, cambio postural, visión borrosa, dolor de cabeza, fatiga ocular, ardor de ojos, ojo seco, trastornos musculoesqueléticas, parpadeo frecuente con lagrimeo de ojo. (Forero, 2022).

La ergonomía define la adaptación del trabajo y su entorno laboral; desde el punto de vista del medio ambiente socio-técnico, con una valoración cuantitativa y cualitativa para la mejora continua que permita incrementar la producción de la organización. (Gutiérrez y Apud, 1992). La ergonomía adapta el trabajo y su entorno a los contenidos del ser humano: biomecánicas, fisiológicas y mentales. La evaluación ergonómica y de su entorno genera trastornos músculo esqueléticos o lesiones corporales que se conoce como factores de riesgos disergonómicos (Ergo/IBV, 2016).

El factor de riesgo psicosocial en el teletrabajo en Ecuador presentó sintomatología de cansancio, irritabilidad, ansiedad, insomnio, mareos, falta de atención, estrés, síndrome de Burnout entre otros (Terán, et al., 2021). Los aspectos del entorno laboral como el estrés térmico afecta a la persona en la organización, la falta o exceso de iluminación generan disconfort como un factor de riesgo a ser tomado en cuenta y sobre todo en el sector educativo. (Wang, 2021). El uso de un ordenador y la presencia de molestias musculoesqueléticas y malestar visual en trabajadores en España con alta incidencia de trastornos visuales y musculo esqueléticos por uso excesivo en cuanto a horas de computadoras portátiles y de escritorio. (Soria et al., 2021).

Un estudio en universidades del Perú se encontró 100% de prevalencia de trastornos musculoesqueléticas en docentes que realizan teletrabajo en época de Covid 19, con 67,27% a nivel dorso lumbar y 64,55% cuello, esto se debe a que las jornadas laborales son de más de 10 horas (39,09%) y con jornadas laborales que van de 5 a 7 días (82,73%) (García & Sánchez, 2021).

Resultados sobre niveles de riesgo en el sector de la Construcción en proyecto de vivienda en Sucúa se encontró que los trabajadores de la construcción están expuestos a dolencias ocupacionales (DORT) que provocan enfermedades laborales y absentismo en las actividades en obra. (Velin & Escobar, 2021).

El síndrome de burnout (SB) afecta la capacidad laboral del trabajador en todo tipo de trabajo, siendo una de ellas la docencia con implicaciones en la salud mental y en el desempeño laboral, es decir el proceso de enseñanza aprendizaje. En Ecuador el sector universitario está presente el Síndrome de burnout considerado un proceso generado por una serie de factores de tipo laboral que afectan a la salud en la parte física y mental que debe ser prevenido. (Cabezas, 2016).

El análisis en una empresa de petróleos en Ecuador sobre el afrontamiento y los niveles de estrés por teletrabajo y Covid 19, presenta que existe un afrontamiento de 97.1 % medio y 2.9 % alto y referente al estrés con 51.4 % bajo, 48.6 % medio, se concluye presencia de los mismos en los puestos de trabajo que generan malestar físico y mental en los trabajadores. (Verduga & Ortiz, 2021).

Ante estos aspectos referenciados se plantea la pregunta de investigación ¿Cómo los factores disergonómicos y psicosociales por el teletrabajo en época de Covid 19 inciden en la salud de los servidores y estudiantes de la Universidad Nacional de Chimborazo?

2. METODOLOGÍA

La investigación fue exploratoria-descriptiva, correlacional entre las variables sociodemográficas y las dimensiones del test de fatiga visual y el método de evaluación ROSA para evaluar ergonomía en PVD, es longitudinal porque se analizó en dos instantes de tiempo. La identificación y análisis de riesgos ergonómicos, se efectuó mediante el uso de ergonautas.com y el test CVSS17, para determinar las posturas en miembros superiores y periféricos en PVD, así como los niveles de fatiga visual por efecto del teletrabajo en época de Covid 19.

La evaluación inicia con fotografías de posturas críticas frente al ordenador mediante Goniotrans o Ruler en el que se ubica los ángulos para determinar la desviación de la posición neutral de las diferentes partes del cuerpo analizadas de estudiantes de Ingeniería Industrial que pueden generar TME por la falta de mobiliario ergonómico. Posteriormente se recogió las medidas antropométricas de los estudiantes para el diseño de la estación de trabajo. Se complementa con la evaluación ROSA para determinar el nivel de riesgo y proponer medidas de mejora para prevención de malestar físico y mental.

El criterio de evaluación del método ROSA se establece de la siguiente manera:

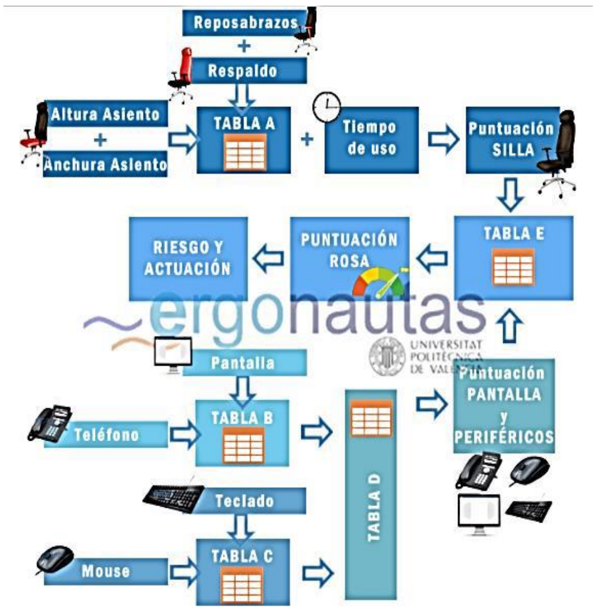


Figura 1. Metodología de Evaluación Método ROSA
Fuente: Universidad Politécnica de Valencia (2021)

La evaluación de Pantallas de visualización digital (PVD), se realizó con el método ROSA el que se presenta en la siguiente tabla:

Tabla 1. Evaluación Ergonómica Método ROSA en PVD

Puntuación	Riesgo	Nivel	Actuación
1	Inapreciable	0	No es necesaria actuación.
2 - 3 - 4	Mejorable	1	Pueden mejorarse algunos elementos del puesto.
5	Alto	2	Es necesaria la actuación.
6 - 7 - 8	Muy Alto	3	Es necesaria la actuación cuanto antes.
9 - 10	Extremo	4	Es necesaria la actuación urgentemente.

Fuente: Universidad Politécnica de Valencia (2021)

El test de fatiga visual CVSS17 aplicado se lo realizó en el google forms, el link se compartió por los correos institucionales de la Universidad Nacional de Chimborazo, quienes libre y voluntariamente contestaron 172 personas entre docentes, empleados y trabajadores, por lo que se decidió trabajar con todos, no existe muestra.

El test consta de fatiga visual tiene 17 preguntas valoradas con una escala de lickers. Se describen las opciones del test:

- ✓ 10 preguntas con 4 opciones: nunca, raramente, frecuentemente y constantemente.
- ✓ 6 preguntas con opciones de: nada, si muy poco, si un poco, si moderadamente, si mucho, si muchísimo.

✓ 1 pregunta con opción: nunca, casi nunca, poco tiempo, parte del tiempo, mucho tiempo, casi siempre, siempre.

El puntaje final del test CVSS17 = (Suma puntuación total de todas las preguntas).

El puntaje va de 17 a 53 puntos; puntajes mayores presenta sintomatología del síndrome de fatiga visual, puntajes = 0 > a 36 es sintomático para fatiga visual y valores < a 36 es asintomático (Arlanzón Lope, 2018).

La fatiga visual se presenta por niveles: del 1 al 6 para determinar la gravedad que va: de leve a severo.

Fatiga Leve: Nivel 1 va de 17 a 22 puntos; nivel 2 va de 23 a 28 puntos
Fatiga moderada: Nivel 3 va de 29 a 35 puntos; nivel 4 va de 36 a 42 puntos
Fatiga Severa: Nivel 5 va de 43 a 49 puntos; nivel 6 va de 50 a 53 puntos

3. RESULTADOS Y DISCUSIÓN

El test CVSS 17 aplicado en el personal universitario de la Universidad Nacional de Chimborazo referente a la fiabilidad y confiabilidad del mismo por medio del Alpha de Crombach es de 0.594, el test es bueno, se puede mejorar eliminando ítems, referente a la confiabilidad por medio del KMO tiene un valor de 0.931 por lo que es muy bueno, se concluye que el test es fiable y confiable, se lo puede aplicar para este entorno de estudio.

En la primera fase de la investigación referente a la fatiga visual en los servidores universitarios se analiza las variables sociodemográficas de los servidores universitarios encuestados.

Tabla 2. Variables socio demográficas de los servidores universitarios

Variables Sociodemográficas	**Género**		**Nivel Educativo**			**Acción de personal**		
Porcentaje (%)	57 % Hombres	43 % Mujeres	0.6 % Secundaria	23.8 % Tercer Nivel	75.6 % Cuarto Nivel	55.2 % Nombramiento Definitivo	10.5 % Nombramiento Provisional	34.3 % Contrato por horas

Las variables sociodemográficas presentan relevancia para poder correlacionarlas y ver la incidencia con las dimensiones de la fatiga visual, se determina la prevalencia de hombres, formación alta de cuarto nivel y nombramiento definitivo, sin embargo existe % en los otros aspectos estudiados.

Otra de las variables sociodemográficas estudiadas es la edad de los servidores universitarios.

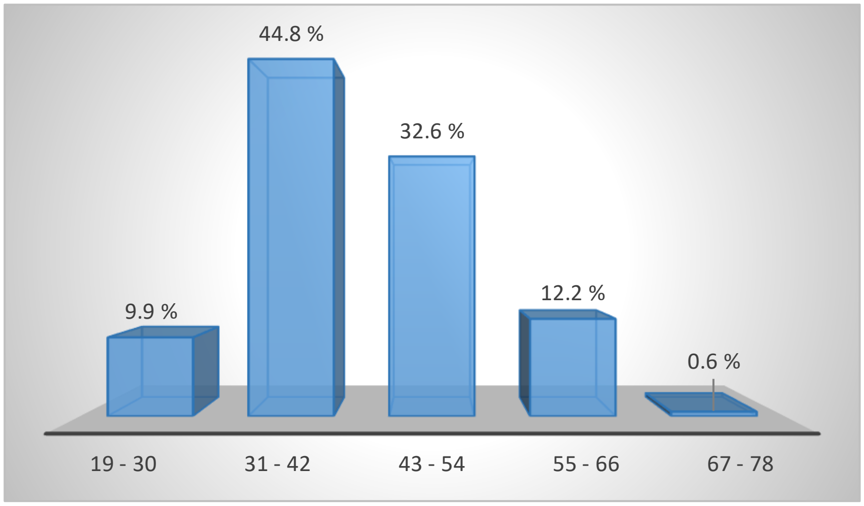


Figura 2. Edad de los servidores universitarios

La población de servidores universitarios analizada es relativamente joven y puede aportar al crecimiento de la universidad en el alcance de logros y metas.

Referente a la función que desempeñan en la Universidad es la siguiente:

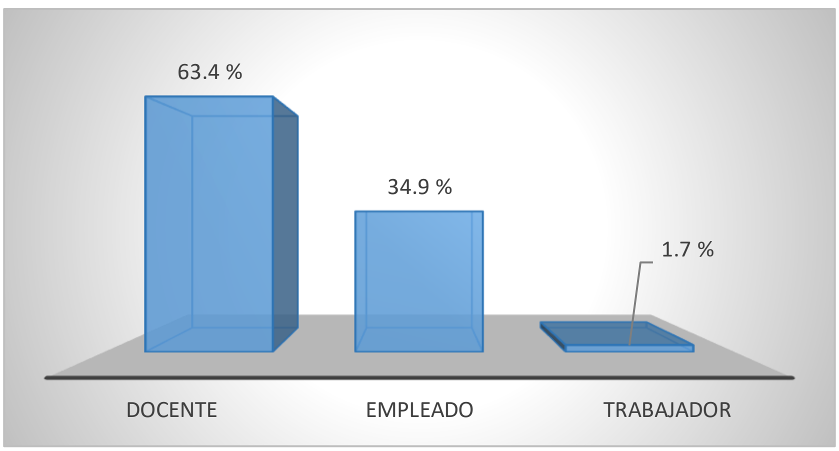


Figura 3. Función de los servidores universitarios

Los servidores universitarios evaluados para determinar la fatiga visual, prioriza al sector docente comparado con trabajadores y empleados.

En la encuesta aplicada se consulta sobre la presencia de enfermedades visuales previas en las que se tiene las siguientes:

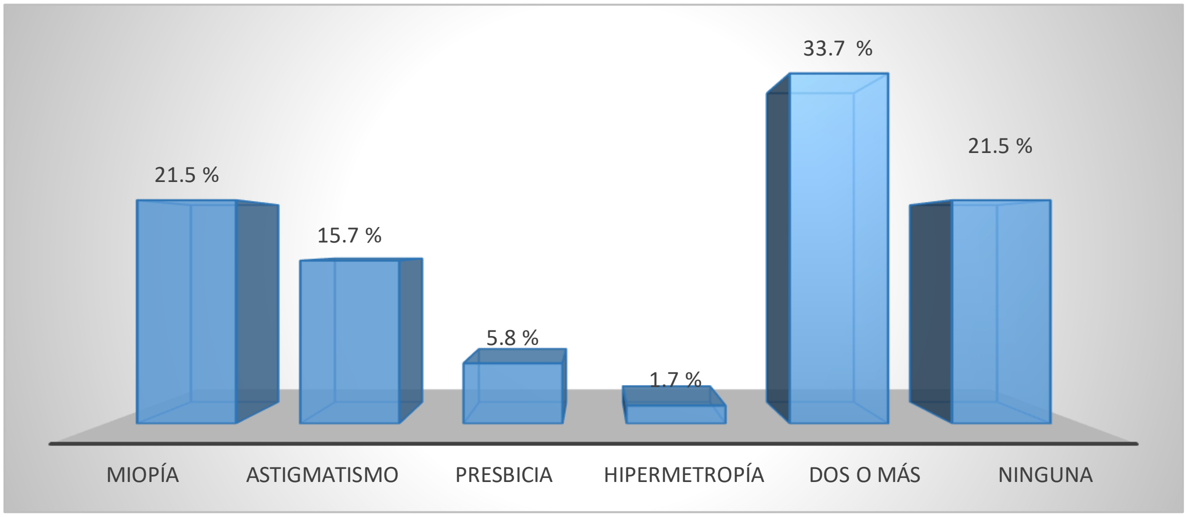


Figura 4. Enfermedades previas de los servidores universitarios

El análisis de Enfermedades previas puede agravar a la presencia de fatiga visual por el uso de ordenadores en época de Covid 19.

Otro de los aspectos que debe analizarse es la frecuencia de uso de PVD.

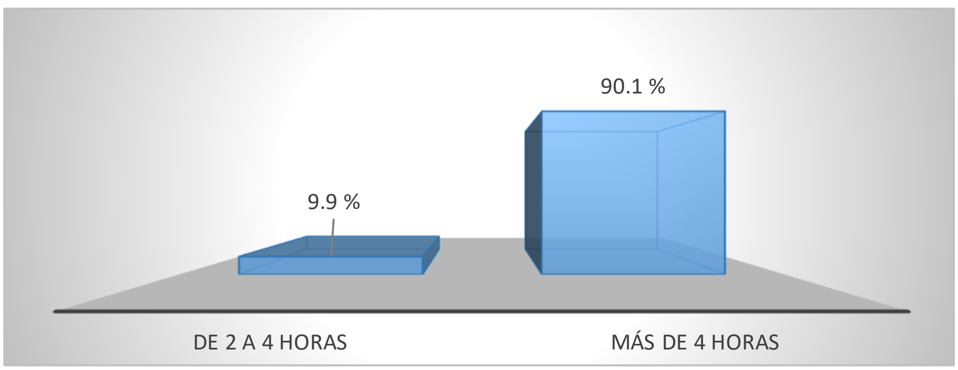


Figura 5. Frecuencia de uso de PVD de los servidores universitarios

Se puede detector que existe alto uso de ordenadores que concuerda con lo que manifiesta García & Sánchez, 2021 que a mayor uso incrementa la fatiga visual por falta de condiciones ergonómicas del usuario.

Referente al test CVSS 17 y la presencia de la fatiga visual de los servidores universitarios, se tiene que:

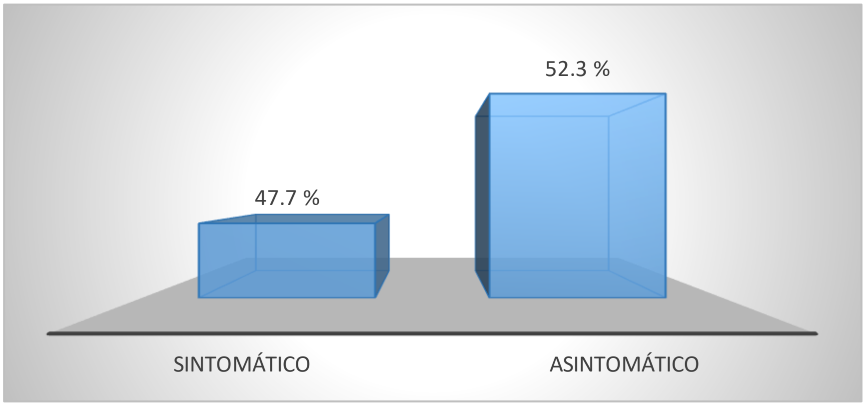


Figura 6. Fatiga visual de los servidores universitarios

La presencia de fatiga visual se presenta de dos maneras con personal sintomático 47.7 % y asintomático en 52.3 % que refleja la presencia del síndrome.

Referente al análisis por niveles de fatiga visual en los servidores universitarios se presenta a continuación:

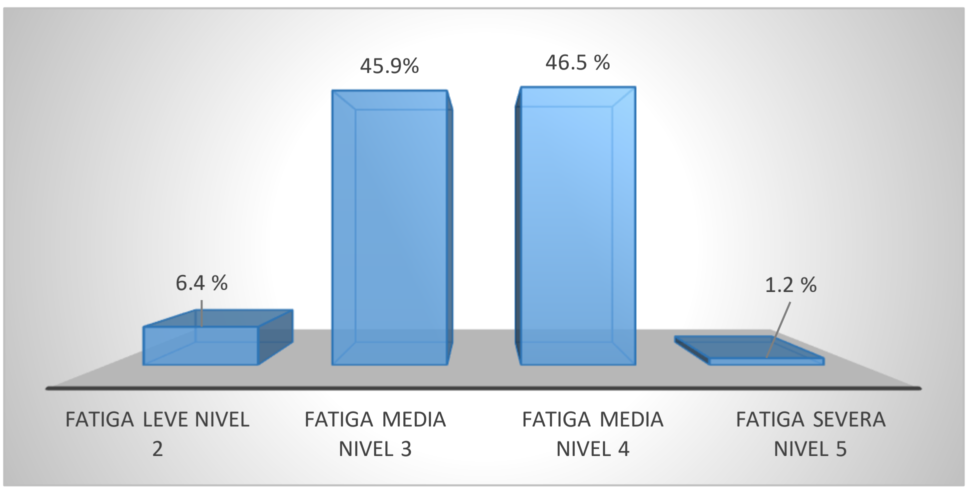


Figura 7. Fatiga visual de los servidores universitarios

La presencia de fatiga visual en los servidores universitarios es evidente que va desde leve a severa y que al existir casos con nivel 5 requiere de intervención inmediata para disminuir problemas de salud física y mental en los servidores.

Referente a la correlación de las variables sociodemográficas con la fatiga visual y los niveles por medio del V de Cramer tenemos:

Tabla 3. Correlación de las variables sociodemográficas y test de fatiga visual

Variables comparadas con el test CVSS 17 y Niveles	V de Cramer	Interpretación de Correlación
Edad	0.124	Pequeña
Género	0.205	Pequeña
Función que desempeña	0.111	Pequeña

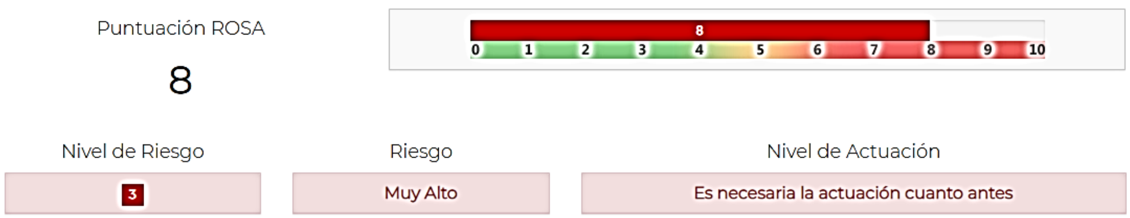
Nivel de Educación	0.214	Pequeña
Acción de Personal	0.088	Despreciable
Enfermedad Crónica	0.172	Pequeña
Frecuencia de uso de PVD	0.199	Pequeña

Al analizar los resultados de las variables sociodemográficas y el test de fatiga visual se establece que no influye no se correlaciona por lo que la presencia de la fatiga visual se debe a otros factores referente al entorno laboral y a condiciones disergonómicas presentes en cada puesto de trabajo.

La segunda fase de la investigación es evaluar por el método ROSA y determinar las medidas antropométricas para el diseño del puesto de trabajo para generar condiciones ergonómicas de trabajo.

La evaluación ROSA antes del diseño del puesto de trabajo realizado en el software ergonautas tenemos:

Tabla 4. Evaluación ROSA sin mobiliario en usuarios PVD



Al existir un nivel de riesgo muy alto requiere medidas preventivas inmediatas por lo que se realiza la toma de medidas antropométricas de estudiantes basados en percentiles para diseñar la estación de trabajo.

Tabla 5. Medidas antropométricas para el diseño del puesto de trabajo

Variables	Descripción	desviación estándar	percentiles P5 (cm)	P50 (cm)	P90 (cm)	P95 (cm)
A	estatura	8.68	151.9	166.2	177.4	180.5
B	alcance lateral del brazo	4.44	77.1	84.4	90.1	91.7
C	alcance vertical de asimiento	10.19	195.4	212.1	225.2	228.9
D	anchura máxima del cuerpo	28.55	4.8	51.8	88.5	98.7
E	altura del codo	20.00	66.0	98.9	124.6	131.8
F	altura del ojo	19.48	118.8	150.8	175.9	182.9
G	altura vertical en posición sedente	24.22	78.8	118.6	149.8	158.5
H	altura de ojos en posición sedente	23.14	54.8	92.8	122.6	130.9
I	altura de rodillas	17.42	22.5	51.2	73.6	79.8
J	altura de muslo	25.78	11.2	31.2	64.3	73.6
K	altura poplítea	5.44	34.0	43.0	50.0	51.9
L	distancia nalga poplítea	5.01	37.6	45.8	52.3	54.1

Código	
mesa	silla

M	distancia nalga rodilla	7.15	40.6	52.4	61.6	64.1
N	anchura de hombros	6.66	33.1	44.1	52.6	55.0
O	altura en posición sedente erguida	18.90	59.2	90.3	114.6	121.4
P	altura de codo en reposo	19.67	1.9	34.3	59.5	66.6
Q	anchura de caderas	13.63	20.6	43.0	60.6	65.5
R	anchura de codos	11.36	27.6	46.3	60.9	65.0

El cálculo de los percentiles de diseño del puesto de trabajo se da por medio de la siguiente fórmula:

$$P_{\%} = \bar{X} \pm Z_{\alpha}\sigma \quad (1)$$

Donde:

P = Percentil en centímetros de la población o muestra de estudio

X = Media o promedio de los datos

σ = Desviación estándar de los datos

Zα = Grado de confiabilidad

Las medidas antropométricas permiten el diseño de la mesa y silla ergonómica adaptable al trabajador y cumpliendo el criterio ergonómico.

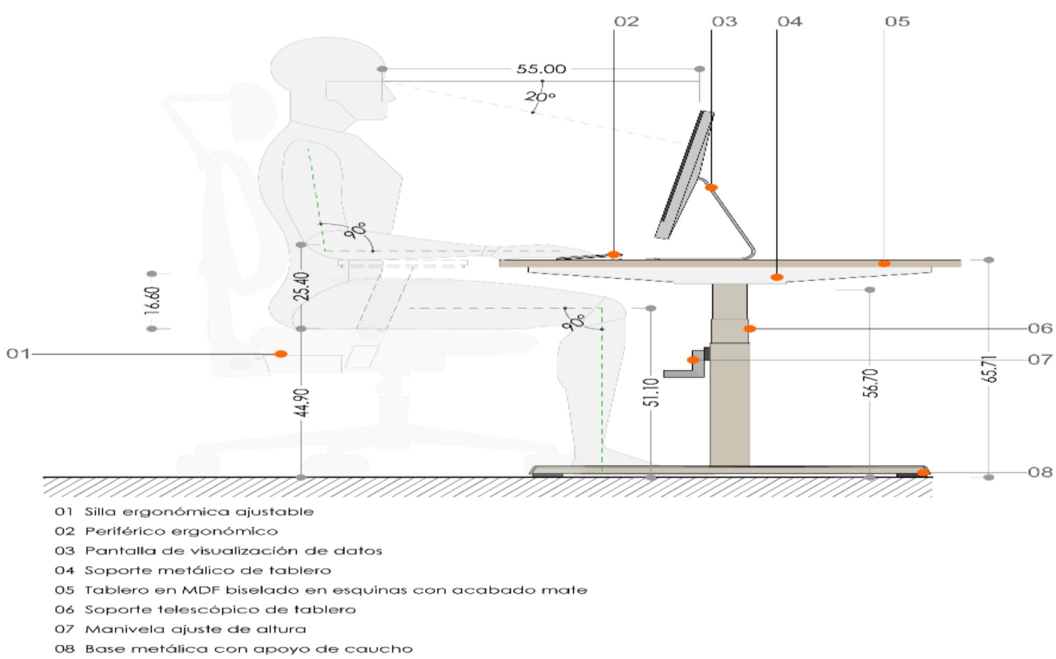
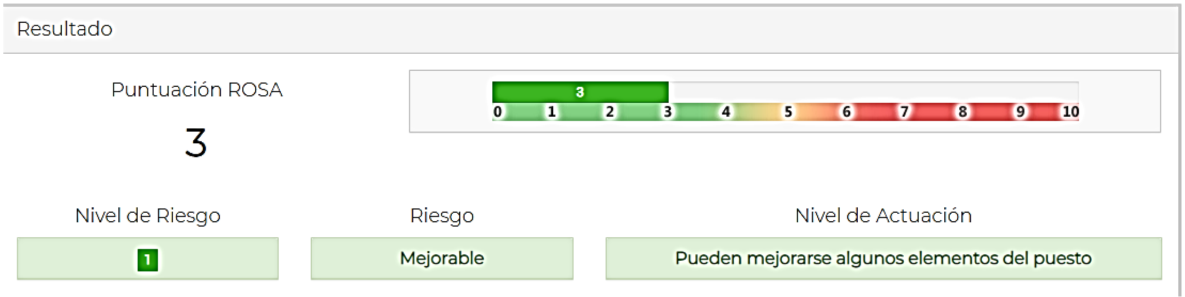


Figura 8. Mobiliario ergonómico basado en medidas antropométricas
Fuente: http://www.revistaespacios.com/a20v41n35/a20v41n35p10.pdf

Luego de implementar el puesto de trabajo ergonómico se procede a evaluar nuevamente con el método ROSA para determinar su impacto.

Tabla 6. Evaluación ROSA con mobiliario en usuarios PVD



Se puede observar la intervención que a corto o mediano plazo genera confort y disminución de las molestias musculoesqueléticas.

4. CONCLUSIONES Y RECOMENDACIONES

La fatiga visual detectada en: 39.1 % sintomáticos y 60.9 % asintomáticos se establece a factores del entorno que generan disconfort, estilos de vida no adecuado, la correlación es baja de las variables sociodemográficas por lo que no se atribuye incidencia en el fenómeno investigado, al revisar investigaciones similares se concluye que la frecuencia de uso en horas del ordenador afecta al órgano de la visión provocando sequedad, evaporación alta de lágrimas en el ojo, entre otros síntomas por lo que se recomienda mitigar con ejercicios de visión como el 20-20-20, pausas activas entre otros.

La biomecánica y la antropometría permite diseñar puestos de trabajo ergonómicos con la implementación de apoya brazos, asiento regulable entre otros aspectos que son necesarios para mantener la posición neutra brazo – antebrazo, muslo pierna con efectos positivos en la reducción de molestias: dorso lumbar, cuello, mano muñeca y otras partes del cuerpo evitando las TME.

El uso de mobiliario inadecuado y el alto uso de un ordenador en época de COVID-19, contribuyó a que se adopten posturas disergonómicas que generan malestar y dolor en diferentes partes del cuerpo por lo que requiere de una intervención inmediata en el campo de la Ergonomía como lo es el rediseño del puesto de trabajo con medidas antropométricas que disminuye los niveles de riesgo encontrados.

Las medidas preventivas permiten mitigar las deficiencias ergonómicas provocadas por el teletrabajo en el puesto de trabajo que se asocia a la presencia de las dolencias musculoesqueléticas por ausencia de mobiliario ergonómico que agravan las lesiones corporales en la zona cervical, toráxica y espalda baja, extremidades superiores que pueden causar túnel carpiano o epicondilitis, tendinitis entre otras patologías, se concluye que una alta prevalencia de síntomas musculoesqueléticos se debe al teletrabajo, confinamiento por el COVID-19 que deben ser atenuadas con pausas activas, alimentación adecuada, organización del trabajo.

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CONTRIBUTIONS IN ERGONOMICS OF THE STUDY ON RISK FACTORS IN DENTISTS: LITERATURE REVIEW.

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Resumen: Los trastornos musculoesqueléticos se definen como al conjunto de lesiones asociadas a sobreesfuerzos o fatiga tendinosa, que representan la principal causa de enfermedad profesional en la población laboral mundial. Para la Organización Internacional del Trabajo los trastornos musculoesqueléticos son uno de los problemas más importantes de salud en el trabajo, lo que implica costos elevados e impacto en la calidad de vida. Los TME son causados por trabajos que implican posturas prolongadas, mantenidas y forzadas, además de manipulación de cargas y movimientos repetidos. Particularmente la odontología es una profesión donde el desarrollo de TME se ha caracterizado por la adaptación de posturas forzadas gracias a las altas exigencias visuales. Dentro de las posiciones que incrementan la tensión muscular se encuentra; el estar parado o sentado aunado con la excesiva presión de algunos tejidos y las rotaciones de la columna que generan altas cargas estáticas. El uso de fuerza y movimientos repetitivos con la falta de descanso pueden afectar negativamente la calidad de vida de los dentistas y provocar una jubilación anticipada. Los TME son atribuidos a la naturaleza del trabajo dental por interactuar con un área de trabajo pequeña; estar sentado por tiempos prolongados con una postura corporal no natural y el uso de fuerza en movimientos repetitivos ayudan al desarrollo de desórdenes musculoesqueléticos relacionados con el trabajo.

Palabras clave: ergonomía, factores de riesgo, odontología, trastornos musculoesqueléticos, ergonomía ocupacional.

Relevancia para la ergonomía: Con esta revisión de literatura se puede ver el panorama del conocimiento que ha generado la ergonomía sobre los factores de riesgo que atribuyen al desarrollo de trastornos musculoesqueléticos, para así idear estrategias que ayuden a mejorar las condiciones en las que trabaja el odontólogo. Al igual, hacer notar que la mayoría de los estudios que se han generado van enfocados a la perspectiva de la micro ergonomía, investigando sobre movimientos repetitivos, cargas posturales, síntomas músculo esqueléticos, etc. Ayudando a ver el área de oportunidad para generar investigaciones con una perspectiva enfocada en la macro ergonomía y estudiar el puesto de trabajo del odontólogo como un sistema.

Abstract: Musculoskeletal disorders are defined as the set of injuries associated with overexertion or tendon fatigue, which represent the main cause of occupational disease in the world's working population. According to the International Labor Organization, musculoskeletal disorders are one of the most important occupational health problems, involving high costs and impacting the quality of life. MSDs are caused by work that involves prolonged, maintained, and forced postures, as well as the handling of loads and repeated movements. Dentistry is a profession where the development of MSDs has been characterized by the adaptation of forced postures due to high visual demands. Among the positions that increase muscle tension are standing or sitting together with the excessive pressure of some tissues and the rotations of the spine that generate high static loads. The use of force and repetitive movements with a lack of rest can negatively affect the quality of life of dentists and lead to early retirement. MSDs are attributed to the nature of dental work by interacting with a small work area, prolonged sitting with unnatural body posture, and using force in repetitive movements aid in the development of work-related musculoskeletal disorders.

Keywords: ergonomics, risk factors, dentistry, musculoskeletal disorders, occupational ergonomics.

Relevance for ergonomics: This literature review provides an overview of the knowledge that ergonomics has generated on the risk factors that contribute to the development of musculoskeletal disorders, to devise strategies to help improve the conditions in which dentists work. It should also be noted that most of the studies that have been generated are focused on the perspective of micro ergonomics, investigating repetitive movements, postural loads, musculoskeletal symptoms, etc. This helps to see the area of opportunity to generate research with a perspective focused on macro ergonomics and to study the dentist's workplace as a system.

1. INTRODUCTION

Dentists are responsible for carrying out meticulous and complex procedures, so it is common for them to adopt incorrect postures and movements to achieve fine and precise movements, involving high visual demands required by their work. For these reasons, dentists are a population vulnerable to the development of musculoskeletal disorders (MSDs).

The risk factors present at the dentist's workstation can be biomechanical or psychosocial. The possibility of acquiring an MSD is not only influenced by the physical and biomechanical factors, but also by the psychosocial factor, which plays an essential role in acquiring MSDs in dentists.

As mentioned, the risk factors present in dental work are conducive to the development of MSDs, which have been characterized by the adaptation of awkward postures (Meisha et al., 2019). Because the work area is small, uncomfortable positions are adopted, some of which increase muscle tension, such as, for example, standing or sitting for long periods, together with the excessive pressure of some tissues and the rotations of the spine that generate high static loads. As well as the use of force and repetitive movements, lack of rest can negatively affect the quality of life of dentists and lead to early retirement. (Gopinadh et al., 2013)..

Low back problems are the most common among dentists, followed by hand, neck, and shoulder problems. Similarly, they present symptoms of paresthesia in the hands due to injury of some surrounding nerve. (Gupta et al., 2019). Therefore, dentists are exposed to different risk factors from the ergonomic point of view that can affect their professional performance and cause health problems. The objective of this work is to identify through a literature review the contributions of ergonomic research in ontology and to identify the risk factors that increase the incidence of musculoskeletal disorders.

2. METHOD

The bibliographic review was performed through the academic Google database, Pubmed, Ergonomics, and Elsevier. Articles were taken from the years 2012 to 2022. The terms used for the search were *dentistry, ergonomics, musculoskeletal disorders, ergonomic risk factors in dentistry, and psychosocial risks.* For the selection of the articles, we began by inspecting the titles that were related to the objective of this article, and the abstract of the article was analyzed. Once the articles that added knowledge for the development of this article were selected, the method, results, and discussion of each one was analyzed.

3. RESULTS

From the literature review that was carried out, 16 articles were identified that would add knowledge about the findings of ergonomics in dentistry. The articles were classified into four subgroups according to the focus of the research: 1) musculoskeletal disorders, 2) postures, 3) ergonomic tools and chairs and 4) psychosocial risks. The distribution of the articles according to the subgroups is shown in Table 1.

Table 1. Classification of articles according to subgroups.

Subgroups	No. of items
Musculoskeletal disorders	7 items
Positions	3 items
Ergonomic tools and chairs	4 items
Psychosocial risks	2 items

The findings of the following subgroups will be described below:

3.1 Musculoskeletal disorders

According to Franco et al. (2017). work-related MSDs are becoming more and more frequent. Injuries affecting ligaments, and intervertebral discs, in addition to muscles, tendons, and bones. MSDs can result from minorand repeated trauma, such as:

- Increased pace of work.
- Constant strength in hands, wrists, and shoulders.
- Forced and static postures.

Franco et al. investigated included all workers who were registered with social securty, of those who were classified as having occupational diseases from 2012 to 2014. According to the statistical data obtained from the IMSS, in the state of Jalisco, during the years 2012 to 2014 an average of 76,932 companies were obtained, with 1,372,942 workers under IMSS insurance, where 59,653 occupational risks were registered, with 45,846 occupational accidents, 13,447 commuting accidents, 360 occupational diseases, and 107 deaths. The most common MSDs found in these figures were, in the first place, Quervain’s tenosynovitis, followed by carpal tunnel syndrome, enthesopathy, shoulder injuries, and, lastly, epicondylitis.

According to Fimbres et al., (2016) the prevalence of signs and symptoms of hand disorders has risen to 33% which may be related to practicing dentistry whose predominance was in the right hand (92.2%), highlighting symptoms of paresthesia of the hand (26.6%), paresthesias of a finger (25.24%) and the most prevalent sign is joint pain (12.62%). Fimbres et al., (2016) The authors conducted an observational study in a dental clinic in Hermosillo, Sonora, to identify MSDs in the dentists of the clinic. They recorded sociodemographic variables of 30 subjects who participated in the study such as age, sex, dominant hand, years of professional practice, predominant professional dental activity, and whether they had any condition or disease. They also applied the Nordic Standardized Questionnaire and the REBA method.

The mean age of the subjects was 31.6 years and the mean number of years practicing dentistry was 8.53 years. 56.7% of the participants were male and dentistry was the predominant dental activity with 40%. According to the results of the Nordic Questionnaire, the most affected anatomical region in the last 12 months was the neck (70%), with the right elbow or forearm as the least affected region (10%). Regarding symptomatology in the last 7 days, the neck, dorsal and lumbar areas were the regions with the greatest symptomatology (43.3%) and the elbow was the site with the least symptomatology (6.7%).

The shoulder is the segment that presents the most discomfort for a prolonged period between 1 and 2 years (20%). Regarding postural assessment, with the help of the REBA method, it was observed that 70% of the scores were between 4 and 7, which means that the dentists show a medium level of risk.

Another study was conducted with the aim of Juntzo et al., (2012). To describe musculoskeletal disturbances and their association with physical and environmental factors in dental students. They applied a structured questionnaire to classify the students, according to the presence or absence of discomfort exposures. An osteomuscular evaluation was also carried out with the help of two expert physiotherapists, the anteroposterior position of the cervical, dorsal, and lumbar curvatures was evaluated through clinical observation qualifying them as increased, normal, and decreased; as well as palpation in the cervical area, upper trapezius, middle trapezius, latissimus dorsi, and lumbar area; finally, the pain was evaluated when moving the trunk and neck in flexion, extension, rotation, and lateralization. For the measurement of postures, the RULA instrument was used to systematically record the postures.

In the results, it was highlighted that the most used position was seated in an armchair, as well as using both types of vision to perform their treatment (direct and indirect) and almost half of the students affirmed that they did not stretch at the end of their dental practice. In the osteomuscular physical assessment, pain on palpation was noted in the upper trapezius with a score between 1 and 4 on the Visual Analog Scale (VAS) of pain in a little more than half of the participants. Presence of pain in cervical lateralizations with a score between 1 and 3 on the VAS scale.

Regarding the evaluation of clinical work using the RULA method, it was observed that the posture was poor in 43% of the students with a final score of 7, which indicates that an urgent change in the work posture is needed. In 34.8% a score between 5 and 6 was obtained, indicating that a rapid change of posture was necessary.

Gowri et al., (2012) conducted a questionnaire at an orthodontic conference in India to provide a starting point for ergonomics. He applied the modified Nordic Questionnaire, which was given directly to all registered orthodontists at the conference in February 2010. For statistical analysis, the dentists were divided into three groups according to their work experience, less than 5 years, 5 to 10 years, and more than 10 years. A total of 400 dentists received the questionnaire and only 259 questionnaire forms were included in the final analysis.

The results showed that 82% of the subjects were men and their ages ranged from 28 to 69 years, the mean number of years working was 11.36 years. About a quarter of the dentists worked more than 8 hours a day (24.32%) and 44.8% of the dentists stated that they did not perform any exercise regularly. It was found that 41.69% of the subjects suffered MSDs affecting one or more parts of the body. Wrist pain and low back pain were the most common MSDs among the subjects.

A Yates correlation statistical analysis showed that there is a statistically significant correlation ($p < 0.05$) between the prevalence of MSDs and variables related to the type of work and weekend work. MSDs are significantly higher in groups with 5 to 10 years of work experience (or = 4.18) and in those with more than 10 years of experience (or = 4.12).

Marshall et al., (1997) conducted a study in New South Wales to describe the prevalence and distribution of MSDs occurring in dentists and to identify the relationship between symptoms and work practices. A questionnaire was distributed to 442 dentists in New South Wales, comprising 18 questions that sought information about the dental practice and the MSDs they had experienced in the month before receiving the questionnaire.

The average work performed without taking 10 minutes rest was 172 minutes, the most selected option was 1-2 and 4-5 hours of work duration before taking 10 minutes rest. Regarding the position of the dentists about the patient, it was found that 85% of the subjects used the position between 10 and 12 taking into account that a clock faces the mouth. And of the 22 subjects who reported being left-handed, they used the position of 12 and 2. 87% of the subjects preferred the seated position, and 10.5% preferred to work standing up.

Among the symptoms that occurred in the month before receiving the survey were: headache, pain, numbness, paresthesia, and weakness in the fingers. Eighty-two percent of the subjects reported having presented one or more of these symptoms. Sixty-four percent reported the presence of pain; 54% reported headaches; 19% reported paresthesias; 17% reported weakness, and 13% reported numbness. Regarding the body segments, 59% reported pain in the trunk distributed symmetrically.

Another study was conducted by Shaik et al, (2016). in two dental colleges and 20 private dental clinics in Mangalore city, South Kartanaka district, India. Aiming to analyze the correlation between ergonomic risk factors and MSDs in terms of pain perception. 130 participants from dental colleges and private dental practitioners with one year of work experience and moderate to severe pain on a scale of 0-10 were invited. An MSD and dental workstation rating scale and an observation checklist were used to help correlate risk factors and MSDs.

They developed an Ergonomic Awareness Training Program for six weeks, where they received training such as lectures, discussions, and demonstration sessions. As risk factors they considered manual handling of materials, physical energy demands, instruments, environment, and other musculoskeletal demands; as MSDs they took into account the perception of pain and stiffness experienced by the dentist.

Using Pearson's P statistical test, it was seen that in the pre-test it could be noted that there was a positive correlation between manual material handling, physical energy demands, instruments, environment, other musculoskeletal demands, and pain frequency, but there was no statistical significance. In the post-test, there was a positive correlation between manual material handling, physical energy demands, instruments, environment, other musculoskeletal demands, and pain frequency, and there was statistical significance between physical energy demand and pain frequency. A high statistical significance was also observed between other musculoskeletal demands and pain frequency.

In the correlation of risk factors and pain intensity, in the pretest, there was a positive correlation between the two variables and statistical significance between other musculoskeletal demands and pain intensity. In the post-test, there was a positive correlation between the two variables and high statistical significance between physical energy demand, other musculoskeletal demands, and pain intensity. And finally, in the correlation in the correlation of risk factors and stiffness frequency, in the pretest there was a positive correlation between the two variables, but there was no statistical significance. In the post-test, there was a positive correlation between the two variables and high statistical significance between other musculoskeletal demands and stiffness frequency. Concluding that after the Ergonomic Awareness Training Program there was a reduction in MSDs in terms of pain frequency, pain intensity, and stiffness frequency.

Mikuľáková et al., (2016). conducted a study to evaluate the incidence of spinal changes in dentists and students. It was conducted on it between 2010 and 2011 at the Faculty of Health Care, Prešov University, Slovak Republic. It consisted of 50 dentists and 75 dental students, who were examined for shape and mobility (flexion and extension) in individual sections of the spine in the sagittal and frontal plane with the help of a device called SpinalMouse. To evaluate them, they were divided into 2 groups: dentists and students.

In the results in the group of dentists, it was observed that the most significant problems in the sagittal plane were in the thoracic spine, 40.7% had a hyperkyphotic posture and 11.1% had a flat back. And in the students, it was observed in the thoracic region that 18.3% of the students presented hyperkyphotic curvature and 10.7% flat back. And 16% presented increased curvature in the lumbar section. In the frontal plane, 48 2% of the dentists were diagnosed with scoliosis in the so and 25.9% in the lumbar section. In the group of students, 30.6% presented scoliosis in the thoracic section.

When examining the mobility in terms of spinal flexion in the group of dentists, approximately 48.1% had reduced mobility in the lumbar section and this was compensated with the movement of the hip joint. In the student group, 7.4% of the subjects had lumbar hyperlaxity. When evaluating extension mobility, in the group of dentists 59.3% presented reduced amplitude in the lumbar region and 18.5% in the thoracic region. In the group of students, a reduced range of extension mobility was observed in 30.7% of the subjects examined, and greater mobility was observed in the hip joint.

3.2 Positions

In the field of ergonomics applied in dentistry, one of the most discussed topics is the working posture of the dentist. A good posture of the dentist provides him with optimal conditions to perform his work and, on the other hand, a good posture helps the dentist to have more energy, reduces the level of stress, increases comfort, and favors the absence of pain and muscle tension thus reducing the incidence of MSDs. On the other hand, poor posture induces premature fatigue, pain, stress, negative work attitude, poor quality of work, and a high incidence of developing MSDs. (Pîrvu et al., 2014)..

Pîrvu et al., (2014) conducted a study where they analyzed the postures adopted by dentists when working starting with the balanced posture and moving on to different postures. The working posture is highly influenced by the relationship between the body and the elements of the workstation, therefore, if there is a bad design of the workstation or it is incorrect, the posture will be affected. The posture described in the "ISO Standard 11226 Ergonomic evaluations of static operating postures" is recommended for dentists to use the neutral posture, which is a natural, unforced, stress-free, symmetrical sitting posture that considers the biomechanics of the human body. Neutral posture consists of maintaining an upright back, a maximum trunk flexion of 20°, accompanied by a section of 20°-25° to observe the oral cavity. The arms should be placed at the side of the body-oriented forward within 10° and the forearms raised to 25° from the midline, the popliteal angle should have an angle between 105 and 110° or more and the feet should be touching the floor oriented forward placed symmetrically under the operator's hands. This posture does not necessarily need to be rigid but should have some freedom to move within certain limits so as not to be detrimental to the body.

Static work is more strenuous than dynamic work, although it requires less oxygen consumption, static work produces a large number of proprioceptive impulses from tendons, ligaments, and muscles, which are sent to the nerve center of the cerebral cortex which means that there is a prolonged continuous situation of the nerve centers, and this mechanism explains why static work is more strenuous than dynamic work. On the other hand, static posture can affect the supply of oxygen to the muscles, and this can be expressed in inefficiency and even pain. (Pîrvu et al., 2014)..

Shirzaei et al., (2015) conducted a study to evaluate ergonomic factors and work-related postures, as well as the relationship between demographic factors and working conditions with pain in Zahedan University, Iran. They used first and second-year students without clinical practice in dental school as a control group and fifth and sixth-year students with clinical practice. A questionnaire was administered to them to find out about musculoskeletal disorder’s pain and whether they performed stretching exercises, to evaluate postures the Reba method was used. subjects who had a history of diagnosis of musculoskeletal diseases were excluded from the study.

The results showed that 88% of the students had an incorrect posture during their clinical activity. 58.3% of the students adjusted their chairs to adopt a better posture when working. The intensity of musculoskeletal pain was reported as a function of gender. The average pain in female students was higher than in male students, but there was no statistical significance between gender and pain. The highest and lowest average pain in terms of specialties were the specialty of surgery as major and reconstructive, with the lowest average, according to the results of the questionnaire. The average REBA method score in the areas of endodontics, surgery, fixed prosthodontics, and reconstructive dentistry was 6, 6, 5, and 4 respectively. This means that 32% of the subjects are in the highest level of danger, 52% are in the medium level and only 16% are exposed to the low-risk level.

Ng et al., (2016) conducted a study with the aim of determining the prevalence of musculoskeletal pain and postural deficits in dental students and investigating any risk factors that may influence the rate of MSD. To achieve these objectives, I was given the prevalence of MSD using a questionnaire and a postural assessment. The participants were first and final-year undergraduate oral health and Doctor of Dental Surgery Students at the University of Melbourne, Australia. The questionnaire was an adapted version of the original Smith and Leggat tool previously used in medical, dental, nursing, and occupational therapy students; the Branson dental operator posture assessment was used to assess posture. Fisher's exact test was used to analyze the data obtained from the postural assessments. And Wilcoxon test was used in the first-year students of both majors as a control group and the senior groups. The groups are BOH1 (first-year undergraduate), BOH3 (senior undergraduate), DDS1 (first-year Ph.D.), and DDS4 (senior Ph.D.).

Fifty percent of the undergraduate students reported neck pain lasting more than 2 days. Students showed an increased prevalence of low back pain respective to their courses, i.e., BOH1 reported 33.3% and BOH3 62.5%; DDS1 reported 44.7% and DDS4 64%. Wrist and hand pain was also frequently reported among students, undergraduate students had a significantly higher rate of wrist pain than Ph.D. students. Posture assessment data showed that most students were able to achieve an acceptable degree of posture. It was shown that first-year students in both majors demonstrated a higher percentage of students with acceptable postures. The DDS4 group was shown to have 8% of harmful postures and 60% of compromised postures. Within the undergraduate group, it was shown that the majority had poor trunk posture, on the other hand, in the Ph.D. group it was seen that the hip, trunk, and shoulders had poor scores in the senior group.

3.3 Ergonomic tools and chairs

Posture can be affected by various factors such as workplace equipment, patient position, and even the dentist's chair. The dental chair should allow the dentist to sit in a stable, relaxed position, with a straight back, without twisting the spine or turning the head, and with a good view of the work area. (Huppert et al., 2021). Huppert et al., (2021) examined 6 dentists' chairs to see if they adopted a more asymmetrical posture when sitting in the chairs and examined whether the different chair designs showed a clinically relevant difference in the usual sitting posture and working posture.

The study sample consisted of 59 subjects who were divided into 3 groups, group 1 the control group consisted of healthy subjects, group 2 consisted of dentists and students with work experience of fewer than 10 years and group 3 consisted of dentists with work experience of more than 10 years. The subjects were evaluated using the ABS Body Mapper, a lightweight optical device based on video recording stereography. According to the coding given to the chairs by the authors, they were classified into chair 1, chair 2, chair 3, chair 4, chair 5, and chair 6, to see the images please refer to the study by (Huppert et al., 2021). To describe the results of this study, the coding given by the authors will continue to be used. The result showed that the thoracic flexion angle was significant for chairs 1, 5, and 6, while the lumbar flexion angle was significant for chairs 2, 3, 4, and 5. The kyphosis angle was significant for chairs 3, 4, and 5, while the lordosis angle was significant for chairs 2, 3, and 4. This analysis showed that ergonomic chairs have no relevant significance on the upper body.

Bud et al., (2021) conducted a study to evaluate the different magnification systems that could improve the working posture of dental students, as well as the students' perception when using magnification systems. the sample consisted of 17 subjects in their third year of university. to evaluate them they performed a task that consisted of preparing a cavity in the first mandible and mounting a dental arch in the simulator. the students performed this task 3 times, the first time with the unaided eye, the second time using magnifying lenses, and the third time using a dental microscope.

According to the results, both the loupes and the microscope had a positive impact on the posture of the dentists, however, the microscope was found to lead to a significant posture improvement of 30.2%. Microscope use showed a 50% improvement in head and neck posture and a 23.6% improvement in shoulder posture. When magnifier viewing was analyzed, the overall ergonomic improvement was less, 11.89% improvement in head and neck posture and 5.9% improvement in shoulder posture. Regarding the measurement of perception of the Use of magnifying glasses and microscope rated on a Likert scale from 1 to 5, it was found that the mean perception for comfort was 2.82 for the microscope 4 for magnifying glasses, and 3.9 for unaided eyes. The mean perception means for posture correction was 4 for the microscope, 3.5 for the Magnifying glasses, and 2.7 for the unaided eye. The perceptual means for fatigue after the task was 3.2 for the microscope, 3.5 for the magnifying glasses, and 3 four for the unaided eye. The mean perception for concentration during the task was 4.4 for the microscope, 3.9 for the magnifying glasses and 3.3 for the unaided eye and finally, the mean adaptation to the use of visual aid was 3.7 for the microscope and 4.2 for the magnifying glasses.

García et al, (2019). Conducted a study at the University of Murcia, they recruited 36 dentists among students and professors. They evaluated the influence of different ergonomic supports on muscle activity by electromyography of three muscles (upper trapezius, anterior deltoid, and middle deltoid) while performing a posterior restoration, consisting of three tasks: drilling the tooth, filling the tooth, and polishing the tooth. The ergonomic tools used were magnifying glasses and a chair with adjustable lumbar support. All participants performed the same procedure four times with 15 min of rest between each one. The first time without the aid of the ergonomic tools, the next two times with each of the tools and the last time with both ergonomic tools.

According to the ANOVA results, there was a significant difference in the three tasks (drilling, filling, and polishing). It was shown that the upper trapezius had more muscle activity in the condition without ergonomic support than with each of the three ergonomics. Muscle activity decreased in all three tasks when the ergonomic tools were used. The upper trapezius was the muscle that had the greatest reduction in muscle activity with the help of the ergonomic chair and the magnifying glasses, with muscle activity decreasing between 89% and 93%. Likewise, the anterior and middle deltoid had a reduction in muscle activity. The muscle activity of the middle deltoid decreased using the ergonomic tools only in the filling and polishing tasks, but it was shown that this muscle had no difference in the drilling task. The anterior deltoid, in contrast to the middle deltoid, was found to have decreased muscle activity in the drilling task and increased in the filling and polishing tasks. The activity of the anterior and middle deltoid decreased with the combination of ergonomic tools by 81% to 97%.

Another study by Carpentier et al. (2019) also evaluated the impact of magnifying lenses on the posture of 40 dental students. It showed that the magnifying lenses helped improve the posture of the students, 90% of the students reported that the magnifying lenses improved their vision, 62% reported comfort when wearing them and 82% reported a positive change in working posture. However, 62% of the students found working with the loupes challenging, while 30% experienced physical symptoms such as vertigo pain, eye pain, or migraine while working with the loupes. On the other hand, 62% said they found it easy to adapt to the loupes, 47% said the quality of their work increased, and 53% of the students said there was no noticeable impact on quality.

3.4 Psychosocial Risk

MSDS, pain, stress, and mental strain are very prevalent today and are one of the important health problems in the dental profession. As well as high exposure to awkward postures, high forces exerted by the hand and fingers, and prolonged static load on neck and shoulder muscles, high levels of stress can contribute to the development of MSDs (Marklund et al., 2021). Marklund et al., (2021) evaluated how dentists experienced their working conditions and tried to identify possible factors associated with a high workload. He applied 212 questionnaires asking about their employment status, influence on work, social support, work demands, ergonomics, working hours, and workload.

Fifty percent of the participants reported a high workload, 70% perceived their work as both psychologically and physically demanding, while 8.6 experienced the work as physically demanding and 50% reported low control over their work. The high workload was associated with the unsatisfactory ergonomic situation, low social support, and low control over work.

Psychosocial factors can directly cause MSDs. In several studies with electromyography, it has been shown that stress generates an increase in muscle activity particularly in the trapezius muscle, just as people who work with high levels of psychosocial or psychological stress are more likely to develop physical pain (Taib et al., 2017).

Taib et al., (2017) distributed a questionnaire to 85 dentists. where they addressed physical factors, psychosocial factors, musculoskeletal symptoms, treatment choice, and ergonomic conditions. They found that the prevalence of musculoskeletal disorders in Malaysia was very high. The most affected regions according to the questionnaire in order were the neck the dorsal area of the back the lumbar area and the wrist without hands. only 2 4% of the participants reported symptoms in only one body segment, 13.4% of the dentists reported pain in minimum

2 body segments, 26.8% reported in 3 segments 28% reported pain in four segments, the rest of the participants reported pain in more than 5, 6 and 7 body segments. To measure psycho-social stress, the generic work stress questionnaire was used where the stressors were divided into 6 groups: conflict in the group, work requirements, job satisfaction, mental demand, work hazards, workload, and responsibility. It was found that hand and wrist pain was associated with 3 psychosocial stressors, as well as neck pain was related to stressor job satisfaction. Wrist and hand pain as well as neck pain were significantly associated with 3 psychosocial stressors.

4. Conclusions

From the literature reviewed, it can be concluded that dentistry is an area prone to developing musculoskeletal disorders due to the high number of risk factors that are present at the workstation and when performing their tasks. The risk factors present in dentistry are multifactorial and could be categorized as biomechanical and psychosocial, among the most common physical risk factors in dental practice are the adoption of static and uncomfortable postures, repetitive work, force, poor lighting, and visual demand, among others. The organization, demand, control, workload, as well as mental demand, are considered one of the most common psychosocial risk factors in dental practice.

The body segments with the highest incidence of developing musculoskeletal disorders reported in the literature reviewed were the neck, the dorsal area, the lumbar area and the wrist and hands. This is due to the static and inadequate postures they must adopt, and the repetitive and precision work they must perform to successfully achieve the treatment their patients undergo. Gopinadh et al., (2013) argues that the number of segments with pain, in addition to the frequency of pain episodes is higher in men than women, as well as assures that general dentists tend to develop MSDs more frequently than prosthodontists, oral surgeons, endodontists, and periodontists. However, there are other authors such as Meisha et al, (2019) who found that the segments with greater involvement in women compared to men were the neck, shoulders, dorsal back, elbows, and wrists. And another identical study concluded that MSDs are due to recurrent and repetitive motion, coupled with their long days in static postures without sufficient rest.

Ergonomic tools, such as magnifying glasses and the dental microscope, help to improve the dentists' posture when performing their tasks, but it was shown that it takes time to adapt to them. They would also help to reduce the muscular activity of some muscle groups, such as the neck and shoulder girdle, due to the correction of their posture. Using the chairs, the correction of vicious postures was evidenced in some cases, helping to conserve the natural curvatures of the spine; however, it was also found that some types of chairs could favor lumbar hyperlordosis, which could favor the development of MSDs.

Psychosocial risks are another important factor in the development of musculoskeletal disorders. Stress generated by risk factors, such as low job control, mental workload, workplace problems, and job satisfaction, can favor the development of musculoskeletal disorders. Hence the importance of also studying the psychosocial risks present in dentistry.

So far, there is no evidence of studies that evaluate the workstation as a system, which may create an area of opportunity for future research.

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ERGONOMICS APPLIED TO WORK WITHIN AN OFFICE

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Resumen: La normativa que existe internacionalmente en el campo de la Prevención de Riesgos Laborales emana del reconocimiento del derecho de los trabajadores a la protección de la salud frente a los riesgos derivados de las condiciones de trabajo. El incremento en los últimos años en lesiones musculoesqueléticas, especialmente en cuello y extremidades superiores, entre trabajadores de oficina es un tema significativo para la ergonomía ya que es un tópico relacionado con el bienestar físico del trabajador y con la productividad de las empresas, lo anterior está avalado en diferentes estudios (Escalante & Guaita, 2022; Mohammadipour, et al. 2018; Sadegh & Babamiri, 2021). El incremento de estas lesiones está muy relacionado con el uso de Computadoras en los ambientes de oficina y como ejemplo se encuentran la cervicalgia, dorsalgia, lumbalgia, alteraciones a nivel del hombro, síndrome del túnel del carpo, tendinitis y epicondilistis (Hurtado, Londoño, & Lozana, 2016)

En los últimos años se ha incrementado el uso de "oficinas flexibles" aquellas donde trabajadores, empleadores y consultores comparten la oficina para trabajar alternadamente unas cuantas horas al día, compartiendo el mismo sistema hombre-máquina para diferentes actividades. El trabajo en la oficina flexible se incrementará a partir del 2020 (Chandra, et al. 2009), lo anterior desde el punto de vista ergonómico viene a incrementar el interés de buscar en la etapa de diseño de estos lugares de trabajo el cumplir con los lineamientos ergonómicos que permitan una mayor adaptabilidad de este tipo de sistemas hombre-maquina.

De esta forma en numerosos artículos y documentos técnicos de la ergonomía hacen referencia a los principios de la acción preventiva, que forman parte del conjunto de normas generales, dispuestas para "adaptar el trabajo a la persona, en particular en lo que respecta a la concepción de los puestos de trabajo, así como a la elección de los equipos y los métodos de trabajo a fin de poder atenuar el trabajo monótono y repetitivo y a reducir en la mayor medida posible la aparición de lesiones musculo esqueléticas". En este sentido, es recomendable realizar evaluaciones de riesgos ergonómicos, a fin de adoptar cuantas medidas sean necesarias para la protección de la seguridad y salud de los trabajadores. En el caso particular de este estudio se utilizará el método de Rapid Office Strain Assesment (ROSA).

Palabras clave: Evaluación ergonómica de puesto de trabajo, ROSA, Ambiente laboral en Oficinas.

Relevancia para la ergonomía: Las oficinas hoy en día deben diseñarse teniendo en cuenta no solo a los trabajadores y clientes, sino también un aspecto muy importante del entorno de la estación de trabajo: la tecnología, especialmente los terminales de visualización visual, teclados, mouses y otros periféricos relacionados con la computadora. Relacionado con esto, es importante entender la ergonomía de la oficina como una búsqueda de diseño que se ajuste a las necesidades y capacidades de los trabajadores no solo para cuidar su bienestar sino también para mejorar la productividad de la organización. También es importante tener en cuenta la viabilidad del uso de la oficina como una "oficina flexible", lo que significa que se debe tener en cuenta la adaptabilidad a diferentes antropometrías.

Abstract: The increase in recent years in musculoskeletal injuries, especially in the neck and upper extremities, among office workers is a significant issue for ergonomics since it is a topic related to the workers' physical well-being and companies' productivity; the above is supported in different studies (Mohammadipour et al. 2018; Sadegh & Babamiri, 2021). The increase in these injuries is closely related to the use of computers in office environments. Examples are cervicalgia, dorsalis, low back pain, alterations at the shoulder level, carpal tunnel syndrome, tendonitis, and epicondylitis (Hurtado, Londoño, & Lozana, 2016).

Articles and technical documents on ergonomics refer to the principles of preventive action, which form part of the set of general rules designed to adapt work to the person, in particular concerning workstations design, as well as the choice of equipment and working methods to be able to attenuate monotonous and repetitive work and to reduce by the greatest extent the appearance of musculoskeletal injuries. In this sense, it is advisable to carry out ergonomic risk assessments to adopt as many measures as necessary to protect the workers' safety and health. In the particular case of this study, the Rapid Office Strain Assessment (ROSA) method will be used.

Keywords. Ergonomic workplace analysis, ROSA, Office working environment.

Relevance to Ergonomics: Offices nowadays should be designed considering not only workers and customers but also an essential aspect of the workstation environment: technology, especially Visual Display Terminals, keyboards, mouses, and other computer-related peripherals. Related to this, it is necessary to understand office ergonomics as a pursuit of design that fits the workers' needs and capabilities not only to take care of their wellbeing but also to improve the organization's productivity. It is also essential to consider the feasibility of using the office as a "flexible office," which means that adaptability to different anthropometrics' should be considered.

1. INTRODUCTION

The international regulations in the field of Occupational Risk Prevention emanate from the recognition of the right of workers to the protection of health against the risks derived from working conditions; the above is true in every workplace. In recent years, there has been an increase in musculoskeletal injuries among office workers, especially in the neck and upper extremities; this is a significant ergonomic issue since it is a topic related to workers' physical well-being and productivity. This increase is supported in different studies (Mohammadipour et al., 2018; Sadegh & Babamiri, 2021).

The increase in these injuries is closely related to the increased use of computers in office environments to perform diverse tasks such as: preparing reports, planning, database development, accounting, videoconferencing, managing the financial area, scheduling tasks, purchasing, inventory control, sales and a much more, which has resulted in the time of work in the office increasing considerably and with these musculoskeletal injuries such as cervicalgia, dorsalis, low back pain, alterations at the shoulder level, carpal tunnel syndrome, tendonitis and epicondylitis (Hurtado, Londoño, & Lozana, 2016).

Articles and technical documents on ergonomics refer to the principles of preventive action, which form part of the set of general rules designed to adapt work to the person; in particular concerning workstations design, as well as to the choice of equipment and working methods to be able to attenuate monotonous and repetitive work and to reduce the appearance of musculoskeletal injuries as much as possible. In this sense, it is advisable to conduct ergonomic risk assessments to adopt as many measures as necessary to protect the workers' safety and health.

Regarding the standards and guidelines related to ergonomic aspects in the office, ISO 9241 can be mentioned, which is the standard focused on quality in usability and ergonomics of both hardware and software. It was created by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) in 1999, seeking to improve human-machine interaction (Cognitios, 2021). Another standard is the ANSI/HFS 100-2007 (the American National Standard for Human Factors Engineering of Visual Display Terminal Workstations), which was developed originally in 1988 and updated in 2007. It has a primary objective of providing specific guidance for designing and installing office workstations that include displays, input devices, and furniture (HFES, 2022).

The year 2012 saw the publishing of the article "Development and evaluation of an office ergonomic risk checklist: ROSA – Rapid office strain assessment" in the 43rd volume of the journal "Applied Ergonomics." This method was developed in Ontario, Canada, by University of Windsor professors and expert consultants in Ergonomics (Sonne et al., 2012). The main objective of this method was to quickly quantify the risks associated with computer use and establish a level of action or change based on the worker's discomfort. The elements considered are the chair, the monitor, the telephone, the keyboard, and the mouse.

To give us an idea of the importance of this methodology in recent years, a search was made for articles related to it, finding that 12,700 articles under the term "ROSA Method Ergonomics" had been published from 2013 to the present day, and using the same term in Spanish (Método ROSA Ergonomía) 15,700 results were obtained, the search was conducted in August 2022.

2. OBJECTIVE

Improvement of operational conditions in an office working environment, based on the results obtained via an ergonomic analysis using the ROSA method.

3. DELIMITATION

The Department of Treasury of Cd. Cuauhtémoc’s local government is responsible for implementing and operating the policies, standards, systems, and control procedures necessary to safeguard the financial resources of the entity; promoting the efficiency and effectiveness of management control, and attending with opportunity and competence to the requests for payment of the different commitments contracted by the entity under the provisions of the Budget Law, Accounting and Federal Public Expenditure and its Regulations, taking care that the documentation that supports the expenditures complies with the requirements of a fiscal nature and internal control. In this department, we can find furniture; a desk with a computer and calculator, a filing cabinet, a printer, a mini-Split, a window with curtains, artificial light, a chair, and drawers, among other things.

4. METHODOLOGY

To carry out the research, the following steps were necessary:

1st. Direct observation of the human-machine system in the Department of Treasury of Cd. Cuauhtémoc municipal government. Observing equipment, tools, work times, dimensions, and spaces.

2nd. Videos, photographs, and dimensions of the tasks and equipment related to the workplace were taken (Figure 1).

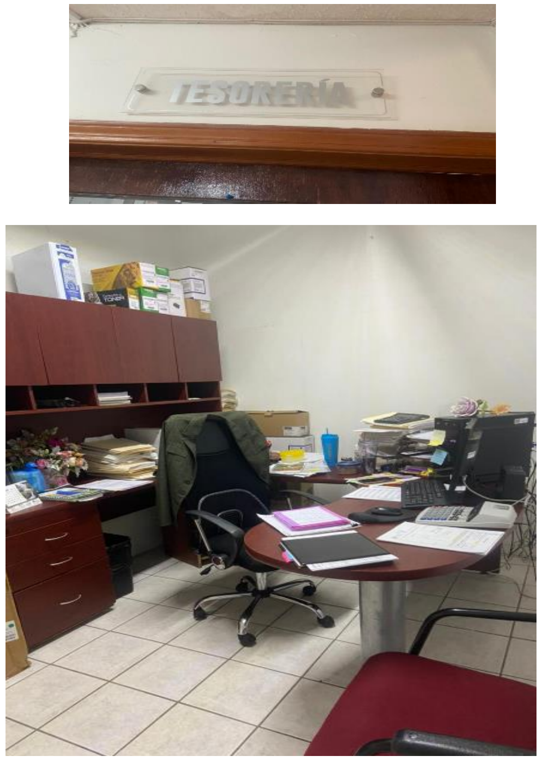

Figure 1. Office workspace analyzed.

3rd. Identification of the ergonomic risk using the ROSA method.
4th. Proposal to implement changes to improve the posture(s) and decrease ergonomic risks of musculoskeletal injuries

5. RESULTS

The ROSA method proposed by Sonne et al. (2012) was followed, and the result was as presented in figure 2.

The ergonomic risk was identified based on the results obtained, and a sketch from the actual layout was made to identify the elements in the man-machine system (Figure 3). A simulation of the movement of the different aspects was done, and the ROSA method was evaluated in each one until the layout gave us the lowest score (Figure 4). The final results from the ROSA method are presented in figure 5 and show a score of five, two points less than the initial one; it can not be less because it is tough to change the chair due to money issues.

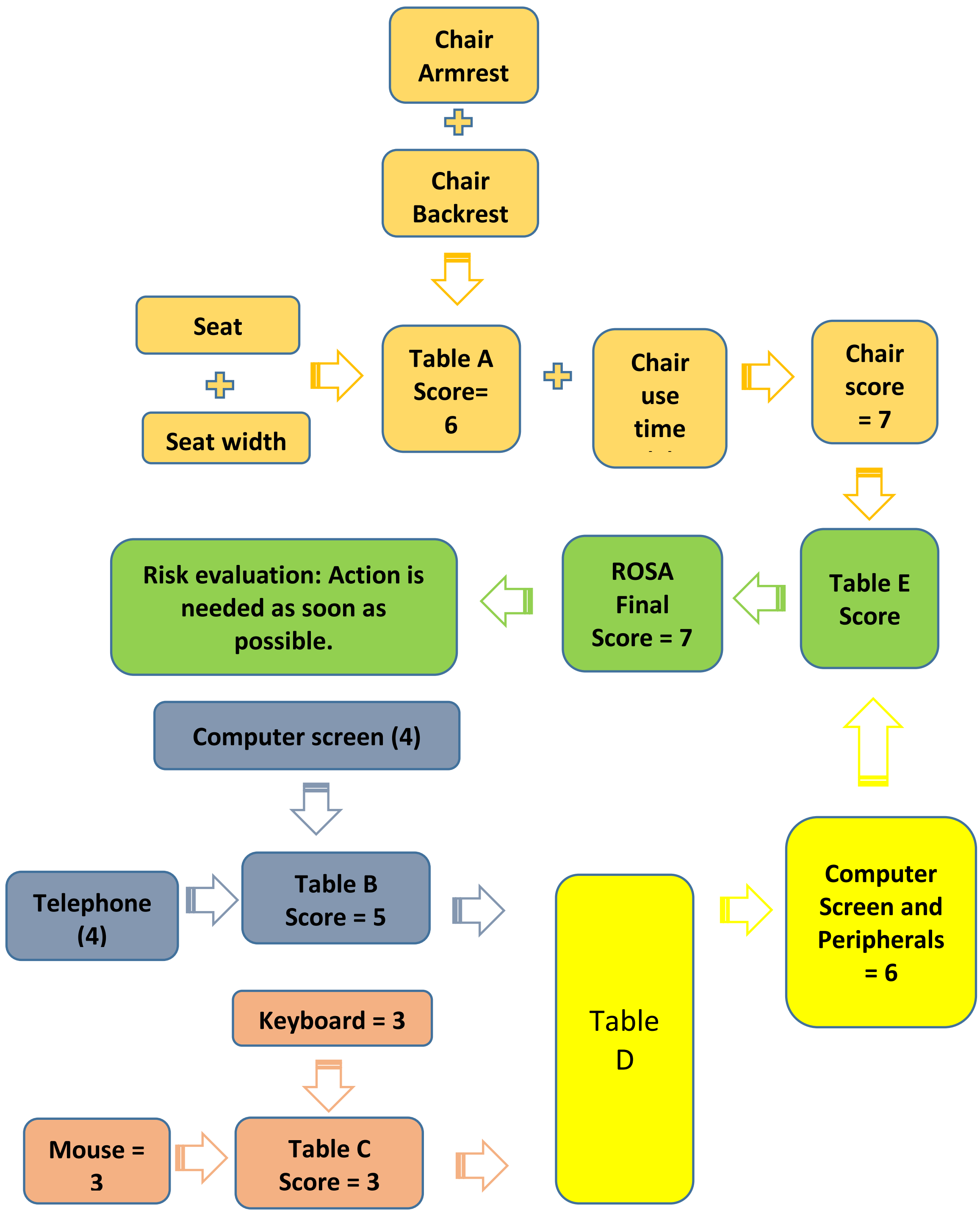

Figure 2. ROSA Method initial results.

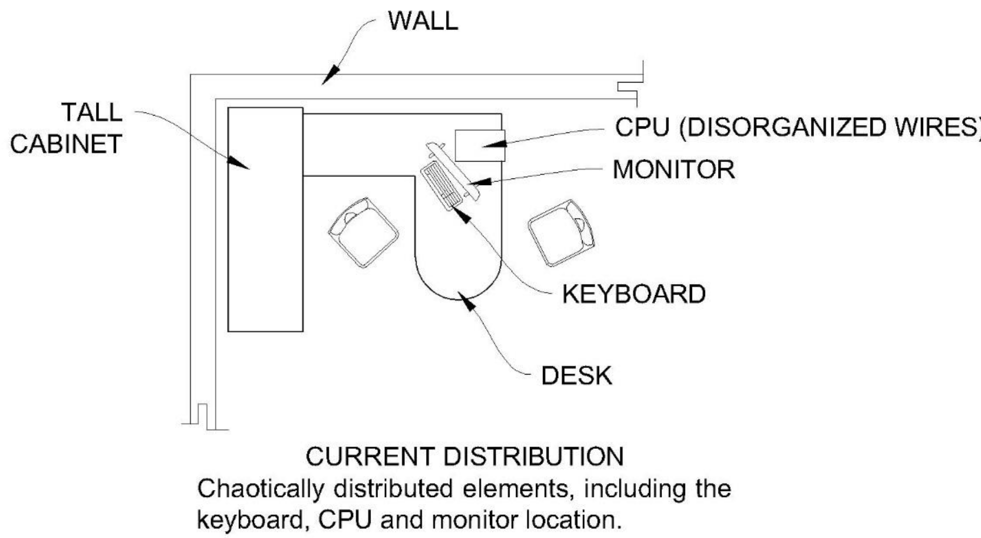

Figure 2. Current Distribution

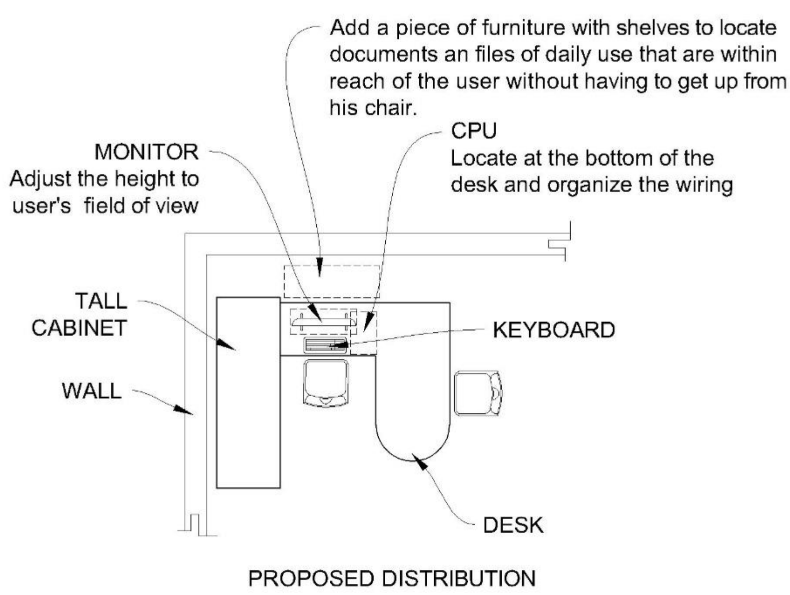

Figure 3. Proposed Distribution

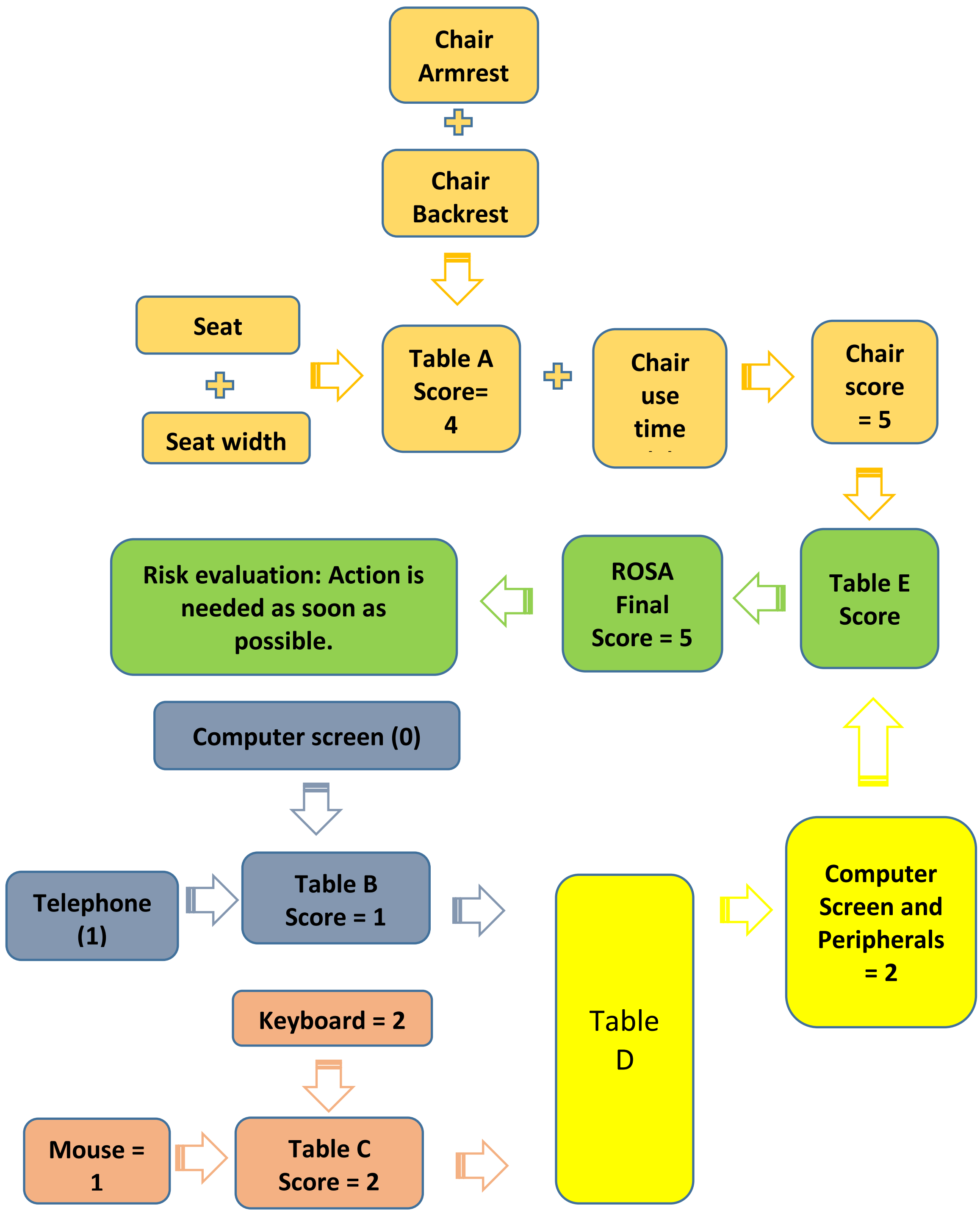

Figure 4. ROSA Method final results.

6. DISCUSSION/CONCLUSIONS

Based on results from the ROSA method, it is recommended to have training talks regarding the importance of correct postures and equipment positions concerning the worker from the ergonomic point of view to reduce musculoskeletal injuries, especially in the neck and upper extremities. The effectiveness of these ergonomic guidelines training sessions is already established in scientific articles (Sadegh & Babamiri, 2021).

Also, following ergonomic guidelines, it could be considered to have the files and documents organized in a way that facilitates the worker's mobility, either by not stretching the arms as much or even avoiding excessive movement, such as an accommodation of the most central desk pointing to the window to take advantage of natural light. It could also be contemplated that because it is a job in which most of the time the worker is sitting, it is essential to avoid slouching the back since otherwise it could cause problems to the spine, or in any case, walk during lunch hour or during breaks to stretch legs and place one or several ornamental naturals plants as they help clean the air of the office and reduce static noise. They should be plants suitable for closed environments and that require little light, such as the aloe plant or the lily of peace.

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DESIGN OF THE ERGONOMIC CONDITIONS OF THE OPERATIONS IN MECHANIC SERVICES SANTAOLAYA, LOCATED IN SINALOA, SALVADOR ALVARADO

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Resumen El presente proyecto muestra información de una investigación que se desarrolló con la finalidad de generar un diseño de las condiciones ergonómicas en el puesto de trabajo de un mecánico, con el fin de evitar accidentes y enfermedades profesionales, disminuir la fatiga, así como aumentar la eficacia y satisfacción del trabajador en el taller servicios mecánicos Santaolaya.

"Ergonomía es una ciencia multidisciplinar que estudia las habilidades y limitaciones del ser humano, relevantes para el diseño de herramientas, máquinas, sistemas y entornos".((I. Leirós, 2009)

Las condiciones ergonómicas que se desarrollaron en el área del taller servicios mecánicos Santaolaya ayudo de manera significativa a mejorar el proceso en las operaciones y las condiciones de trabajo, seguridad, control, reducción de tiempo, y comodidad para el trabajador, logrando un mejor manejo en el área de trabajo. Sé evaluará las condiciones de trabajo en el taller mecánico, Se realizará la toma de datos durante 3 semanas para después presentar la propuesta de diseño de condiciones ergonómicas.

Palabras clave: Diseño de puesto de trabajo, Método Rula, Condiciones ergonómicas y Taller mecánico.

Relevancia para la ergonomía: El diseño de los espacios de trabajo es esencial en la productividad de los procesos. La aportación de la ergonomía garantiza la optimización de los recursos y la optimización de los sistemas Hombre- Máquina. Generando un sistema más eficiente en sus operaciones, cuidando la seguridad y salud del trabajador.

Abstract: The present project shows information of a research that was developed with the purpose of generating a design of ergonomic conditions in the work station of a mechanic, in order to avoid accidents and occupational diseases, decrease fatigue, as well as increase the efficiency and satisfaction of the worker in the workshop mechanical services Santaolaya.

"Ergonomics is a multidisciplinary science that studies the abilities and limitations of the human being, relevant to the design of tools, machines, systems and environments." (I. Leirós, 2009).

The ergonomic conditions that were developed in the area of the Santaolaya mechanical services workshop helped significantly to improve the process in the operations and working conditions, safety, control, time reduction, and comfort for the worker, achieving a better management in the work area. The working conditions in the mechanical workshop will be evaluated. Data will be collected during 3 weeks and then a proposal for the design of ergonomic conditions will be presented.

Keywords: Workstation design, Rula, Ergonomic conditions and Machine shop.

Relevance to Ergonomics: The design of workspaces is essential in the productivity of processes. The contribution of ergonomics guarantees the optimization of resources and the optimization of the Man-Machine systems. Generating a more efficient system in its operations, taking care of the safety and health of the worker.

1. INTRODUCTION

The application of ergonomics in the prevention of occupational and ergonomic risks is of utmost importance due to the number of incidents, accidents, injuries and occupational illnesses of the muscular and lumbar spine type that occur in any area of work.

Manual work in workshops is of utmost importance, as the activities that are carried out provide significant work in terms of the details that have to be performed with inadequate postures and in unsafe conditions.

Ergonomics is a multidisciplinary science that studies the abilities and limitations of human beings, relevant to the design of tools, machines, systems and environments" (I. Leirós, 2009).

In India, Singh and Singh's study was designed to assess work-related musculoskeletal disorders among auto repair mechanics. This cross-sectional study included 125 auto mechanics, conveniently selected from different licensed and unlicensed workshops. For data collection they applied a comprehensive questionnaire to seek information on disorders using the rapid whole-body assessment (REBA) technique to assess the level of risk of musculoskeletal symptoms (CASTILLO BOLAÑOS, 2021).

In Mexico, the Mexican Institute of Social Security in its 2020 technical report indicates that occupational diseases per 10,000 workers in the area of construction, reconstruction and assembly of transport equipment and its parts is 789 cases, occupying the third sector with the highest occupational diseases, permanent disability and deaths (IMSS, 2020).

This project shows information from a research that was developed with the aim of generating a design of ergonomic conditions in the workplace of a mechanic, in order to prevent accidents and occupational diseases, reduce fatigue, as well as increase the efficiency and satisfaction of the worker in the Santaolaya mechanical services workshop.

The ergonomic conditions that were developed in the area of the workshop mechanical services Santaolaya helped significantly to improve the process in the operations and working conditions, safety, control, time reduction, and comfort for the worker, achieving a better management in the work area. The working conditions in the mechanical workshop will be evaluated. Data will be collected during 3 weeks and then the proposal for the design of ergonomic conditions will be presented.

2. OBJECTIVE

To design ergonomic conditions in a mechanic's workplace according to the anatomical characteristics of the worker in order to improve work productivity.

3. DELIMITATION

The analysis is focused on designing ergonomic conditions in the workplace of a mechanic according to the anatomical characteristics of the worker to enhance labour productivity in the municipality of Salvador Alvarado in the state of Sinaloa. Evaluating the postures of the workers in the activities they carry out, with the RULA and Corlett & Bishop method in a working day of 9 hours a day for 6 days a week. This company has 2 operators and 4 different areas: administrative office, pressing and cutting area.

4. METHODOLOGY

1.- Draw up a current diagnosis of the production process of mechanical services. Through the identification of STPS Standards and ergonomic principles.
2.-. To carry out evaluations for the identification of musculoskeletal injuries and cumulative trauma disorders through the Corlett and Bishop's Bodily Discomfort map method (Corlett, 1976) and the Rula Method.
3.- To design the ergonomic and safety conditions in the production process.

5. RESULTS

The ergonomic analysis was carried out in the mechanical service company, the activities are carried out by 2 workers who are men, aged 36 and 45. They work 9 hours a day, 6 days a week.

Figure 1. Workstation where the greatest problems occur

The analysis determines the ergonomic principles that are not complied with at the workstation of operator 1.

Table 1. Ergonomic principles applied to workstation 1

Principles	Remarks
Principle 2: Use the elbow height as a reference.	Working at the wrong height leads to vicious positions and unnecessary strain. Elbow height: Work is carried out at the height of the elbow whether sitting or standing, above or below the elbow the effort is greater. Considering the current situation in the company, which has three work tables with a height of 50, 75 and 90 centimetres, our corrective action is to design these tables at the height of the elbow of the worker, which is 112 centimetres, so that the worker can develop in the best possible way and avoid unnecessary effort.
Principle 4: Find the correct position for each task.	There are very bad habits with respect to some tasks, therefore, on many occasions workers do not look for the correct position to carry out an operation, a very clear example is that on occasions heavy objects are moved, and when they are lifted, they do so incorrectly and the back is subjected to the most pressure. The workshop has a small tool for this task, but it is not commonly used
Principle 6: Minimise fatigue Many times workers overtax their physical capacity by doing activities that can cause muscle damage	In addition, sometimes, due to space constraints in the workshop, workers have to work outside in direct sunlight

Principle 7: Minimise direct pressure.	The workshop has a work belt, which is rarely used, in fact, it is used because they feel a pain in their back. Ideally it should be worn every day to prevent any fractures
Principle 8: Adjustment and change of posture	No matter how much the worker wants to adjust, it is difficult as there is no ergonomic table or stretcher available, which affects the back when carrying out operations under a trolley.
Principle 9: Provide space and access It is of great importance that working space is provided for each element and easy access to whatever is needed.	Therefore, to ensure adequate working space, our corrective action is to make an efficient distribution in which it is proposed that the old iron is stored in drums to prevent them from obstructing the sides of the workshop, as well as moving the engines and transmissions that are in the central part to the storage warehouse, with this we intend to avoid accidents at work and have better space to work comfortably
Principle 12: Improve the organisation of the work If the tool trolley were well organised,	the work would be more efficient as we would save time looking for the tool that is needed. Moreover, this principle is not fulfilled because the distribution of space is not the most appropriate.

Duranig the ergonomic assessment, little use of the STPS legal framework was identified. The Official Mexican Standard NOM-025-STPS-2008. It is not applied because of the lighting conditions, there is insufficient lighting for the minuscule work carried out at the workstation.

The Official Mexican Standard NOM-011-STPS-2001, Safety and hygiene conditions in workplaces where noise is generated. The workstation does not control the number of decibels used in the process, exposing the worker to decibels above 90 decibels during the workday. The Official Mexican Standard NOM-001-STPS-2008 does not have a specific distribution for the processes carried out in the workshop. The official Mexican standard NOM-015-STPS-2001 sets out the appropriate conditions for exposure to temperatures. In the workshop they are exposed to 42 to 48 degrees, generating an unsatisfactory thermal environment, causing fatigue and mental exhaustion.

Figure 2. Unsuitable posture 1 for analysis under the Rula and Corlett and Bishop method

5.1. Application of the RULA Method in station 1.

Figure 3. Unsuitable posture 2 for analysis under the Rula and Corlett and Bishop method

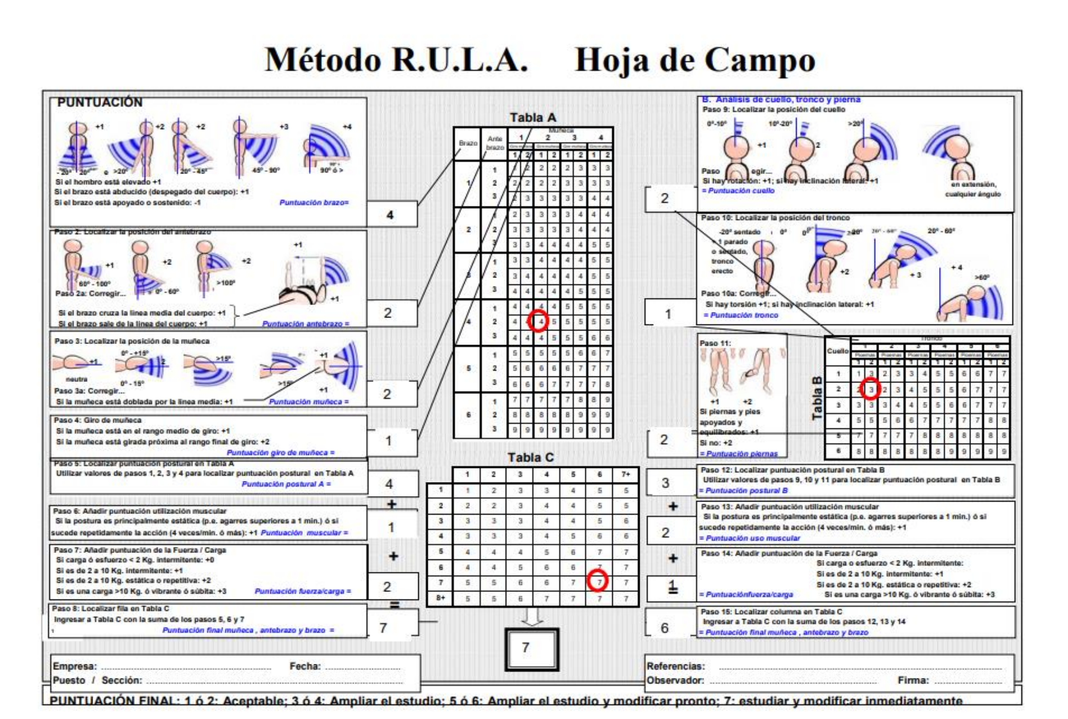


Figure 4. Application of the RULA Method in workstation 1.

As a result of the application of the RULA Method, the value 7 is recorded, which specifies that it is Study and modify immediately.

5.2. Application of the Corlett and Bishop Method in the inadequate posture of the worker.

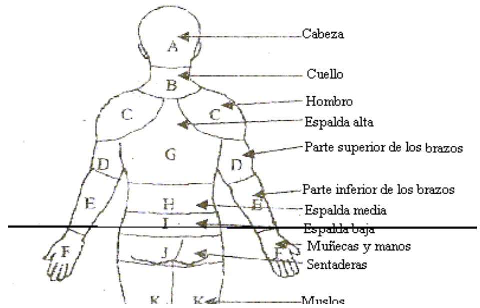
Corlett and Bishop Body Discomfort Map Method, (Corlett, 1976).

This method can be used to detect body discomfort. The method was applied 3 days in the morning at the beginning and at the end of the day. An operator fatigue questionnaire was also carried out. The main areas of discomfort at the beginning of the day were the head, neck, shoulders, middle and lower back. There is pain in the wrists for 3 days from the beginning to the end of the workday.

Marque con una cruz las partes del cuerpo donde sienta alguna molestia o dolor y numérelas en orden ascendente según su grado de molestia o dolor

M=Molestia
D=Dolor

(Corlett & Bishop, 1976)



	ENTRADA							SALIDA						
A		M	M											
B		M							M					
C									M					
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O									M					

Figure 5. Application of the Corlett and Bishop method

6. CONCLUSIONS / DISCUSSIONS

The ergonomic analysis allowed identifying the risk factors in the mechanic workshop workstation. The operator performs the work at an incorrect height because the work tables are out of the elbow height which is 112 centimeters, as well as changing the posture of blades to perform the operations.

The Rapid Upper Extremity Assessment (RULA) and the ergonomic principles helped to have a better perspective of the ergonomic risk levels that affect the health of the operator in station 1.

The most feasible solution would be to insert an anti-fatigue mat in the work area, seeking to reduce operator fatigue, as well as suggesting that the workbench be placed on a work table to climb and be within reach.

The benefits provided by the improvement of the workstation for the worker are very significant in comparison with the design and structure that was previously considered, since in this way it is avoided that the operator has an inclined posture, work in an uncomfortable way, or present some type of accumulated fatigue, which can cause injuries. With this modification, the operator's quality of life and productivity would increase, since the worker would be located in a more comfortable station, which makes the operator a more productive worker, which is basically what is sought after in any company.

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EVALUATION OF ERGONOMIC RISK FACTORS IN WORKERS OF A TORTILLERIA

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Resumen Es muy importante que el trabajador sea capaz de reconocer los riesgos ergonómicos existentes en su puesto de trabajo para poder llevar a cabo acciones para prevenirlos. Para lo cual en el presente trabajo se acudió a un establecimiento comercial dedicado a la elaboración de la tortilla, que es un alimento prioritario en la alimentación de los mexicanos, lo anterior con el fin de evaluar las condiciones de trabajo en la que se encuentra utilizando métodos ergonómicos y realizar basándose en los resultados del análisis y de acuerdo con los lineamientos ergonómicos las recomendaciones pertinentes para mejorar el ambiente laboral y eliminar lesiones musculoesqueléticas en trabajadores.

Palabras clave: Ergonomía, REBA, BRIEF, LEST, OWAS

Relevancia para la ergonomía: Este proyecto provee información que contribuye al bienestar de los trabajadores buscando detectar y evitar posturas y cargas que fácilmente puedes provocar lesiones musculoesqueléticas lo cual lleve a que la organización mejore su ambiente laboral, disminuye la rotación de personal y aumente la productividad, todos objetivos relacionados con la ergonomía.

Abstract: Organizations and workers must recognize the ergonomic risks in their workplace to carry out actions to prevent them. In the present work, we went to a commercial establishment dedicated to tortillas elaboration, which is a priority food in Mexicans' diet, the above to evaluate the working conditions using ergonomic methods: LCE (Ergonomic Checklist), LEST (Global Job Evaluation), REBA (Rapid Entire Body Assessment), BRIEF (Basic Risk Identification of Ergonomic Factors) and OWAS (Ovako Working Analysis System), Based on the results of the analysis and by ergonomic guidelines, the pertinent recommendations were given to improve the work environment and eliminate musculoskeletal injuries risks in workers**.**

Keywords. Ergonomics, REBA, BRIEF, LEST, OWAS

Relevance to Ergonomics: This study provides information that contributes to the workers' wellness by avoiding postures and loads that can easily provoke musculoskeletal injuries, which leads the organization to improve the work environment, decrease worker rotation and increase productivity, all these objectives being related to ergonomics.

1. INTRODUCTION

The main objective of ergonomics is to ensure that the working environment is in harmony with the activities carried out by the worker. This goal is valid in itself, but its achievement is not easy for many reasons. The human operator is flexible and adaptable and learns continuously, but the individual differences can be substantial. Some differences, such as those in physical constitution and strength, are evident, but others, such as cultural, style, or skill differences, are more difficult to identify.

Ergonomics can propose different solutions to reduce or eliminate the harmful effects of these risks on the worker. Many of these solutions are simple and easy to apply; others can be more complex. It is, therefore, essential to consider ergonomic criteria from the initial design stages of machines, tools, and working environments (Escalante & Guaita, 2022).

In any case, Ergonomics can help improve working conditions and, as a consequence, the state of worker's health: ergonomic improvements reduce the physical demands of work, resulting in fewer work-related injuries or ailments, which, in turn, translates into increased efficiency and productivity (Adaramola & Ugbebor, 2014; Sohrabi & Babamiri, 2021; Anusha Chintada & Umasankar, 2022).

The economic activity represented by the tortilla industry is significant at the national level because of the cultural aspect since this food is considered the primary element in the Mexican diet. From the point of view of competitiveness, Aguilar (2020) established that the tortilla sector has aspects to strengthen and generate competitive advantages; He also indicated that the MSMEs manufacturing tortillas in their native Baja California are moderately competitive with a crucial downward trend.

That is why It has been sought, through different efforts, to improve the activity of the elaboration of tortillas. Such is the case of Araiza (2015), which proposes the design of a compact tortilla machine with rotating comals with a vertical axis. The cooking of the tortilla is carried out in three stages, employing a gas flow limiter, the temperature of the flame in each one is controlled, and the control of cooking time using the rotational speed of the central axis; varying the parameters depending on the thickness of the tortilla and the type of flour used.

Nevertheless, to improve productivity, organizations and workers must recognize the ergonomic risks existing in the workplace and carry out actions to prevent them (Ruiz et al., 2022). In the present work, we went to a tortilleria to evaluate the actual working conditions. Based on the analysis results and following the ergonomic guidelines proposed to the business, the pertinent recommendations are to improve the work environment and eliminate risks of musculoskeletal injuries in workers.

2. DELIMITATION

Tortillería “La Gorda” is a company dedicated to elaborating and commercializing Corn Tortillas, Nixtamal Grinding, among other derivatives. This investigation is limited to this establishment.

3. OBJECTIVE

The objective of this project is to consider the commercial establishment called "Tortillería La Gorda" (Figure 1) to perform a detailed ergonomic analysis using the methodologies LCE (Ergonomic Checklist), LEST (Global Evaluation of the Workplace), REBA (Rapid Entire Body Assessment), BRIEF (Basic Risk Identification of Ergonomic Factors) and OWAS (Ovako Working Analysis System), seeking to determine the current working conditions, seeking to present the organization with proposals for improvements following the ergonomic guidelines to optimize the safety and comfort conditions of your workers.

Figure 1. Establishment exterior

4. METHODOLOGY

To carry out this ergonomic improvement project, the work area in which the analysis is focused is first delimited, in this case, the production area.

Subsequently, observations must be made of the tasks carried out by the operator, mainly the postures they adopt and the loads they handle when performing their duties, obtaining videos of the different activities. The relevant environmental measurements are carried out using appropriate equipment (Temperature, Humidity, Sound Level, etc.).
For example, figures 1a to 1c show the posture workers adapt when filling the masa maker equipment.

Figure 2a. Filling the masa’s blender step 1

Figure 2b. Filling the masa’s blender step 2

Figure 2c. Filling the masa's blender final steps

5. RESULTS

The establishment consists of a rectangular shape divided into three sections, the entrance area where it is located, the reception, and different counters with the sales products. Section 2 is the production area, where you can see the entire process of making corn tortillas, among other products. Finally, the third section is the warehouse where the sacks of flour and tools used in the establishment, among other things, are located. It should be noted that each operator works as a team with the others, so their work areas vary considerably.

In the front of the business is the reception, in the central and back are the tortilla machines and on the left are the dough revolver and the nixtamal machine, next to a small laundry room. Figure 3 shows a plant layout diagram to exemplify the above better.

The LCE comprises 128 items related to the workplace; when carrying out the analysis, seventy actions are proposed, of which seventeen are considered urgent and none very urgent. Most of the improvements (eleven) correspond to the area of handling and storage of materials since it is in this area where nixtamal bags of 20 kilos or more are handled.

The Risk factor obtained with the BRIEF method was 28, which places the workstation in a medium priority classification. Concerning de REBA method, the risk factor obtained was 12 (Figure 3), which corresponds to an actuation level of 4 which means that immediate changes are required to prevent musculoskeletal injuries in the workers. Results obtained with the OWAS (risk factor 3) confirm the requirement for immediate corrective action.

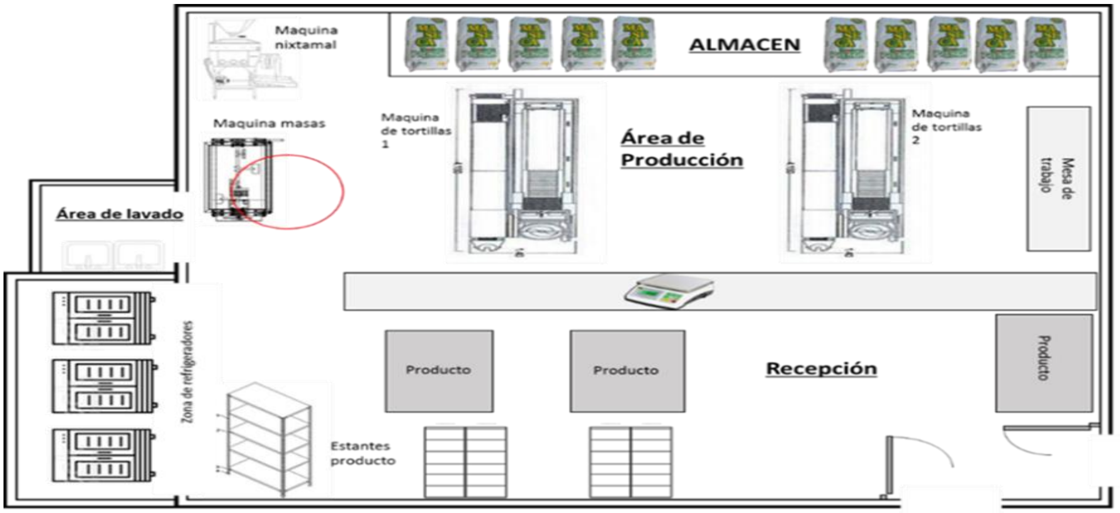
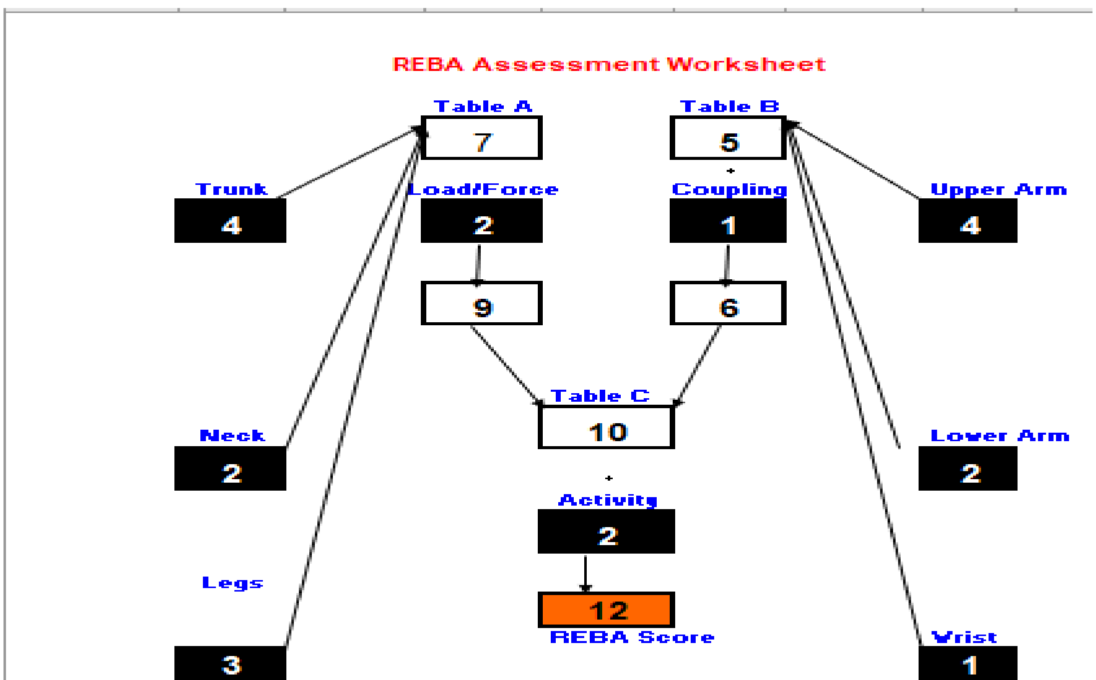


Figure 3. Business layout.



REBA Score	Risk Level	Action
1	Negligable	None necessary
2-3	Low	May be necessary
4-7	Medium	Necessary
8-10	High	Necessary soon
11-15	Very High	Necessary now

Figure 4. REBA results

The LEST methodology returned results in its five dimensions, as shown in the following figure 5

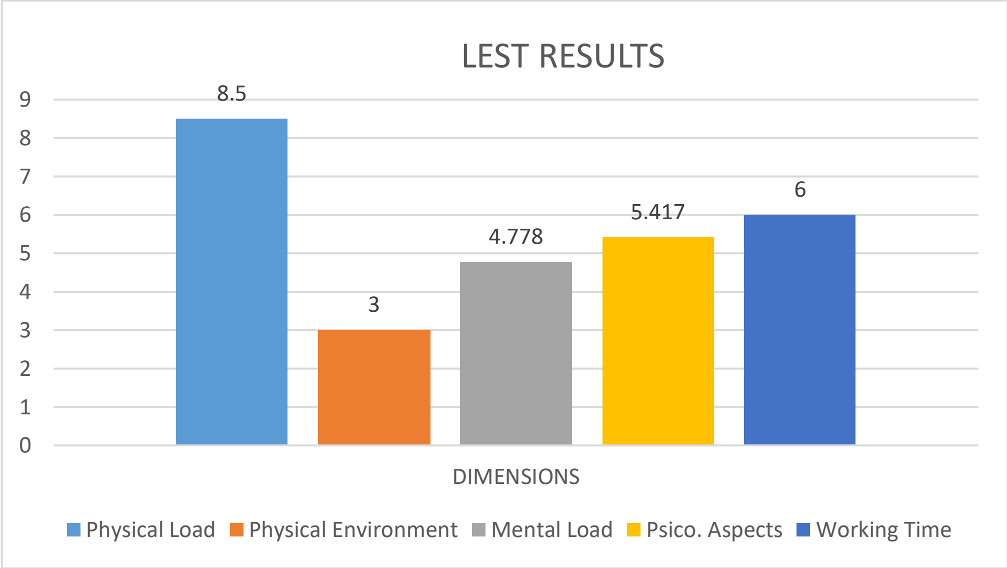


Figure 5. LEST results

6. DISCUSSION/CONCLUSIONS

The following recommendations were made, and most of them were implemented immediately:

- Use of postural girdle: This recommendation is aimed at ensuring that the load and risk of back injuries by the operator are significantly lower since, by making such loads continuously, the operator is being exposed to possible back injuries that could easily be mitigated with the use of a postural girdle, the latest based on Cholewicki et al. (1999) that states tan a raised Intra-abdominal pressure (IAP) and wearing a postural girdle can each independently, or combined, increase lumber spine stability, but the use of the postural girdle should be with caution in the context of the decreased activation of a few trunk extensor muscles.
- Adaptation of the dough mixer height: Being able to adapt the revolver to a lower altitude would be of great help to reduce the load on the shoulders of the operator when placing the flour in the hopper, which in turn would reduce the risk of excessive physical fatigue and possible injuries.
- Keep the loads attached to the body at the time of unloading: At the time of unloading, the operator uses the force of his arms to pour the flour into the revolver, this directly affects the load received by the shoulders during unloading, so it would be advisable to keep the load attached to the body to reduce the burden on the shoulders.
- Avoid lifting at ground level: Lifting at ground level is an unnecessary risk for the operator that could cause excessive physical fatigue in the operator, and that could be avoidable when implementing hydraulic tables

with height adjustment or worktables for heavy loads that have a height more significant than the height of the operator's hip

- Alternate the operator's tasks with lighter tasks: The continuous and prolonged lifting of heavy loads entails a significant load for the operator, so to reduce this physical load it w, it would be an excellent option to alternate them with other lighter tasks.
- Use of anti-skid mats: To load heavy materials and avoid possible slips and falls, it would be advisable to use some anti-skid material on the floors.

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FOOD WORKSHOP TASKS IMPROVEMENT THROUGH ERGONOMIC EVALUATION AND PROTOTYPE DESIGN

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Resumen: El trabajo desarrollado durante las actividades realizadas en elaboración de alimentos dentro del taller de Ingeniería de la Industria Alimentaria está en constante crecimiento y con ello surge la necesidad de evaluar cada una de las condiciones en las que se realizan las prácticas, así como el desarrollo de actividades, para verificar la seguridad y salud de los usuarios (alumnos y personal docente).

Diferentes métodos observacionales ayudan a evaluar los riesgos debidos a la carga postural. La Evaluación Rápida de todo el Cuerpo (REBA) es el método que permite el análisis de posturas adoptadas por los miembros superiores e inferiores del cuerpo, siendo sensibles a actividades que soportan cambios bruscos de postura, comúnmente debido a las maniobras de cargas vacilantes o impredecibles.

A partir del análisis ergonómico se propone un prototipo para reducir la carga relacionada con el transporte de algunos equipos de cocina y también para reducir las posturas que pueden conducir a lesiones musculoesqueléticas.

Palabras clave: REBA, Talleres de Industrias Alimentarias, Evaluación ergonómica de puesto de trabajo

Relevancia para la ergonomía: Los laboratorios en instalaciones educativas son sistemas hombre-máquina en los que se dan procesos educativos que implican la manipulación de equipos y herramientas por parte de personas de diversas medidas antropométricas, sin embargo, el aspecto ergonómico es muy raramente considerado en su diseño y distribución, y esto puede afectar la reducción de molestias y cargas musculoesqueléticas, así como la comodidad de profesores y estudiantes.

Abstract: The work developed during the activities carried out in food processing inside the Food Industry Engineering workshop is constantly growing and with this arises the need to evaluate each of the conditions in which the practices are carried out, as well as the development of activities, to verify the safety and health of users (students and teaching personnel).

Different observational methods help assess risks due to postural load. REBA (Rapid Entire Body Assessment) is the method that allows the analysis of postures adopted by the upper and lower limbs of the body, being sensitive to activities that support sudden changes in posture, commonly due to the maneuvering of hesitant or unpredictable loads.

Based on the ergonomic analysis, a prototype is proposed to reduce the load related to carrying some kitchen equipment and reduce postures that can lead to musculoskeletal injuries.

Keywords. Ergonomic workplace analysis, REBA, Food Industry Workshops

Relevance to Ergonomics: Laboratories in educational facilities are human-machine systems in which educational processes involve manipulating equipment and tools by people of various anthropometric measures. However, the ergonomic aspect is rarely considered in their design and distribution, which can affect the reduction of musculoskeletal discomfort and loads and the comfort of teachers and students.

1. INTRODUCTION

The food processing activities within the Food Industry Engineering workshop are constantly growing. With this, the need to evaluate each of the conditions in which the practices are carried out becomes more apparent (Ruiz et al., 2022), as well as the development of activities to verify the safety and health of users (students and teaching personnel) (Peña & Espinoza, 2017). As mentioned by Ariyanto et al. (2021), “manual load handling in the food industry is unavoidable, and it is associated with musculoskeletal disorders (MSDS) (Rodriguez et al., 2022; Coral, 2020). The severity caused by MSDs can significantly reduce employees’ work productivity. Sohrabi & Babamiri (2021) also mention the close relationship between ergonomics and productivity.

Ergonomics allows adapting the relationship of the human being with his environment, to anticipate any possible risk, promoting physical, mental, and social well-being; despite the importance of food industry workers, the awareness of ergonomics in this sector is relatively poor at present (Rai et al., 2012).

Correcting bad postures in the human being is necessary, identifying, eliminating, or reducing different possible risks of occurrence and negative impacts on health (Albarracin et al., 2018; Anusha Chintada & Umasankar, 2022).

Corrective measures are carried out through engineering modifications, readjustments of routines, and procedures, workplace adjustment, work management, and improved occupational health services and work methods (Ariyanto et al., 2021; Escalante & Guaita, 2022). One of the risk factors most commonly associated with musculoskeletal pathologies is an excessive postural or static load, hence the importance of applying fundamental measures that favor the reduction of these factors.

Different observational methods help assess risks occurring due to postural load. REBA (Rapid Entire Body Assessment) is the method that allows the analysis of postures adopted by the upper and lower limbs of the body, being sensitive to activities that support sudden changes in posture, commonly due to the maneuvering of hesitant or unpredictable loads as happens in the food industry, necessary to mention that is a method frequently used in the food industry to do ergonomic posture assessment (Mahmood et al., 2019).

Based on the ergonomic analysis, a prototype is proposed to reduce the load related to carrying some kitchen equipment and reduce postures that can lead to musculoskeletal injuries.

2. OBJECTIVE

Improvement of work postures in the use of equipment and utensils in the food workshop, based on the results obtained via an ergonomic analysis using the REBA method and a prototype design.

3. DELIMITATION

This research was carried out at a food workshop of the Instituto Tecnológico de Cd. Cuauhtémoc, carrying out a postural risk analysis to the handlers of the workplace, delimiting this evaluation to the processing of fruits, using the apple pulp processing line, which will allow reduction of musculoskeletal injuries triggered by inadequate postures during the development of this process.

4. METHODOLOGY

To carry out the research, the following steps were necessary:

- 1st. Direct observation of the human-machine system in the Institute's food workshop. We observe equipment, tools, work times, dimensions, and spaces.
- 2nd. The decision to do an ergonomic analysis to find musculoskeletal risks about loads in lifting equipment and utensils in the work area.
- 3rd. Videos, photographs, and dimensions of the tasks and equipment related to the workplace were taken

4th. Identification of the type of postural ergonomic risk using the REBA method, which uses a diagram of body posture, including angles of body parts such as arms, wrist, neck, trunk, and legs.
5th. Proposal to implement changes to improve the posture(s) and decrease loads.
6th. Evaluate the change's effectiveness.

5. RESULTS

A careful observation of the area corresponding to the food workshop was carried out, where it can be observed that in the activities where the use of equipment and tools is carried out in the processing of fruits and vegetables, many actions put postural risk to the operators. Also, it can be observed that most of the professors and students who use this workshop are female.

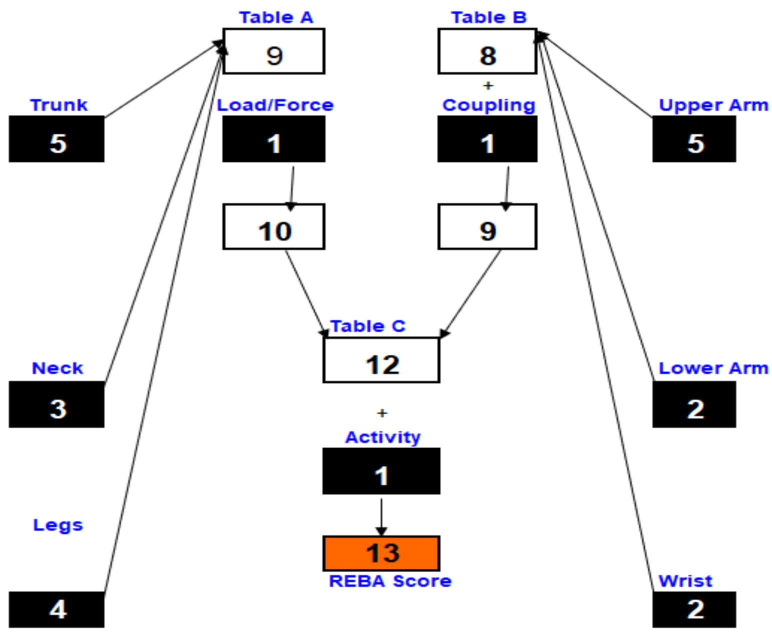
Figure one shows the posture that a person adopts emptying the fruit in the industrial kettle; essential to mention that previously this pot full of fruit with a weight greater than fifteen kilos had to be transferred from the sanitization sinks that were at a distance of four meters manually, by two people. Later the pot is raised from the floor to the appropriate height (1.10 meters) to be empty.

Figure 1. Posture loading fruit in the industrial kettle.

After the fruit is processed in the blender, it is unloaded into the ground-level pot. This is transported to a pulping machine managed by two people; the machine is located 3 meters away from the blender. In figure two, you can see the positions adopted when the fruit is deposited in the pulper.

Figure 2. Posture loading fruit in the industrial kettle.

After this evaluation, the type of postural ergonomic risk is identified using the REBA method. After analyzing the different combinations, a final score of 13 is obtained, which is interpreted according to the method as a very high risk (Figure 3). This result suggests that strategies for implementing the necessary changes in these activities must be carried out.



REBA Score	Risk Level	Action
1	Negligable	None necessary
2-3	Low	May be necessary
4-7	Medium	Necessary
8-10	High	Necessary soon
11-15	Very High	Necessary now

Figure 3. REBA results

As can be seen, after analyzing the postures of the food workshop operators, it can be identified that the working conditions are not ideal for carrying out these activities, requiring immediate intervention due to the sizeable ergonomic impact caused by the level of risk. Likewise, it is apparent there is a need to implement preventive strategies and measures that contribute to the mitigation of the possible consequences that can occur due to inadequate postures when performing activities where injuries to muscles, tendons, and joints are involved, among other parts of the body; Which is why a prototype cart is designed (Figure 4) that allows the handling of pots and various instruments, without compromising the body in loading materials or their weight, a situation which would force verification of the improvement actions.

Figure 4. Prototype

Some tests were done using an adjustable bench to determine the height, dimensions, and characteristics the prototype should have (Figure 5), resulting in the dimensions shown in figure 6.

Figure 5. Test to determine prototype ideal height

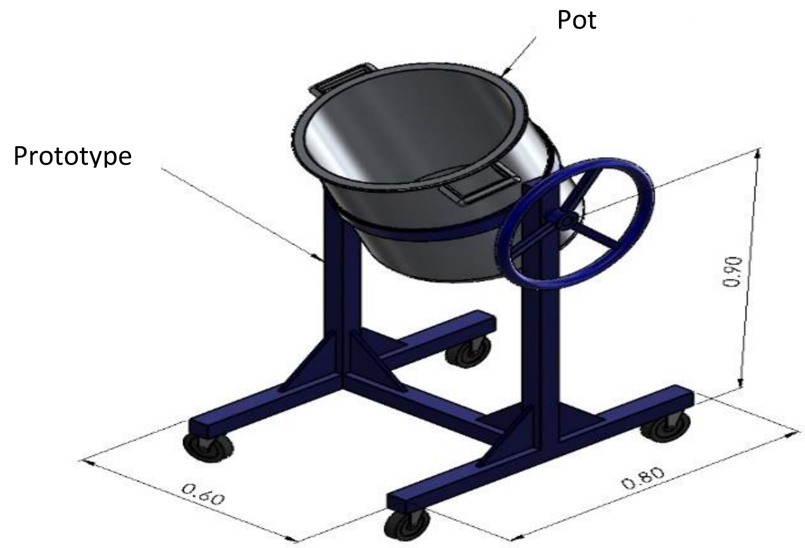


Figure 6. Prototype final dimensions.

The proposed design implementation results are reflected in Figure 7, where a significant improvement can be observed in the category of the score obtained, which leads us to high risk. However, with slight modifications in this process, it would already be classified as medium risk.

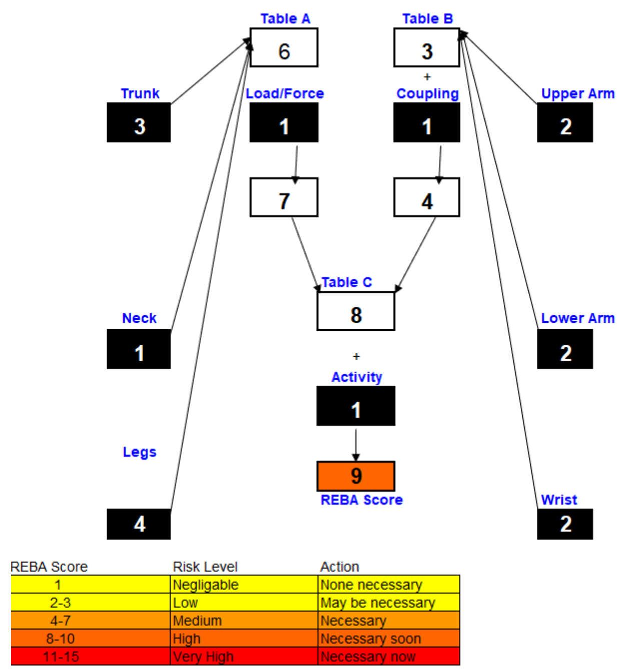


Figure 7. REBA analysis after using the prototype

6. DISCUSSION/CONCLUSIONS

Based on the support prototype designed to implement changes that would help reduce the risk after inadequate work postures were detected in the food production process, it is possible to identify the reduction of the risk indicator from very high to high in the REBA analyses performed before and after implementation of the support prototype, with the possibility of implementing more changes that favor the gradual reduction of postural risk.

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WORKSTATION EVALUATION FOR THE REDESIGN OF THE SHRIMP DEVEINING AREA IN AN AQUACULTURE COMPANY.

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Resumen: En el presente trabajo se realizó un estudio donde se analizaron e identificaron los factores de riesgo que se presentan en la actividad manual de descabece de camarón en una empresa acuícola comercializadora de camarón. Para realizar este estudio se visualizó minuciosamente la serie de movimientos que realiza el trabajador para descabezar el camarón y se evaluó la postura que supone una mayor carga postural. Posteriormente se seleccionó la postura a evaluar, la cual consiste en tomar con sus dos manos la mayor cantidad de camarones posible y posteriormente ir descabezando uno a uno aplicando fuerza con su dedo pulgar en la cabeza del camarón logrando así que esta se desprenda, enseguida se seleccionaron los métodos para su evaluación (RULA, ART Tool) el método RULA permite evaluar la exposición de los trabajadores a riesgos debidos al mantenimiento de posturas inadecuadas que pueden ocasionar trastornos en los miembros superiores del cuerpo, por otra parte el método ART Tool es una herramienta de evaluación de tareas repetitivas (ART) está diseñada para ayudarlo a evaluar el riesgo de tareas que requieren movimientos repetitivos de las extremidades superiores (brazos y manos).

Los resultados obtenidos del método RULA nos indicaron que existe un nivel de riesgo alto para el trabajador que ejerce la tarea de descabece de camarón, por lo que se requiere un rediseño del área, posteriormente los resultados del método ART Tool se obtuvo una exposición de más de 22 puntos el nivel es alto, se recomendó aplicar el método en otros trabajadores que compartan características con este trabajador para hacer una comparativa de la exposición a la que se encuentran. Con base a los resultados obtenidos en ambos métodos se identificó que el trabajador presenta mayor nivel de riesgo y carga postural en el cuello, brazos y manos, por lo que se recomendó a la empresa un rediseño de la estación de trabajo, el cual consiste en añadir herramientas que ayuden a mejorar la postura y disminuyan los futuros daños por una mala postura.

Palabras clave. Ergonomía, descornado, acuicultura, RULA, ART Tool, FRE

Relevancia para la Ergonomía: Busca contribuir al bienestar de los trabajadores mejorando su calidad de vida, reduciendo posibles lesiones ocasionadas por un mal diseño del lugar de trabajo

Abstract (Spanish/English, this order): In the present work, a study was carried out to analyze and identify the risk factors that occur in the manual activity of shrimp beheading in an aquaculture company that sells shrimp. In order to carry out this study, the series of movements performed by the worker to de-head the shrimp was visualized in detail and the posture that represents the greatest postural load was evaluated. Subsequently, the posture to be evaluated was selected, which consists of taking as many shrimp as possible with both hands and then removing the head one by one by applying force with the thumb on the head of the shrimp, thus making it detach, and then the methods for evaluation were selected (RULA, The RULA method evaluates the exposure of workers to risks due to improper postures that can cause disorders in the upper limbs. The ART Tool is a repetitive task evaluation tool (ART) designed to help evaluate the risk of tasks that require repetitive movements of the upper limbs (arms and hands).

The results obtained from the RULA method indicated that there is a high level of risk for the worker who performs the task of shrimp deveining, so a redesign of the area is required, then the results of the ART Tool method showed an exposure of more than 22 points, the level is high, it was recommended to apply the method in other workers who share characteristics with this worker to make a comparison of the exposure to which they are exposed. Based on the results obtained in both methods, it was identified that the worker has a higher level of risk and postural load in the neck, arms and hands, so it was recommended to the company to redesign the workstation, which consists of adding tools to help improve posture and reduce future damage due to poor posture.

Keywords. Ergonomics, dehorning, aquaculture, RULA, ART Tool, FRE

Relevance to Ergonomics: Seeks to contribute to the well-being of workers by improving their quality of life, reducing possible injuries caused by poor workplace design.

1. INTRODUCTION

Ergonomic risks are those that can lead to musculoskeletal disorders (MSDs) in the working person and derive from forced postures, continuous application of forces, repetitive movements and manual handling of loads in the workplace.
Although the possibilities of suffering injuries at work are many, nowadays existing tasks are evaluated and improved with specific procedures, nowadays, ergonomic risk factors, such as poor posture and repetitive movements, are taken into account more seriously in the evaluations.

Currently, according to the International Labor Organization, more than 160 million people worldwide suffer from non-fatal diseases every year (ILO, 2002).
Depending on what aspects or risk factors have been determined to require a risk assessment, a number of specific techniques and methodologies should be employed. However, a procedure oriented to an ergonomic study can be used,

taking into account all the dimensions to be considered: task, worker and working conditions.

The following is a study that analyzed and identified the risk factors that occur in the manual activity of shrimp deveining in an aquaculture company that sells shrimp, implementing two ergonomic methods (RULA and ART Tool) that allowed studying the postures and conditioning of the deveining area in the company, in order to analyze whether workers are performing their activities incorrectly, which could be affecting their health. After the evaluation, a redesign of the area was proposed to reduce or eliminate these risks.

Objectives: To evaluate the workstation in the descabece area using the RULA and ART Tool ergonomic methods, to analyze the activities with the greatest ergonomic impact, to propose a redesign of the area according to the results obtained based on the method.

1.1 Evaluation of Musculoskeletal Disorders

According to (EU-OSHA, 2020), work-related MSDs mainly affect the back, neck, shoulders and extremities - both upper and lower - and include any damage or disorder of joints or other tissues. Health problems range from mild aches and pains to more serious conditions requiring sick leave or medical treatment. In chronic cases, these disorders can lead to disability and prevent the affected person from continuing to work. The (World Health Organization, 2021) defines the scope of musculoskeletal disorders as comprising more than 150 disorders affecting the locomotor system. They range from sudden, short-term disorders, such as fractures, sprains and strains, to chronic diseases that cause limitations of functional abilities and permanent disability.

1.1.1 RULA - Rapid Upper Limb Assessment Method

The RULA method was developed in 1993 by McAtamney and Corlett of the University of Nottingham (Institute for Occupational Ergonomics), with the aim of assessing the exposure of workers to risk factors that cause a high postural load and can lead to upper limb disorders. For risk assessment, the method considers the posture adopted, the duration and frequency of this posture and the forces exerted when it is maintained. The RULA method evaluates individual postures and not sets or sequences of postures; therefore, it is necessary to select those postures that will be evaluated from among those adopted by the worker in the position. Those that, a priori, involve a greater postural load due to their duration, frequency or because they present a greater deviation from the neutral position will be selected. (Diego-Mas, 2015).

1.1.2 ART Tool Method - Assessment of Repetitive Tasks (ART)

The Assessment of Repetitive Tasks (ART) tool is designed to help assess the risk of tasks that require repetitive movements of the upper extremities (arms and hands). It helps to assess some of the common risk factors in repetitive work that contribute to the development of upper extremity disorders (ULD). The ART tool is intended for individuals with responsibility for the design, evaluation, management and inspection of repetitive work.

Repetitive tasks are typically found in assembly, production, processing, packaging, packing, packing and sorting work, as well as work involving the regular use of hand tools (Health and Safety Executive, 2021).

2. METHODOLOGY

In order to carry out this study, the risk factors that occur in the manual activity of shrimp de-scaling in an aquaculture company were identified, thanks to this analysis, it was determined that it was necessary to apply two ergonomic methods to evaluate postures, so it was decided to apply the RULA Method (Rapid Upper Limb Assessment) in order to evaluate the exposure of workers to risk factors in which the Action Level is determined to indicate whether the posture is acceptable or to what extent changes or redesigns are necessary in the work area, Subsequently, the ART Tool Method was applied to complement and reaffirm the results obtained in the RULA method, since this method is based on assessing the risk of tasks that require repetitive movements of the upper extremities, this tool uses a numerical score and a traffic light approach to indicate the risk level of twelve factors. These factors are grouped into four stages: A: Frequency and repetition of movements, B: Strength, C: Awkward postures of the neck, back, arm, wrist and hand, D: Additional factors, including breaks and duration and presented in a flow chart that leads you, step by step, to assess and rate the degree of risk.

2.1 Application of the RULA Method

1. To begin with the application of the method, it was necessary to perform a thorough visual analysis of the series of movements performed by the worker to de-head the shrimp and evaluate the posture that entails the greatest postural load.

2. The posture to be evaluated was selected, which consists of taking as many shrimp as possible with both hands and then removing the head one by one, applying force with the thumb on the shrimp's head, thus causing it to fall off. Once the video images were observed, it was decided that the posture to be evaluated would be the one on the left side of the worker, as shown in the following image, since a priori it is considered that it involves a significant postural load (see Figure 1).

Figure 1. Posture evaluated

3. Subsequently, the evaluation began using the method, which divides the body into Group A, which includes the upper limbs (arms, forearms and wrists) and Group B, which includes the legs, trunk and neck. Using the tables associated with the method, a score is assigned to each body zone (legs, wrists, arms, trunk) and, based on these scores, global values are assigned to each of the groups A and B.

4. Once the scores for each of the members of Groups A and B have been obtained, the overall scores for each group are calculated.

5.The overall scores for Groups A and B consider the worker's posture and then the static or dynamic nature of the posture and the forces exerted during its adoption must be assessed. The scores for Groups A and B increase according to the type of activity (see Table 1).

Table 1. Scoring by type of activity

Type of activity	Score
Static (maintained for more than one minute at a time)	**+1**
Repetitive (repeated more than 4 times every minute)	**+1**
Occasional, infrequent and of short duration	**0**

6. On the other hand, the above scores will be increased as a function of the forces exerted. Table 2 shows the increase as a function of the load supported or forces exerted.

Table 2. Scoring by load or exerted forces

Load or force	Score
Load less than 2 Kg. maintained intermittently	**0**
Load between 2 and 10 Kg. maintained intermittently	**+1**
Static or repetitive load between 2 and 10 Kg.	**+2**
Load greater than 10 Kg. maintained intermittently	**+2**

Static or repetitive load greater than 10 Kg.	**+3**
Sudden or abrupt shocks or forces are produced.	**+3**

7. The scores of Groups A and B, increased by the scores corresponding to the type of activity and the loads or forces exerted, will be referred to as scores C and D respectively. The scores C and D allow to obtain the final score of the method used. This overall final score for the task will range from 1 to 7, the higher the risk, the higher the score.

8. The scores for each member and group, as well as the strength and muscular activity scores, will indicate to the evaluator the aspects on which to act in order to improve the position. Once the final score has been obtained, the following table (see Table 3) proposes different levels of action to be taken on the job.

Table 3. Levels of action according to the final score obtained

Score	Level	Performance
1 o 2	**1**	Acceptable Risk
3 o 4	**2**	Changes to the task may be required; further study is desirable
5 o 6	**3**	Redesign of the task is required
7	**4**	Urgent changes in the task are required

2.2 Application of the Method ART Tool

1. To start with the application of the ART Tool method, it was necessary to make a table in which general data of both the person to whom the method is applied and the people who apply it are established, the description of the activities developed by the person being analyzed must be shown. The table shows the cycles per station, the time that the worker spends without a break, and the body extremities needed to do the work.

Table 4. Description of the operation

FORMAT DESCRIPTION OF THE OPERATION	
Name of reviewer: BRENDA DELGADO, YLENIA GAXIOLA, DIANA CAMACHO, BRAYAM VILLA	Date: 05/SEPTIEMBRE/2022
Name of the Company: ACUÍCOLA LOS AHUMADA	Plant: CASA BLANCA
Workstation: DESCABECE DE CAMARÓN	Área: DESCABECE
Description of the Activity: The operator takes his bucket and places it in the appropriate place to empty the headless shrimp, proceeds to drag the shrimp from the center of the work table to a position where it is easier to take it, continues taking 3 to 5 shrimp with each hand and applying pressure with his thumb removes the head of each shrimp.	

Weight of materials/tools: 500g	
Upper extremity used: Arm, hand, fingers	
Hand tools used: No	
Production rate (Units per hour, per minute): 5 units per hour	
Cycle time per station (minutes): 11 minutes	
Time between breaks: 4 hours	
Time the worker lasts without an official break (maximum): 4 hours	
Time that the effective working day lasts: 8 hours	
The worker rotates to another workstation: NO	(Yes) For how long (hours/day):
Worker rotates to another workstation:	(Yes) For how long (hours/day):
¿Does the rotation consider muscle groups? N/A	
Include video, photos:	
Does the activity have a history of complaints, disabilities? Complaints of left arm, feet, and neck fatigue	

2. Depending on the method, it must be decided whether to evaluate the left or right side or only the arm that participates the most in the task. In this case both arms were evaluated.
3. The way in which the method is applied is by stages, these are the following:
   - Stage A: Frequency and repetition of movements.
   - Stage B: Strength
   - Stage C: awkward postures
   - Stage D: Additional factors

For each stage it is necessary to follow the flow chart and/or the evaluation guide to determine the risk of each factor.

4. The risk levels can be seen in Table 5.

Table 5. Risk levels

V = GREEN low risk level
A = YELLOW medium risk level-examine the task closely
R = RED high level of risk-immediate action needed

5. The assigned colors will help to identify where to apply measures to achieve risk reduction.

6. In step A: Frequency and repetition of movements. A1: arm movement, only arm movements should be observed to determine the most appropriate category. In A2: Repetitions: This refers to movement of the arm and hand, but not of the fingers, you should observe movements that are repeated in a certain established time.

7. In stage B: Force, to determine the level of force applied by the worker when performing the activity, it is necessary to analyze it using Table 2, as long as the conditions are appropriate, the worker should be consulted to indicate what is present. After establishing the type of force applied in the work, we must know the frequency with which the force is applied in order to know the score. Figure 2 shows the score for the type of force and frequency applied.

	Light	Moderate	Strong	Very strong
Infrequent	G0	A1	R6	Changes required*
Part of the time (15–30%)	G0	A2	R9	Changes required*
About half the time (40–60%)	G0	A4	R12	Changes required*
Almost all the time (80% or more)	G0	R8	Changes required*	Changes required*

Figure 2. Scores for frequency and force applied

8. Stage C: Awkward postures, several factors were analyzed such as: C1: head/neck posture, C2: back posture, C3: arm posture and C4: wrist posture.

In the case of C1, the neck is considered to be bent or twisted as long as an obvious angle between the neck and back is observed.

In the case of C2, only the posture of the back should be observed when performing activities, in this case the back should not make abnormal movements, such as bending, crossing the arms implies a load on the back.

In the case of C3, the posture of the arm is analyzed; it is considered that the arm adopts an uncomfortable posture if the elbow is elevated around chest height and the arm is not supported.

In the case of C4 the posture of the wrist is analyzed, we will consider the time that the wrist is flexed or deviated.

In the case of C5 the hand/finger grip is analyzed, any awkward grip or wide finger grip during the performance of activities should be identified.

9. Stage D: Additional factors, factors such as: D1: breaks, D2: work rhythms and D3: other factors were analyzed.

D4: Duration, is the amount of time a worker spends performing repetitive activities in a day or shift.

The following table was helpful in identifying the results obtained by applying the ART Tool method:

Table 6. Exposure results

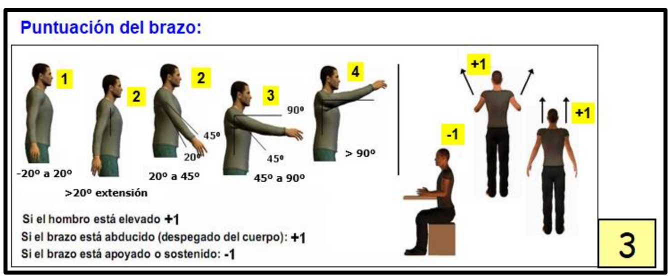
Exposure result		Recommended action
0 - 11	Low	Consider the particular results
11 a 21	Medium	Further research is required
22 o mayor	High	Further research is urgently required

3. RESULTS

The application of each of the methods to the posture selected for evaluation yielded the following results.

3.1 Results RULA Method.

1. Initially, Group A was evaluated, in which the following scores were obtained for each of the parts related to this group (arms, forearms and wrists) according to the posture of the selected worker to be evaluated, in addition to adding the corresponding scores for the type of muscular activity and load/force.



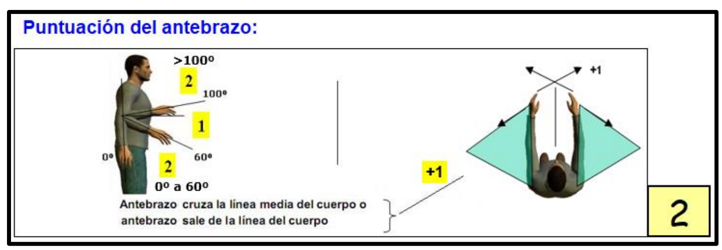


Figure 3. Scoring of the arm

Figure 4. Scoring of the forearm

Figure 5. Wrist scoring and wrist rotation.

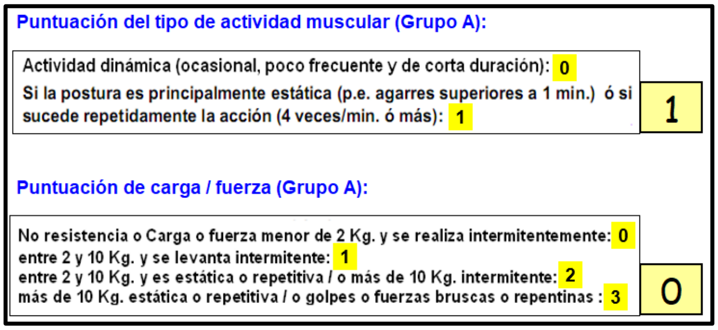


Figure 6. Scores by type of muscle activity and load/force of data Group A

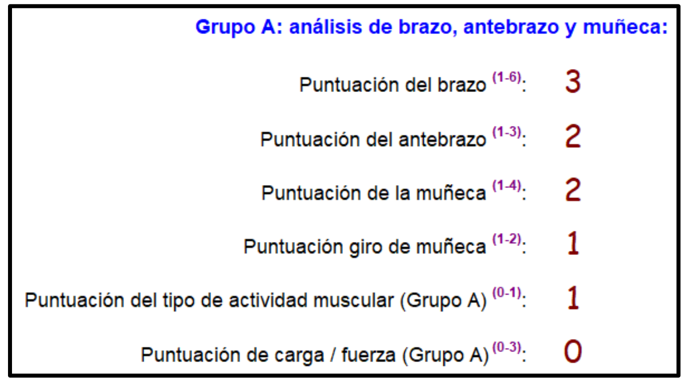


Figure 7. Summary

2. Subsequently, Group B was evaluated, in which the following scores were obtained for each of the parts related to this group (legs, wrists, arms, trunk) according to the posture of the selected worker to be evaluated, in addition to adding the corresponding scores for the type of muscular activity and load/force.

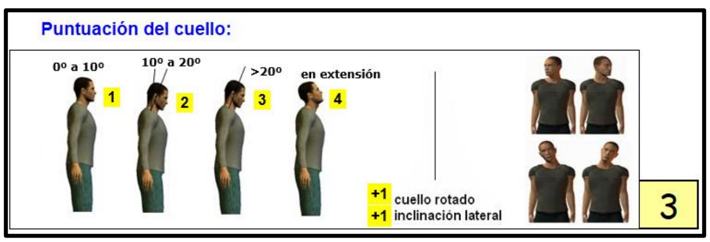


Figure 8. Neck scoring

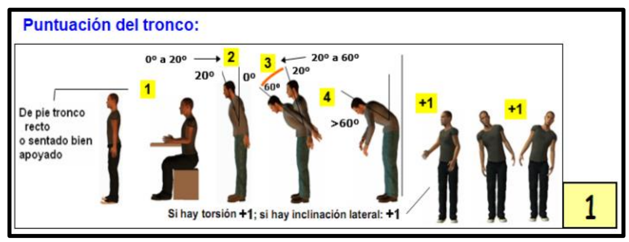


Figure 9. Trunk score

Figure 10. Scoring of legs

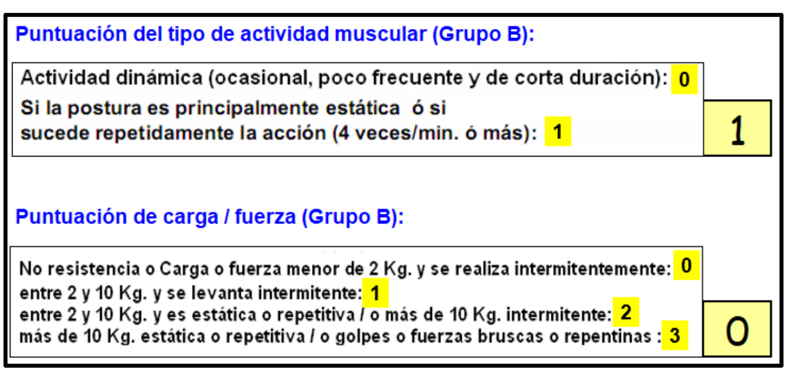
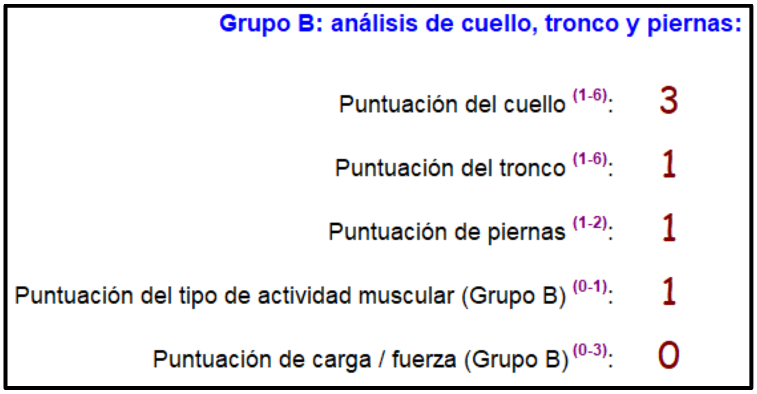


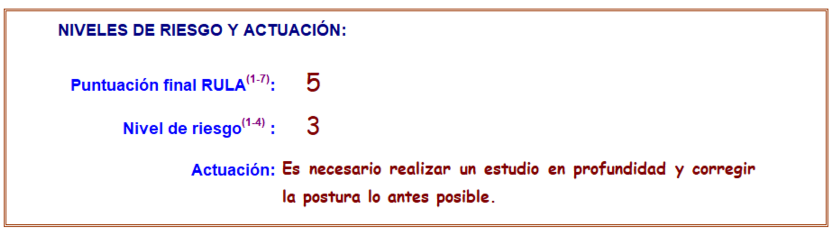
Figure 11. Scores by type of muscle activity and load/strength



Grupo B: análisis de cuello, tronco y piernas:	
Puntuación del cuello (1-6):	3
Puntuación del tronco (1-6):	1
Puntuación de piernas (1-2):	1
Puntuación del tipo de actividad muscular (Grupo B) (0-1):	1
Puntuación de carga / fuerza (Grupo B) (0-3):	0

Figure 12. Summary of data Group B

3. According to the scores obtained from each of the groups, plus the scores by type of activity and force load, a Final Score of the RULA method was obtained by consulting the tables established by this method, indicating the following result:



NIVELES DE RIESGO Y ACTUACIÓN:	
Puntuación final RULA (1-7):	5
Nivel de riesgo (1-4) :	3
Actuación:	Es necesario realizar un estudio en profundidad y corregir la postura lo antes posible.

Figure 13. Risk level according to the RULA method and recommendation for action.

4. The RULA method indicates that there is a high level of risk for the worker who carries out the task of shrimp de-scaling; therefore, a redesign of the area is required.

3.2 Results Method ART Tool.

1. In stage A, the frequency and movements of the hands and arms when performing the activities were analyzed.

A1: In the case of the worker, it was determined that both arms present an A3, which means that she has regular movements with some pauses, but frequently.

A2: The worker was observed in a cycle that lasts to fill a bucket, which takes approximately 10 minutes, in which she made less than 10 movements involving arms and hands, therefore, the result was a G0.

2. In stage B, the strength that the worker needs to perform the work was analyzed.

B: It was observed that the worker applies moderate strength to perform the work, the shrimp does not need the help of a tool to perform the work and it is easy to do it, what was noticed is that she works with a frequency of 80% of the time, for this reason she was given a score of R8, having moderate strength and an activity of 80% or more of the time.

3. In stage C, the postures of the neck, back, arm and wrist were analyzed.

C1: When analyzing the worker at the time of performing her activities, it was observed that the angle between her neck and back is considerably large (see Figure 14).

Figure 14. Position analyzed

The worker bends or turns her neck more than 50% of the time, which is why she was given a score of 2 which represents a red level.

C2: In the case of the worker an almost neutral posture was considered with a score of 0, the greater amount of time she spends doing the work. The activity does not demand movement in terms of crossing arms or leaning forward, sideways or backward.

C3: The worker's elbow always remained close to the body, which is why she was given a score of 0 for both arms.

C4: The worker presents a neutral or straight posture almost all the time, that is why she was given a score of 0.

C5: The task performed by the worker demands more than 50% of the time in the form of pincer grasping, that is why the color was determined to be red with a score of 2.

4. In stage D, additional factors that may affect the worker and her work rhythm were analyzed.

D1: Normally the workday can be divided into two, morning and afternoon, without breaks between activities, the worker on average lasts 3 to 4 hours of continuous work without a break, that is why it was given a score of 6.

D2: Being a job that demands a lot of production, it is complicated for any worker to follow the rhythm of work with which he/she starts, even with that, the worker only sometimes presents difficulties to maintain the rhythm of work, that is why the score is 1.

D3: In this case the worker only presents one factor, therefore the score is 1 point.

D4: The worker has an average duration of between 4 to 8 hours, that is why we will multiply the subtotal x 1.

Table 7 Results of the method ART Tool

MÉTODO ART TOOL				
	LI		LD	
Activity	**Color**	**Value**	**Color**	**Value**
A1 Arm movements		3		3
A2 Repetition of movements		0		0
B1 Strength		8		8
C1 Neck posture		2		2
C2 Back posture		0		0
C3 Arm posture		0		0
C4 Wrist posture		0		0
C5 Hand/finger grip		2		2
D1 Breaks		6		6
D2 Work pace		1		1
D3 Other factors		1		1
Subtotal		23		23
D4 Duration factor		1		1
Exposure level		**23**		**23**

It can be observed how the multiplication of the subtotal by the D4 duration factor is applied, thus obtaining the level of exposure to which the worker is exposed according to the application of the ART Tool method.

D5: It was observed that the factors present in the workstation are the following:

- Monotonous work
- Requires high levels of attention and concentration
- Demanding work demands

Result of the worker's exposure: When obtaining an exposure of more than 22 points, the level is high, so further research should be done, it is recommended to apply the method in other workers who share characteristics with this worker to make a comparison of the exposure to which they are exposed.

3.3 Proposal for improvement

Based on the results obtained in both methods, it was identified that the worker presents a higher level of risk and postural load in the neck, arms and hands, which is why a redesign of the workstation was recommended to the company, which consists of adding tools that help improve posture and reduce future damage due to poor posture.

One of the recommended tools is an armrest on which the worker can lean and which helps the task to be performed at a higher level, thus correcting the inclination of the neck.

Another recommended tool is a step on which the worker can rest one of his feet to improve posture comfort.

Figure 15. Representation of improvement proposal

4. CONCLUSIONES

Applying the RULA method was of great help, since it is a method that allows a direct observation of the task being performed, but also allows to know what the worker thinks and feels at the time of development, which is why the results have a high percentage of accuracy.

To complement the results obtained from the RULA method, the ART Tool method was applied, which helped to identify the repetitive tasks that represent risks of disorders in the upper parts of the body.

Thanks to the application of both methods, a comparison was made in order to find more precisely which repetitive activities represent a greater postural load for the worker. It was determined that the greatest wear and tear occurs in the worker's neck and hands, since the task performed demands a high work rate most of the time during the workday.

Comfort is a very important point when it comes to work rhythm and efficiency, which is why it was recommended to the company to make changes in the workstation to help the worker to be more comfortable and especially to correct the inclination of the neck.

To this end, it was recommended that the workstation be adapted with tools that help improve the worker's posture while performing the task, such as an armrest. It was also suggested that a footrest be added, as shown in Figure 15 in the results section.

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ERGONOMIC ANALYSIS IN PROPLASA USING THE LCE, REBA, LEST, OWAS, AND BRIEF METHODS

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Resumen: Procesos Plásticos de San Antonio (ProPlasa) es una empresa del sector industrial dedicada a la elaboración de productos mediante el uso de materiales reciclados, para producir cubiertas y cajas de plástico hechas principalmente de polietileno, realizadas a través del proceso de inyección. Las quejas de los trabajadores de esta estación de trabajo, relacionadas con molestias principalmente en la espalda, muñecas y tobillos, comenzaron la necesidad de evaluar adecuadamente las diferentes tareas que este operador realiza en la empresa, esto se llevó a cabo a través de los métodos LCE, REBA, OWAS, BRIEF y LEST buscando hacer las propuestas pertinentes a la empresa de acuerdo con pautas ergonómicas que conduzcan a mejorar sus condiciones de trabajo, aumentar la comodidad del trabajador, evitar lesiones y accidentes y obviamente aumentar o mantener la productividad.

Palabras clave: OWAS, BRIEF, REBA, LEST, Evaluación ergonómica de puesto de trabajo

Relevancia para la ergonomía: La adopción continua o repetida de posturas dolorosas durante el trabajo genera fatiga y a la larga, puede provocar trastornos en el sistema musculoesquelético. Esta carga estática o postural es uno de los factores para tener en cuenta en la evaluación de las condiciones de trabajo, y su reducción es una de las medidas fundamentales a adoptar en la mejora de las posiciones. Es por eso por lo que la aplicación de los métodos de evaluación postura cobra relevancia como herramientas de mejora que nos permite estar monitoreando la salud del operador y saber cuándo es arriesgado tenerlos en una posición durante un período prolongado de tiempo.

Abstract: Procesos Plásticos de San Antonio (ProPlasa) is a company in the industrial sector dedicated to the elaboration of products through the use of recycled materials to produce plastic covers and crates mainly made of polyethylene, carried out through the injection process. Complaints from these workstation workers related to discomfort in the lower back, wrist, and ankle began the need to properly evaluate the different tasks that this operator performs in the company; this was carried out through the methods LCE, REBA, OWAS, BRIEF, and LEST seeking to make the pertinent proposals to the company according to ergonomic guidelines that lead to improve its working conditions, increase worker comfort, avoid injuries and accidents and increase or maintain productivity.

Keywords. Ergonomic evaluation, OWAS, BRIEF, REBA, LEST.

Relevance to Ergonomics: Ergonomics is the interaction between humans and other elements of a system. This study provides information that contributes to improving working conditions to carry out redesigns, improvements, and training with an ergonomic approach that ensures the worker's well-being, comfort, and productivity.

1. INTRODUCTION

The ergonomic analysis carried out in companies' workspaces allows to glimpse conditions that perhaps would not "appear" in a simple visual inspection; the interrelation of the operator with his labor factors is increasingly important to raise the company's productivity without forgetting workers' safety and efficiency. Using ergonomic analysis and measuring instruments makes it possible to arrive at an acceptable presumption of the actions envisaged to correct inefficiencies in performing productive tasks within the workplace. Brito et al. (2019) mentioned that "the effective inclusion of Ergonomics in processes and installations has been proven to decrease costs related to disability, extra or overtime hours, medical care and premiums or fine for occurrences" the latest was also justified by Anusha Chintada & Umasankar (2022) mentioning the improvement of productivity in organizations based on implementing ergonomic improvements.

Ergonomic analyses have been enhanced with new methods and tools with a general application or specific for a particular workplace: methods for workplace analysis and workplace risks, methods for effort evaluation, musculoskeletal disorders, muscle fatigue, different types of questionnaires elaborated for specific workstations, checklists, protocols, focus groups and many other (Albu, 2021, Ruiz, et al. 2022) all the mentioned conditions are much time produced by repetitive movements on the tasks that could lead to severe damages to the worker's health (Albarracín, et al. 2018)

Procesos Plásticos de San Antonio (ProPlasa) is a company in the industrial sector dedicated to the elaboration of products through the use of recycled materials, to produce plastic covers and crates mainly made of polyethylene, carried out through the injection process, which is an integral part of the picking, storage, and transportation of apples, the primary region production. The finished products are verified by an operator who stays at this station for an eight-hour shift.

Complaints from these workstation workers related to discomfort in the lower back, wrist, and ankle began the need to properly evaluate the different tasks that this operator performs in the company; this was carried out through the methods LCE, REBA, OWAS, BRIEF, and LEST seeking to make the pertinent proposals to the company according to ergonomic guidelines that lead to improve its working conditions, increase worker comfort, avoid injuries and accidents and increase or maintain productivity (Escalante & Guaita, 2022; Rochat & Hayek, 2022)

2. OBJECTIVE

Perform an analysis of the working conditions in different tasks related to production and final inspection of plastic crates in ProPlasa, through methods such as the Checklist for initial ergonomics risk evaluation (LCE), the Ovako Working Analysis System (OWAS), the Baseline Risk Identification of Ergonomic Factors (BRIEF), the Rapid Entire Body Assessment (REBA), and the Economics Laboratory and Labor Sociology (LEST), and offer recommendations to improve the workplace and physical conditions.

3. DELIMITATION

The ergonomic analysis was done on one worker during four hours of his eight hours shift. Based on this analysis, the existing conditions will be evaluated, and substantial improvements will be proposed to the organization, which will impact the increase in productivity and worker satisfaction for the benefit of him and the company itself.

4. METHODOLOGY

Regarding the methodology used, it consists of four phases:

1st. The company is approached, and a video is made of the entire eight hours work shift, including the different activities of the worker assigned to the total production of the plastic crate (including final quality inspection and storage in the final product warehouse). Also, measurement of the different environmental conditions at various times is made. Likewise, the interaction between the worker of this station and others is noted. Following are some photos with different postures related to tasks.

Figure 1. Production process initial phase

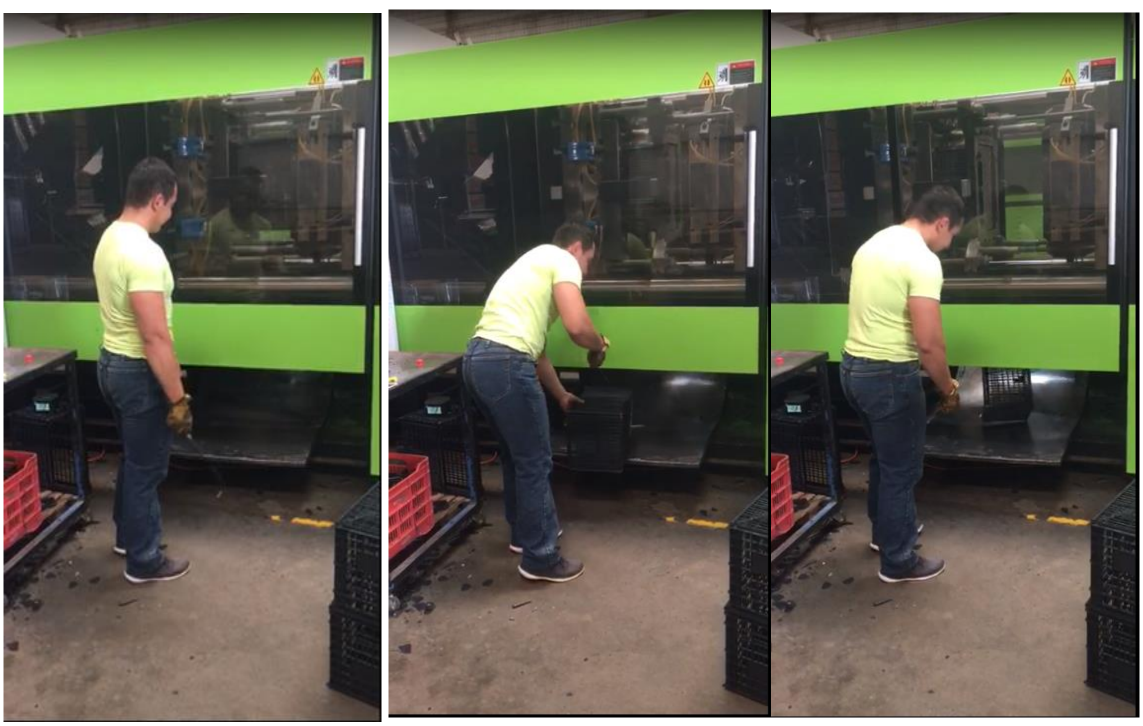


Figure 2. Production process final phase

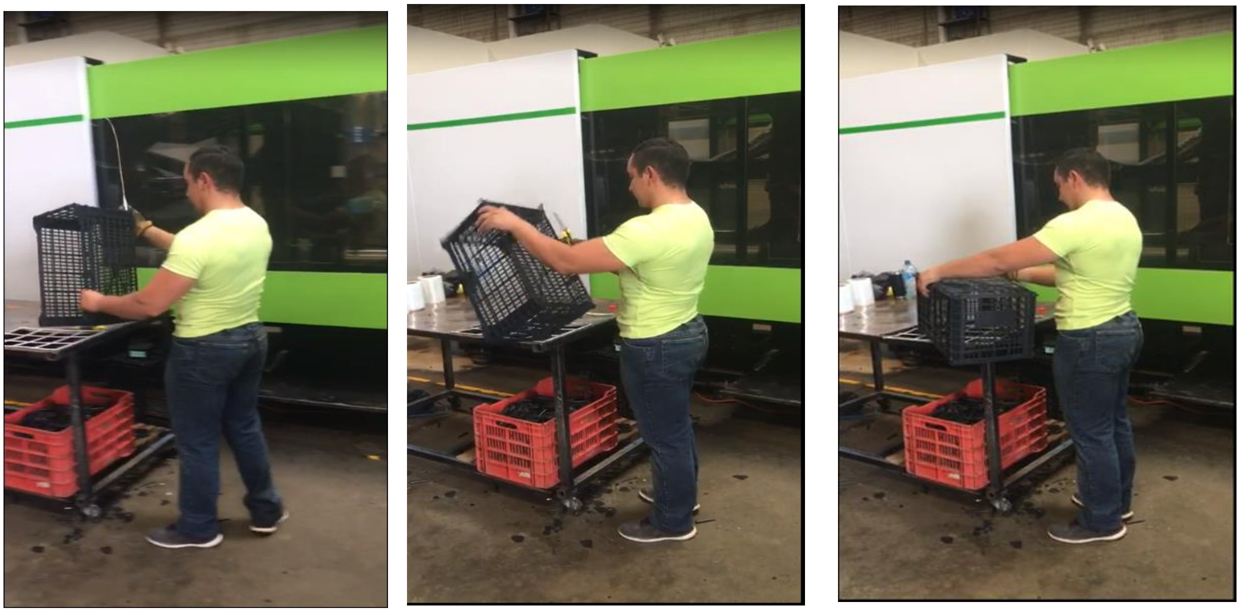


Figure 3. Plastic crate quality inspection

Figure 4. Tasks related to final plastic crate handling and storage.

2nd. A preliminary on-site analysis is performed using the Ergonomic Checklist (LCE) and the OWAS (Ovako Working Analysis System)

3rd. Analyzing the videos thoroughly in conjunction with the measurements made and using the BRIEF (Basic Risk Identification of Ergonomic Factors), REBA (Rapid Entire Body Assessment), and the LEST (Global Assessment) methods, an analysis of the conditions related to the worker's posture and the environmental state of the workplace is obtained.

4th. An extensive report is made with all the findings, which include recommendations based on ergonomic guidelines to reduce the risk of Musculoskeletal injuries, improve working conditions, and maintain productivity.

5. RESULTS

The LCE arrogates twenty-seven proposed actions related mainly to the aspect that the operator is always on his feet, even when it is waiting for production since they do not have access to a chair at any time, and to the lack of personal protective equipment, nine of the actions are considered urgent but none very critical (Figure 5)

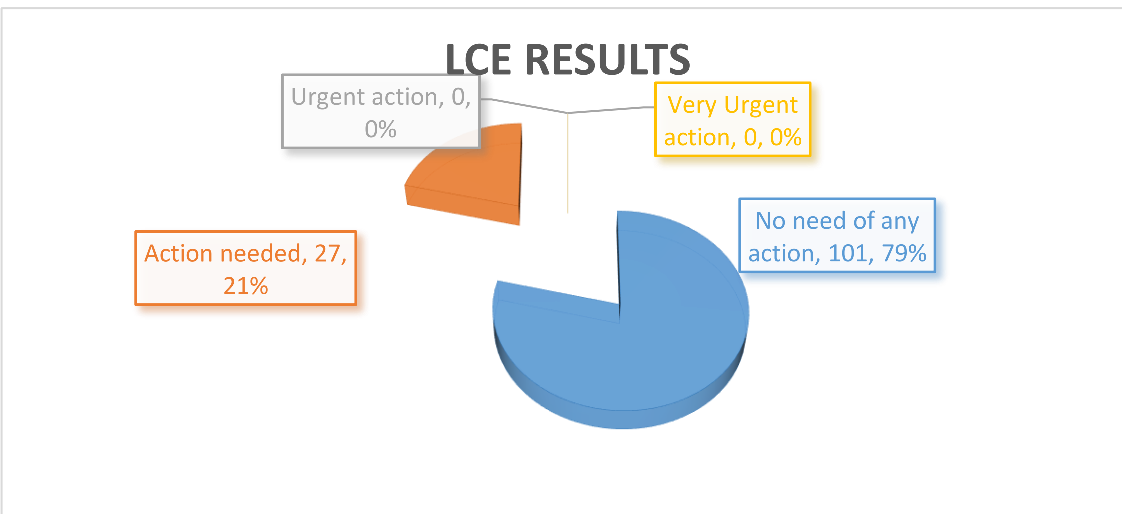
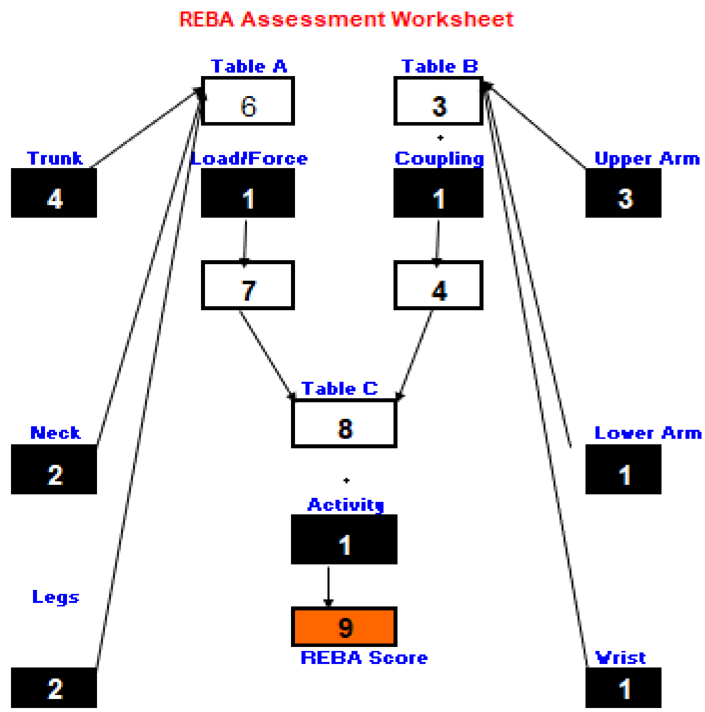


Figure 5. LCE Results

The risk factor obtained with the BRIEF method was 40, which means a high priority to change some tasks and avoid injuries. The OWAS results (Risk Factor 2) complement the BRIEF outcomes as it shows that the postures related to the job can cause injuries to the worker's musculoskeletal system.

The REBA method yields a score of 9, which implies a rapid action level that involves the fact that changes in the postures of the worker are required as soon as possible (Figure 6)



REBA Score	Risk Level	Action
1	Negligable	None necessary
2-3	Low	May be necessary
4-7	Medium	Necessary
8-10	High	Necessary soon
11-15	Very High	Necessary now

Figure 6. REBA results

The LEST methodology allowed us to obtain results in its five dimensions, as shown in Figure 7.

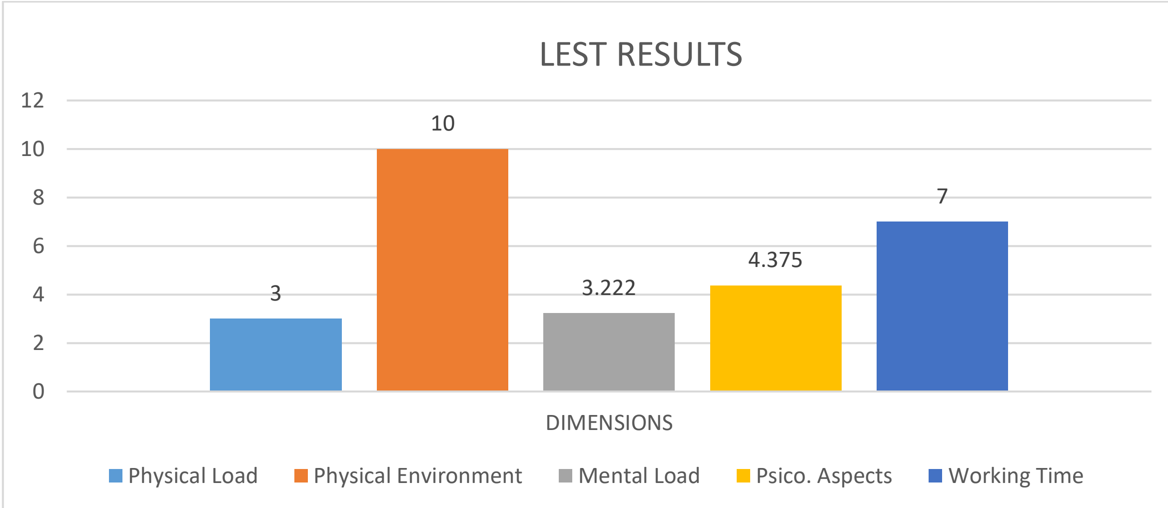


Figure 7. LEST results

6. DISCUSSION/CONCLUSIONS

The proposed changes in the mechanics of work must be implemented, evaluated, and corrected as a basis for the development of work improvements. This has suggested the need for improvement in all aspects of the system for both company management and the worker. Therefore, the risk of harm to the worker is significantly reduced based on these results.

The changes in worker's postures can easily be achieved by training the workers concerning the postures that should be avoided to prevent future musculoskeletal injuries. A bench was granted to the worker allowing him to sit in the moments of waiting for production or when performing some inspection tasks, which leads not only to the worker's comfort but also to avoiding fatigue and injuries to the circulatory system in the future.

The recommendation to support the worker with safety equipment appropriate to their functions, such as safety lenses and essential earplugs that significantly reduce exposure to environmental noise, was also met. On the other hand, it was recommended to buy an industrial type of heater which allowed the temperature to rise to 18 ° C, which is much more comfortable for workers.

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ERGONOMICS APPLIED INSIDE AN ICE CREAM SHOP

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Resumen: La normativa que existe internacionalmente en el campo de la Prevención de Riesgos Laborales emana del reconocimiento del derecho de los trabajadores a la protección de la salud frente a los riesgos derivados de las condiciones de trabajo. De esta forma en numerosos articulados y documentos técnicos de la ergonomía hacen referencia a los principios de la acción preventiva, que forman parte del conjunto de normas generales, dispuestas para adaptar el trabajo a la persona, en particular en lo que respecta a la concepción de los puestos de trabajo, así como a la elección de los equipos y los métodos de trabajo a fin de poder atenuar el trabajo monótono y repetitivo y a reducir en la mayor medida posible la aparición de lesiones musculo esqueléticas. En este sentido, es recomendable realizar evaluaciones de riesgos ergonómicos, a fin de adoptar cuantas medidas sean necesarias para la protección de la seguridad y salud de los trabajadores. En este proyecto se utilizarán diversos métodos para la evaluación ergonómica del puesto de trabajo en una heladería y en base a los resultados se darán las recomendaciones pertinentes para el mejoramiento de la estación de trabajo y el ambiente laboral buscando el evitar lesiones o accidentes en los trabajadores.

Palabras clave: OWAS, BRIEF, REBA, LEST, Evaluación ergonómica de puesto de trabajo

Relevancia para la ergonomía: Los resultados permiten percibir la importancia de realizar una evaluación ergonómica en el lugar de trabajo para el bienestar del trabajador y la productividad de la empresa.

El análisis nos muestra cómo el conocimiento de la Ergonomía aplicada al lugar de trabajo puede marcar una gran diferencia para la organización a corto y largo plazo, afectando al entorno laboral y a la salud y seguridad del trabajador.

Se considera que es de gran importancia entender que este tipo de estudio se puede aplicar a cualquier empresa, ya sea pequeña, mediana, o grande, ya que utilizar esta en cualquier actividad que se realice mejorará cada uno de los aspectos que la componen.

Abstract: The international regulations in the field of Occupational Risk Prevention emanate from the recognition of the workers' right to health protection against the risks of working conditions. In this way, numerous articles, and technical documents on ergonomics, refer to the principles of preventive actions, which are part of the set of general rules designed to adapt work to the person, in particular, related to workplaces designs, as well as the choice of equipment and working methods to be able to mitigate monotonous and repetitive work and reduce as much as possible the occurrence of musculoskeletal injuries. In this sense, it is advisable to carry out ergonomic risk assessments and to adopt as many measures as necessary for the workers' safety and health. In this project, various methods will be used for the ergonomic evaluation in an ice cream shop . Based on the results, pertinent recommendations will be given for workstation improvement and the work environment to avoid workplace injuries or accidents.

Keywords. Ergonomic workplace analysis, OWAS, BRIEF, REBA, LEST.

Relevance to Ergonomics The results allow us to perceive the importance of carrying out workplace ergonomic evaluation for the well-being of the worker and the company's productivity.

The analysis shows us how the knowledge of Ergonomics applied to the workplace can make a big difference for the organization in the short and long term, affecting the work environment and the worker's health and safety.

It is considered that it is of great importance to understand that this type of study can be applied to any company, whether small, medium, or large, since using this in any activity that is carried out will improve each of the aspects that compose it.

2. INTRODUCTION

The ergonomic analysis carried out in companies' workspaces allows to glimpse conditions that perhaps would not "appear" in a simple visual inspection; the interrelation of the operator with his labor factors is increasingly important to raise the company's productivity without forgetting workers' safety and efficiency. Using ergonomic analysis and measuring instruments makes it possible to arrive at an acceptable presumption of the actions envisaged to correct inefficiencies in performing productive tasks within the workplace (Yañez, 2015). Brito et al. (2019) mentioned that "the effective inclusion of Ergonomics in processes and installations has been proven to decrease costs related to disability, extra or overtime hours, medical care and premiums or fine for occurrences."

Ergonomic analyses have been enhanced with new methods and tools with a general application or specific for a particular workplace: methods for workplace analysis and workplace risks, strategies for effort evaluation, musculoskeletal disorders, muscle fatigue, different types of questionnaires elaborated for specific workstations, checklists, protocols, focus groups and many other (Escalante & Guaita, 2022; Albu, 2021, Albarracin, et al. 2018; Ruiz et al., 2022)

Complaints from these workstation workers related to discomfort in the lower back, wrist, and ankle began the need to properly evaluate the different tasks that this operator performs in the company; this was carried out through the methods LCE, REBA, OWAS, BRIEF, and LEST seeking to make the pertinent proposals to the company according to ergonomic guidelines that lead to improve its working conditions, increase worker comfort, avoid injuries and accidents and increase or maintain productivity (Rochat & Hayek, 2022)

2. OBJECTIVE

Develop the ergonomic analysis under the rubric of the Ergonomic Checklist (LCE) and usage of the OWAS (Ovako Working Analysis System), BRIEF (Basic Risk Identification of Ergonomic Factors), REBA (Rapid Entire Body Assessment), and LEST (Global Assessment) methods to obtain results from the different tasks carried out in the work area of an ice cream maker, know the risk involved in each of its movements, postures. The environment in which it performs and finally gives conclusions of results, propose an improvement in the weaknesses in the organization resulting in a general edit (efficiency, productivity, health, and employee care).

3. DELIMITATION

The ice cream shop is responsible for the elaboration of the different types of products sold in this business; it has a small space that is composed of five areas relatively small which are: dining area (1a), customer service bar(1b), ice cream machine area (1c), bathroom(1e), and warehouse (1d), where unused furniture and product refrigerator are located (Figure 1)

1a: Dining Area

1b: Customer Service Bar

1c: Ice cream machine area

1d: Warehouse 1e: Bathroom

Figure 1. Establishment areas

4. METHODOLOGY

Regarding the methodology used, it consists of three phases:

1st. A preliminary on-site analysis is performed using the LCE and the OWAS. At the same time, a video is made of the entire eight-hour work shift, which includes the different worker activities, including customer service and maintaining the establishment clean; also, measurement of the other environmental conditions at various times is made. Following photographs related to the different postures and tasks

Figure 2. Serving Soft Ice Cream.

Figure 3. Ice Coffee station

Figure 4. The initial position for filling ice cream machine or Iced Coffee machine

Figure 5. Final position for filling ice cream machine or Iced Coffee machine

2nd. Analyzing the videos thoroughly in conjunction with the measurements made and using the BRIEF (Basic Risk Identification of Ergonomic Factors), REBA (Rapid Entire Body Assessment), and the LEST (Global Assessment) methods, an analysis of the conditions related to the worker's posture and the environmental state of the workplace is obtained.

3rd. An extensive report is made with all the findings, which include recommendations based on ergonomic guidelines to reduce the risk of Musculoskeletal injuries, improve working conditions, and maintain productivity.

5. RESULTS

The LCE arrogates sixty-six proposed nonurgent actions, the main ones being the seven related to material handling and storage due to enormous loads. (Figure 5)

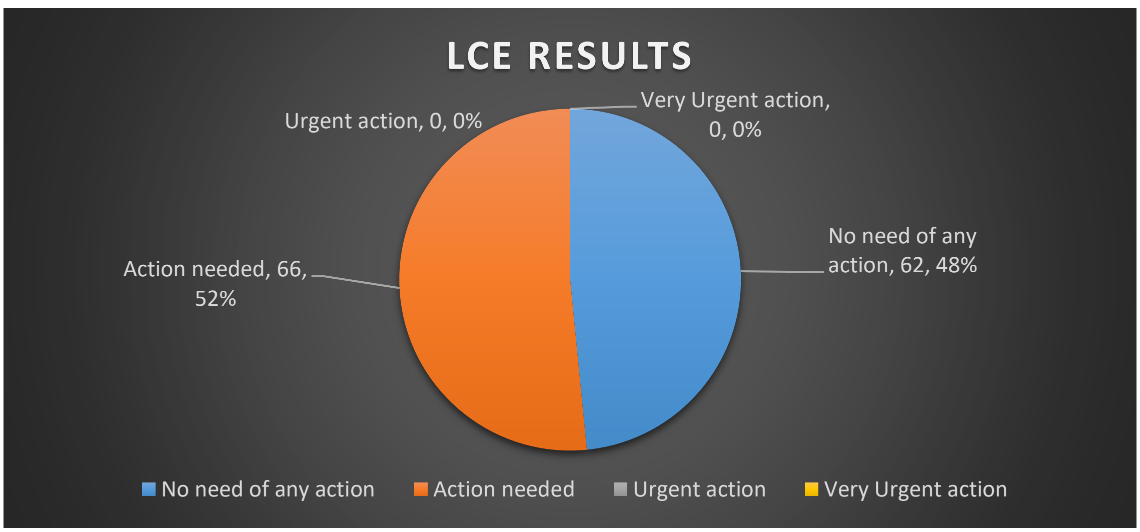


Figure 5. LCE Results

The risk factor score obtained with the BRIEF method was 18.4, which means a medium priority to change some tasks and avoid injuries; however, as the worker does these activities for an extended period, it can cause fatigue or minor injuries.

The OWAS results (shown in figure 6) complement the BRIEF outcomes as most tasks have low risk.

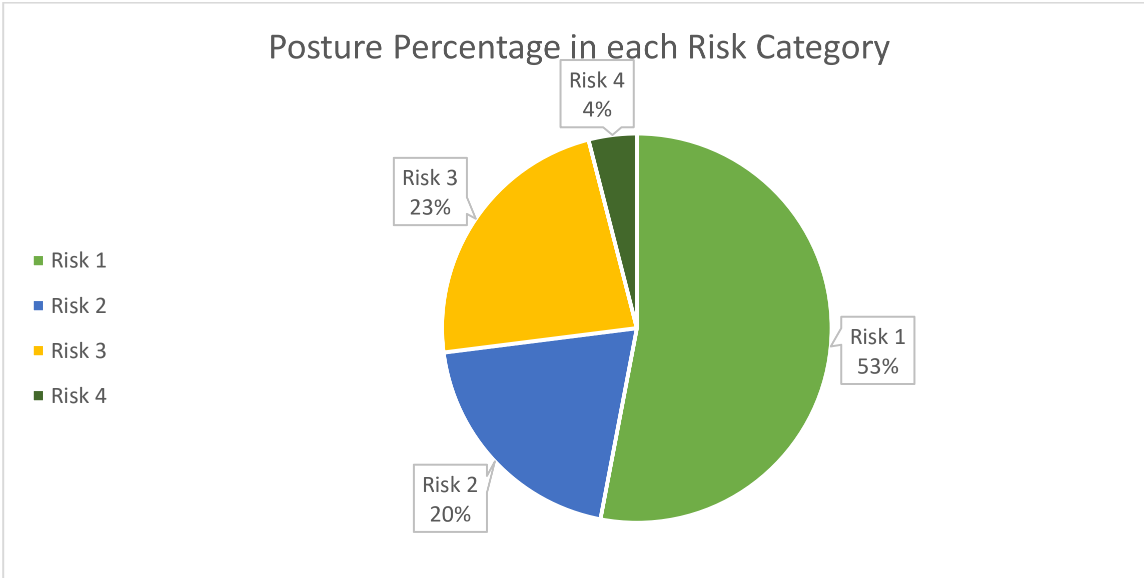
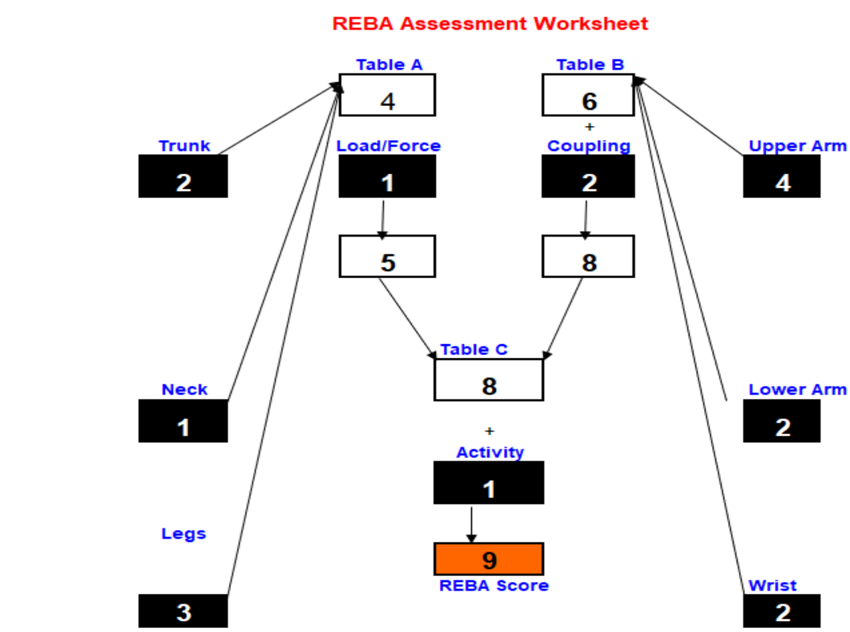


Figure 6. OWAS Results

The REBA method yields a score of 9, which implies a high risk related to necessary (but not urgent) actions.



REBA Score	Risk Level	Action
1	Negligable	None necessary
2-3	Low	May be necessary
4-7	Medium	Necessary
8-10	High	Necessary soon
11-15	Very High	Necessary now

Figure 7. REBA results

The LEST methodology allowed us to obtain results in its five dimensions, as shown in Figure 8.

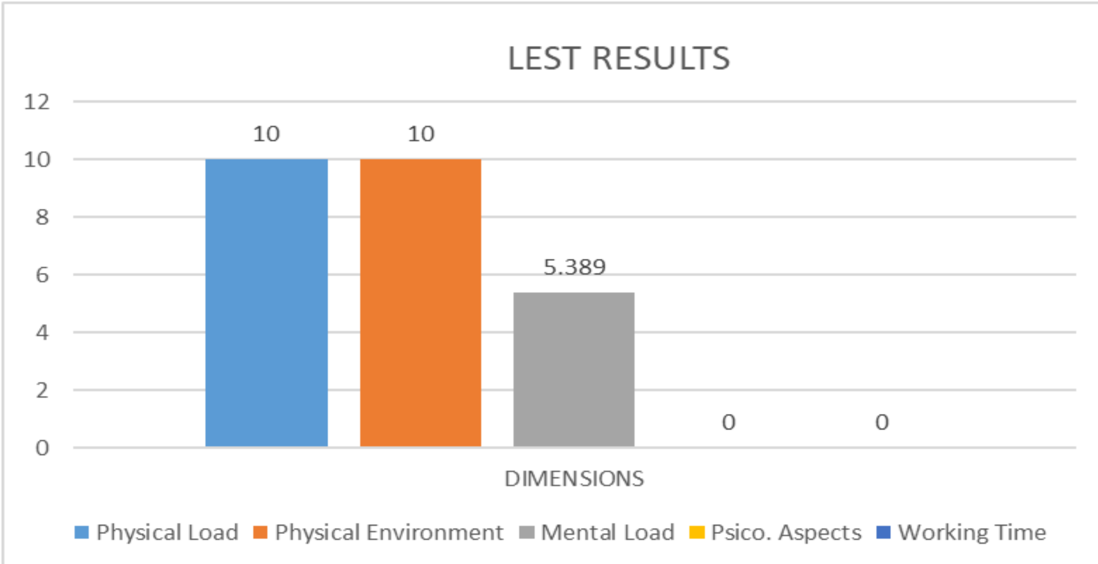


Figure 8. LEST results

The analysis related to the temperature of the organization results in 15°C and 34.6% Relative Humidity, a cold and humid environment that is often uncomfortable for the worker; this is coupled with noise levels between 75.7 and 79 dB(A), which is under the permissible limit to avoid hearing injuries.

6. DISCUSSION/CONCLUSIONS

Within the premises we find different opportunities for improvements that can be made to make the work area safer, avoiding any work risk:

- More lighting throughout the area, especially in the machine and warehouse area.
- The placement of a bench in the back where the machines are located since pouring the liquid into them is difficult due to the height.
- Use a special girdle for weightlifting since when the ice cream barrels are full are entirely somewhat heavy, which would avoid any back injury.
- Placement of light bulbs in the bathroom since it does not have one.
- Placement of anti-skid tape on the floor, specifically in machines and customer service, to avoid falls on slippery floors.
- Signs of danger areas with specific tapes and symbols to specify any risk, since, in the rear area of the ice cream machines, there were cables on the floor of the same devices; stepping on any or tripping over it results in risk.
- Moving material to the warehouse area that is not used and takes up space in the ice cream machine area and reduces the correct advancement of the worker.

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COFFEE SHOP ERGONOMIC EVALUATION: RULA, ERP, AND ENVIRONMENTAL CONDITIONS

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Resumen: Café "Merak" es una empresa joven con un alto sentido de calidad en sus productos, lo que demuestra en la producción de bebidas y alimentos, seleccionando los mejores ingredientes, el producto final generado por esta empresa está dirigido a cualquier persona que sea amante de los postres (galletas, crepes, pastel, etc.) pero especialmente del café, disfrutando de los beneficios que el consumo de café aporta.

Sin embargo, esta empresa no solo se preocupa por la calidad de sus productos sino también por sus empleados, por lo que accedió a la solicitud de realizar un estudio ergonómico de los diferentes puestos de trabajo que la componen, con el fin de tratar de determinar los riesgos laborales que conlleva el proceso de elaboración y con el entorno físico de la empresa.

Palabras clave: Evaluación ergonómica de puesto de trabajo, RULA, EPR

Relevancia para la ergonomía: La ergonomía es la interacción entre los seres humanos y otros elementos de un sistema. Este estudio proporciona información que contribuye a la mejora de las condiciones de trabajo para llevar a cabo rediseños, mejoras y formación con un enfoque ergonómico que garantice el bienestar, la comodidad y la productividad del trabajador.

Abstract: Café "Merak" is a young company with a high sense of quality in its products, which it demonstrates in the production of beverages and food, selecting the best ingredients, the final product generated by this company is aimed at anyone who is a lover of desserts (cookies, crepes, cake, etc.) but especially coffee, enjoying the benefits that coffee consumption brings.

However, this company cares about not only the quality of its products but also its employees, which is why it agreed to the request to carry out an ergonomic study of the different workstations in the organization to try to determine the occupational work risks involved in the elaboration process, customer service and with the company´s physical environment.

Keywords. Ergonomic evaluation, RULA, EPR

Relevance to Ergonomics: Ergonomics is the interaction between humans and other elements of a system. This study provides information that contributes to improving working conditions to carry out redesigns, improvements, and training with an ergonomic approach that ensures the worker's well-being, comfort, and productivity.

1. INTRODUCTION

Ergonomics is a science that tries to adapt products, tasks, tools, spaces, and the environment to the capacity and needs of people, aiming to improve the efficiency, safety, and well-being of workers and users of such products and work environments (Adaramola & Ugbebor, 2014; Sohrabi & Babamiri, 2021; Ruiz et al., 2022). An essential aspect of Ergonomics is that it is people-centered. This means that people are more important than objects or production processes, so in cases where a conflict of interest becomes apparent, the people's best interest must always prevail.

Café "Merak" is a young company with a high sense of quality in its products, which it demonstrates in the production of beverages and food, selecting the best ingredients, the final product generated by this company is aimed at anyone who is a lover of desserts (cookies, crepes, cake, etc.) but especially coffee, enjoying the benefits that coffee consumption. From the cognitive point of view, coffee consumption contributes to favorable emotions, wellness, energy, a positive state of mind, and an enjoyable and trendy lifestyle, as mentioned in Samoggia (2020). Novel approaches in epidemiological studies and experimental research suggest that coffee consumption can help to prevent several chronic diseases, including type 2 diabetes mellitus and liver disease (Nieber, 2017; Poole, 2017).

However, this company cares about not only the quality of its products but also its employees, which is why it agreed to the request to carry out an ergonomic study of the different workstations in the organization to try to determine the occupational work risks involved in the elaboration process, customer service and with the company´s physical environment (Yanez, 2015; Anusha Chintada & Umasankar, 2022), to achieve the latest, diverse measurement equipment (lux meter, hygrometer, thermometer, decibel meter) and the Rapid Posture Evaluation (EPR) and Rapid Upper Limb Assessment (RULA) methods were used, necessary to mention that this method is widely used in diverse investigations (Manghisi et al., 2022; Escalante & Guaita, 2022; Manghisi et al., 2020; Mahantesh, et al. 2021; Joshi & Deshpande, 2021; Blume et al., 2021; Kim et al., 2021; Amit & Song, 2021;

Holzgreve, 2022; Kee, 2022). In the end, the pertinent recommendations were made for improving working conditions and the organization's physical environment following ergonomic guidelines, which had a direct impact not only on the work environment and workers' well-being but also on the comfort of the clients of the establishment.

2. OBJECTIVE

Perform an analysis of the current working conditions of "Merak" coffee, measure environmental conditions, and perform an Ergonomic analysis using the EPR and RULA methods

3. METHODOLOGY

Regarding the methodology used, it is made up of five phases:

1st. Three stations were chosen from all the coffee shops based on the time the worker spent on them: kitchen (Figure 1), coffee bar (Figure 2), and seating area (Figure 3).

Figure 1. Kitchen.

Figure 2. Barista’s area

Figure 3. Sitting area

2nd. The Rapid Postural Evaluation (ERP) method was used to measure the static load considering the type of postures adopted by the worker and the time he maintains them, providing a numerical value proportional to the level of load

3rd. The Rapid Upper Limb Assessment (RULA) method allows us to identify the risk that the worker’s postures and movements can cause.

4th. Noise, luminosity, and temperature measurements were made in the different work areas.

5th. Based on the findings, a discussion and reflection were made where the authors confirmed the existence of improvement opportunities based on ergonomics guidelines.

4. RESULTS

Five postures implicated in the ERP method were identified, and the results are presented in table 1.

Table 1. Barista postures ERP Method

POSTURES	TIME
Seating normal	<10’
Standing normal	<10’
Standing with the arms in frontal extension	10’ to <20.’
Leaning standing	20’ to <35.’
Standing with arms above shoulders	<10’

The ERP method, about the data presented in the table, throws punctuation of nine, corresponding to a performance level of 4. This can be interpreted following table 2, concluding that the worker’s postures can cause Strong discomfort. Hence, it is necessary to introduce improvements in the man-machine system.

Table 2. ERP Method results in interpretation (Diego-Mas, 2015).

Performance Level	Color/Punctuation	Assessment
1	0-1-2	Satisfactory Situation
2	3-4-5	Weak discomfort. Some improvements may provide more comfort to the worker.
3	6-7	Medium discomfort. There is a risk of fatigue.
4	8-9	Strong discomfort. Fatigue
5	10	Harmfulness.

The RULA method yields a score of 7, which implies a level of 4, which indicates that changes in the postures of the worker are urgent (Figure 4).

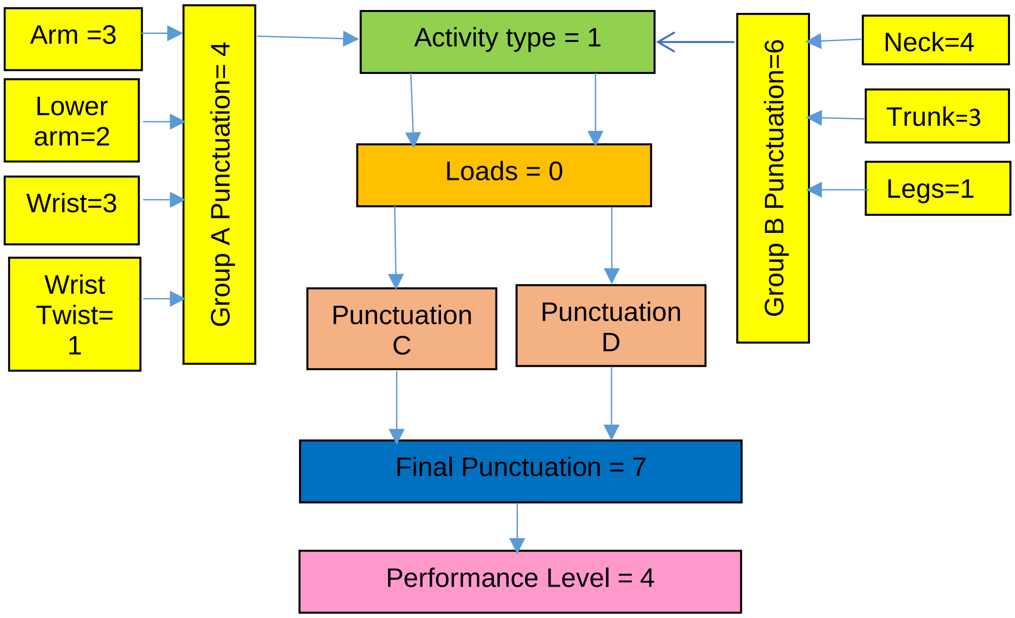

Figure 4. RULA Results

Regarding the measurements of temperature (24°C) related to luminosity, the kitchen area had a variation of luminosity in different points from 10 to 351 lux; this was due to the type of lighting they were using, while in the bathroom area it had the illumination of 19 lux. The dining area had lighting variation between 22 and 500 lux, also caused by the type of lighting used.

5. DISCUSSION/CONCLUSIONS

The changes in worker's postures can easily be achieved by training the workers concerning the postures that should be avoided to prevent musculoskeletal injuries.

It was observed that the high temperatures caused a suffocating environment for both customers and operators (baristas and staff) and is not recommended for health; since the study was performed in the summer, hence it would have been advised to have ventilation in the facilities to reduce the interior temperature of the premises. We recommended an HVAC (heating, ventilation, and air conditioning) system. As an air conditioning system, it acts as heating in winter and as cooling in summer. Its purpose is to provide the user with an indoor environment with a comfortable temperature, relative humidity rate, and air purification.

It was recommended that the current artificial lighting be changed to LED lighting since the latter type of lighting does not generate additional heat like other lighting technologies. LED lighting has the added benefit of promoting a favorable control of energy expenditure since by not generating extra warmth, it maintains an area with the actual temperature, which may reduce unnecessary use of the air conditioning.

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NECK DISCOMFORT ASSOCIATION WITH TEXTING TIME, HEAD TILT ANGLE, AND VIEWING ANGLE IN THE USE OF SMARTPHOES BY WOMEN

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Resumen: Las molestias en el cuello son frecuentes en muchas ocupaciones sedentarias, incluida la odontología y las ocupaciones que implican el trabajo con ordenadores portátiles o tabletas. Las molestias pueden provocar fatiga muscular a corto plazo y problemas potencialmente más extensos a largo plazo. Las molestias en el cuello y los hombros se han asociado al uso de los smartphones. La interacción de factores como el ángulo de inclinación de la cabeza, el ángulo de visión del teléfono, así como el tiempo consumido al escribir los mensajes de texto con el dolor de cuello, han sido escasamente estudiados, por esta razón, se buscó determinar la asociación de estos factores, además de otras variables como son la edad y el IMC con el dolor de cuello cuando se utilizan teléfonos inteligentes. Para el desarrollo de esta investigación se reclutaron cien mujeres jóvenes de la ciudad de Hermosillo, Sonora, México. Los datos sociodemográficos de la muestra considerada en este estudio son los siguientes: edad, estatura, peso e índice de masa corporal (IMC). Se utilizó una muestra de conveniencia para realizar el estudio. Se administró la encuesta del índice de molestias en el cuello en versión española. Se realizaron diez sesiones de actividades de escritura de mensajes de texto en el teléfono. Se midió el tiempo consumido en la escritura de dichos mensajes de texto, así como el ángulo de inclinación de la cabeza de acuerdo con tres ángulos de visión diferentes para el teléfono. Se utilizó un modelo de regresión logística multivariante para determinar la asociación entre las molestias en el cuello y las condiciones experimentales, como el ángulo de inclinación de la cabeza, el ángulo de visión y el tiempo de escritura de mensajes de texto, así como las variables sociodemográficas: edad y el IMC. Los resultados de este estudio sugieren una posible asociación entre las molestias en el cuello y el tiempo consumido al escribir mensajes de texto por parte de los participantes. Aunque esta investigación es preliminar, las asociaciones observadas, junto con el creciente uso de los teléfonos inteligentes, sugieren por una investigación adicional en este campo.

Palabras clave: Molestias en el cuello, teléfonos inteligentes, tiempo.

Relevancia para la ergonomía: El uso del teléfono como herramienta para escribir mensajes de texto, es cada vez más creciente, sin embargo, las posibilidades de riesgos ergonómicos también son evidentes. El abordaje de la ergonomía en estos ámbitos es imperativo, pues las consecuencias pueden ser preocupantes, no solo por los riesgos posturales, si no por que involucra a una gran masa de población en todas las edades.

Abstract: Neck discomfort is prevalent in many sedentary occupations, including dentistry and occupations involving notebook or tablet computer work. Discomfort can result in muscle fatigue in the short term and potentially more extensive problems longer term. The neck and shoulder discomfort have been associated with smartphone use. The interaction of factors such as the viewing angle of the telephone, as well as the texting time in association with neck pain, have been scarcely studied, for this reason, we sought to determine the association of head angle tilt, texting time and some confounders variables such viewing angle, age and BMI with neck pain when using smartphones. One hundred young women from the city of Hermosillo, Sonora, Mexico were recruited for the development of this research. The sociodemographic data of the sample considered in this study are as follows: age, height, weight, and body mass index (BMI). A convenience sample was used to perform the study. The neck disability index survey (NDIS) in Spanish version was administered during the experiment events which consisted of ten sessions of texting activities. Texting time as well as head tilt angle were measured according to three different viewing angles. A multivariate logistic regression model was used to determine the association between self-reported neck discomfort and experimental conditions such as head tilt angle, viewing angle and texting time, as well as confounding variables: age and BMI. The findings in this study suggest a possible association between neck discomfort and texting time while using smartphones by women. Although this research is preliminary, the observed associations, along with the increasing use of smartphones, argue for additional research in this field.

Key words: Neck discomfort, smartphones, texting time.

Relevance for ergonomics: The use of the telephone as a tool for text messaging is growing, but the potential for ergonomic risks is also evident. Addressing ergonomics in these areas is imperative, as the consequences can be worrisome, not only because of the postural risks, but also because it involves a large mass of the population at all ages.

1. INTRODUCTION

Neck discomfort is prevalent in many sedentary occupations, including dentistry and occupations involving notebook or tablet computer work (Keester & Sommerich, 2017), (Hayes et al., 2009). Neck discomfort has been associated with adopting awkward neck postures for prolonged periods of work due to the sustained recruitment of neck extensor muscles (Ohlsson et al., 1995). According to Cerezo-Téllez et al. (2016) this can result in muscle fatigue in the short term and potentially more extensive problems longer term. Furthermore, Berolo et al., 2011) indicate that neck and shoulder discomfort have been associated with smartphone use. Alike to other tasks associated with neck pain, smartphone tasks are performed by users locking downwards (Lee et al., 2015). Instant message sending and receiving on smartphones as well as internet connection are becoming are on the rise (Rainie, 2010). Despite the absence of epidemiological studies, laboratory research suggests that mobile device use may have negative effects on musculoskeletal health (Storr et al., 2007). A research is advised given the growing popularity of smartphones, the public's belief that device use is linked to musculoskeletal problems, and case reports and laboratory studies that suggest this may be a cause for concern. The interaction off factors such as the viewing angle of the telephone, as well as the texting time in association with neck pain, have been scarcely studied, for this reason, we sought to determine the association head angle tilt, texting time and some confounders variables such viewing angle, age and BMI with neck pain when using smartphones.

2. OBJETIVE

Through a multivariate logistic model, the objective of this study is to ascertain the association between head tilt angle, texting time, and confounding variables such as viewing angle, age, and BMI with self-reported neck pain in young women.

2.1 Delimitation

This study is limited to investigate the association of neck tilt angle, texting time, and confounder variables such, age, and BMI, besides viewing angle in the use of smartphones by women.

3. METHODOLOGY

3.1 Participants

One hundred young women from the city of Hermosillo, Sonora, Mexico were recruited for the development of this research. Undergraduate students from Manufacturing industrial engineering program were invited to take part in the study. All young women received a link to the sociodemographic survey via the university mailing list. The sociodemographic data of the sample considered in this study are as follows: age, height, weight, and body mass index (BMI). A convenience sample was used to perform the study.

3.2 Consent to participate

Young women were asked to participate in this study, and 100% (N=100) of them stated that they agreed to do so. The study was approved by the Ethics Committee of the Universidad Estatal de Sonora. The researcher conducted a session to present the methodology and purpose of the study. Young women were free to withdraw from the study at any time and those who chose to do so were provided with the results of the study. All participants provided digital informed consent. Exclusion criteria included neck surgery, neck pain or the use of eyeglasses to read.

3.2 Measures

3.3.1 Self-reported neck pain

The neck disability index survey (NDIS) in Spanish version was administered during the experiment events which consisted of ten sessions of texting activities. The NDIS considers ten questions to determine the severity of neck pain affecting person's daily life. The scoring intervals used for interpretation are as follows: 0-4 = no disability, 5-14= mild, 15-24= moderate, 25-34= severe, above 34= complete.

3.3.2 Head tilt angle

The head tilt angle in the sagittal plane, as shown in figure 1, is one of the measurements considered in this study. Using a goniometer and a digital camera, the head angle was measured (Measuring Angle from Picture, n.d.). This angle is created between the horizontal and a line drawn from the canthus of the eye to the tragus of the ear (Raine & Twomey, 1997). The head is placed farther forward on the neck the smaller the value of this angle. Other names for the head tilt angle have been proposed by various authors, including head alignment from the Frankfurt plane, craniohorizontal angle (Iunes et al., 2008), gazing angle, and cranial rotation angle (Harrison et al., 1996).

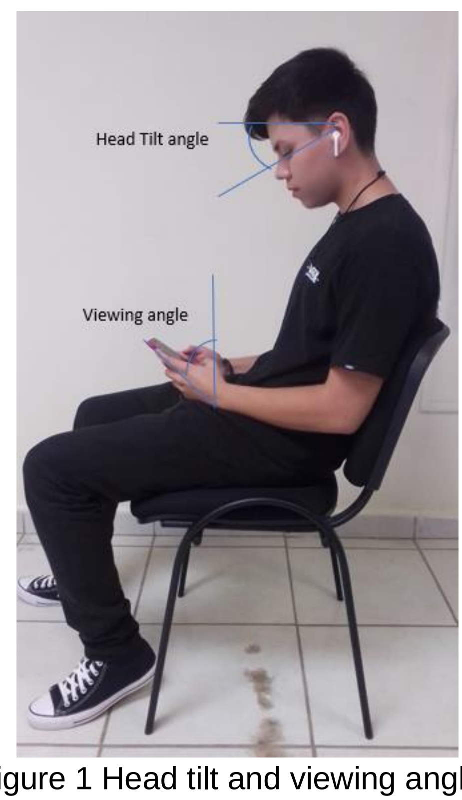

Figure 1 Head tilt and viewing angles

3.3.3 Texting time

Participants typed ten different text messages, with previously assigned extension. The speed of message was measured with a chronometer, allowing ten different testing conditions. The sequences of the testing were randomly assigned to participant. Subjects were trained to focus on accuracy of texting. All texts were printed and displayed in front of participant to have read them. After making the text, participant was asked to answer NDI.

3.3.4 Viewing angle

Is the counterclockwise angle of phone, measured from vertical as illustrated in figure 1. Three different angles were stablished to perform the test, 90°, 85°, 75°.

3.3.5 Confounding variables

The following confounding variables were considered: age and body index mass (BMI).

3.4 Data processing and statistical analyses

The NDI score was calculated for each test condition: head tilt angle, viewing angle and texting time. A total of 3000 data were gathered according to the experiment design. A multivariate logistic regression model was used to determine the association between self-reported neck discomfort and experimental conditions such as head tilt angle, viewing angle and texting time, as well as confounding variables: age and BMI.

Statistical analyses were performed using SPSS version 24 (IBM, Chicago, IL, USA)

4. RESULTS

4.1 Demographic and occupational characteristics of the sample

A total of 100 young women reviewed the online questionnaire. The sample consisted of 100 female students from manufacturing industrial program at Universidad Estatal de Sonora in Hermosillo, Sonora, México. The sociodemographic characteristics of the participants are shown in Table 1:

Table 1 Demographic characteristics of participants

Characteristics	Variables	Value
Age (years)		
	Mean	19.391
	Range	18-22
	Standard deviation	0.578
Body index mass	Mean	24.35
(kg/m^2)	Range	18.13-25.42
	Standard deviation	0.893

According to Table 2, the age of the young women is in the range of 18 to 22 years (with a mean of 19.391 years and a deviation of 0.578 (years). The sample body mass index is in the range of 18.13 to 25.42 kg/m2.

4.2 Statistical analysis

This section presents a summary of the results of the statistical analysis, which will allow us to draw conclusions regarding the objective set.

4.2.1 Neck disability index

Neck disability index (NDI) mean was 48.33%. According to table 2, NDI condition and its percentage for occurrence, was distributed as follows:

Table 2 Neck disability index prevalence

Age	NDI condition	Percentage
18-19 years	0-4 (no disability)	15.34
	5-14 (mild)	25.47
	15-24 (moderate)	33.25
	25-34 (severe)	15.79
	above 34 (complete)	10.15
20-21 years	0-4 (no disability)	10.25
	5-14 (mild)	33.87
	15-24 (moderate)	25.45
	25-34 (severe)	25.39
	above 34 (complete)	5.04
22-23 years	0-4 (no disability)	22.47
	5-14 (mild)	5.28
	15-24 (moderate)	33.45
	25-34 (severe)	22.5
	above 34 (complete)	16.3

This table shows that there is a significant prevalence of mild and moderate NDI across all age groups. This finding may suggest that young women's use of smartphones causes musculoskeletal discomfort. The percentage of participants reporting any neck pain is comparable to that in two other investigations, but more people in the current study report having neck pain. Undergraduate students' self-reported musculoskeletal problems were also evaluated by (Chang et al., 2007), who discovered that 48% of participants complained of neck pain.

4.2.2 Head tilt angle

Photographs taken in the sagittal plane and a digital goniometer were used to measure the head tilt angle during each test. The participant held a comfortable position while flexing and extending their head five times. Following the ten texting trials, the test was then conducted. Table 3 summarizes the head tilt angle gathered in each of the ten texting tests.

Table 3 Head tilt angle by texting time test

	Head tilt angle (degrees)	
Texting test	Mean	Standard deviation
A (20 characters)	23.38	2.01
B (30 characters)	24.58	1.85
C (40 characters)	25.89	2.85
D (50 characters)	28.01	2.78
E (60 characters)	27.69	2.58
F (70 characters)	22.87	1.78
G (80 characters)	27.89	1.77
H (90 characters)	22.89	1.78
I (100 characters)	25.25	1.25
J (110 characters)	21.78	138

4.2.3 Texting time

Texting time was registered using a digital chronometer. Each participant texted the ten texts, and time in seconds was measured. Table 4 shows the texting time mean and standard deviation for all participants.

Table 4 Texting time mean and standard deviation

	Texting time (s)	
Texting test	Mean	*Standard deviation*
A (20 characters)	15.36	*1.05*
B (30 characters)	27.39	*2.75*

C (40 characters)	38.79	*2.43*
D (50 characters)	8.81	*2.78*
E (60 characters)	27.69	*2.58*
F (70 characters)	22.87	*1.78*
G (80 characters)	27.89	*1.77*
H (90 characters)	22.89	*1.78*
I (100 characters)	25.25	*1.25*
J (110 characters)	21.78	*138*

4.2.5 Multivariate logistic regression model

According to results there is a strong association between the amount of time spent texting on the smartphone and the self-reported neck pain. Table 5 shows the most relevant significant associations between variables, confounding variables, and self-reported neck discomfort. Two individual characteristics were considered as potential confounders: age and BMI.

Table 5 Odd-Ratio and Confidence intervals NDI score, head tilt angle, texting time and viewing angle

Variables	Categories	NDI score Odd-ratio (CI) 5%
Head tilt angle	21-22 (degrees)	0.45(0.26-0.96)
	23-24 (degrees)	0.26(0.89-0.99)
	25-26 (degrees)	**1.78(0.23-2.38)**
	27-28 (degrees)	0.25(0.33-0.57)
Texting time (s)	A (20 characters)	0.85(0.57-8.98)
	B (30 characters)	1.28(0.66-3.22)
	C (40 characters)	0.17(0.17-2.56)
	D (50 characters)	0.77(0.78-2.29)
	E (60 characters)	0.78(0.87-4.33)
	F (70 characters)	**3.89(1.12-2.36)**
	G (80 characters)	**3.32(2.87-5.98)**
	H (90 characters)	**2.89(1.24-5.84)**
	I (100 characters)	**1.33(1.25-1.53)**
	J (110 characters)	**2.22(1.16-3.69)**
Viewing angle (degrees)	90 (degrees)	0.88(0.66-1.98)
	85(degrees)	0.78(0.25-0.88)
	75(degrees)	**1.22(1.20-3.69)**

BMI (kg/m2)	Healthy weight	0.33(1.48-2.65)
	Overweight	0.47(0.47-1.45)
	Obesity	0.22(0.21-3.45)
Age	18-19	0.89(0.96-2.73)
	20-21	0.77(0.99-3.93)
	22-23	0.46(0.41-3.26)

p-value < 0.05 in bold, significance level α=0.05

5. CONCLUSIONS

Neck flexion is frequent in the process of texting messages on the smartphone. According to the proposed objective, a very strong association was found between texting time and the self-reported neck discomfort after performing the test. There is a possibility of having a non-full appreciation of neck discomfort because the current test condition lasted for five minutes. In addition, future research should examine a wide age range to see if they provide comparable outcomes. The proportion of participants reporting any pain in the neck is similar to other studies (Chang et al., 2007). The lack of association with confounders variables may be due to a healthy woman's effect. Despite its limitations, this preliminary research is a good starting point given the lack of knowledge in this field.

The findings in this study suggest a possible association between neck discomfort and texting time while using smartphones by women. Although this research is preliminary, the observed associations, along with the increasing use of smartphones, argue for additional research in this field.

Conflict of interest

None to report.

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LEGIBILITY, READABILITY AND VISIBILITY IN EXISTING OFFICIAL HEALTH ADVERTISING ON THE WEB: EYE-TRACKING PILOT TEST

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Resumen: En esta prueba piloto se analizaron los movimientos oculomotores generados en el momento de la lectura -tiempos de fijación, sacadas (o movimientos sacádicos) y diámetro pupilar- para analizar los tres factores ergonómicos de la lectura: legibilidad, legibilidad y visibilidad; como objeto de estímulo para las pruebas se utilizó la publicidad de salud que existe en las páginas web del Gobierno Federal de México. Se realizó un análisis superficial de la relación entre la polaridad de contraste de las interfaces y los niveles de luz ambiental en relación de la usabilidad (vinculada a los factores antes mencionados) con dos representaciones visuales de interfaces de usuario modo claro y modo oscuro, y con dos tipos de iluminación ambiental (iluminación simulada en un ambiente controlado): luz de día y luz nocturna. Se contrabalanceó la secuencia de exposición a ambos factores para reducir algún sesgo en los resultados.

Se encontró que la condición más favorable para la experiencia del usuario y la usabilidad de la interfaz es la lectura en modo oscuro; y las condiciones menos favorables para el usuario es leer en una interfaz en modo claro y con condiciones de luz muy bajas o nulas.

Palabras clave: Leibilidad, usabilidad, interfaz de usuario, polaridad de contraste, rastreador ocular.

Relevancia para la ergonomía: Con esta investigación se pretende que dentro del área del UX, (User Experience, Experiencia de Usuario, por sus siglas en inglés) y UI, (User Interface, Interfaz de Usuario, por sus siglas en inglés) se cuenten con más estudios en estos temas; estudios que sean hechos dentro de la ergonomía, específicamente en temas que se enfoquen en los diferentes tipos de representaciones visuales de interfaces gráficas de usuario, ya que son nulas las investigaciones que existen en estos temas.

El estudio se enfoca en la exploración de áreas nuevas que son de gran oportunidad, tanto en los ámbitos de la ergonomía como del diseño; sobre todo en las cuestiones de reducir tanto errores como accidentes y de la prevención y/o reducción de enfermedades en el ámbito ocupacional. Además, con la sistematización de métodos en investigaciones que involucran rastreo ocular se puede mejorar el entendimiento de la interacción usuario interfaz (Reyes, 2017).

Abstract: In this pilot test, the oculomotor movements generated at the moment of reading were analyzed -fixation times, saccades (or saccadic movements) and pupil diameter- to analyze the three ergonomic factors of reading: legibility, readability and visibility; health advertising on the web pages of the Federal Government of Mexico was used as a stimulus for the tests. A superficial analysis of the relationship between the contrast polarity of the interfaces and the levels of ambient light in relation to usability (linked to the factors mentioned above) was carried out with two visual representations of user interfaces in light mode and dark mode, and with two types of ambient lighting (lighting simulated in a controlled environment): daylight and night light. The sequence of exposure to both factors was counterbalanced to reduce some bias in the results.

It was found that the most favorable condition for user experience and interface usability is reading in dark mode; and the least favorable condition for the user is reading in a light mode interface and with very low or no light conditions.

Keywords: Readability, usability, user interface, contrast polarity, eye-tracker.

Relevance to Ergonomics: With this research, it is intended that within the area of UX, (User Experience) and UI, (User Interface) there are more studies on these topics; studies that are made within ergonomics, specifically on topics that focus on the different types of visual representations of graphical user interfaces, since there are no existing research on these topics.

The study focuses on the exploration of new areas that are of great opportunity, both in the fields of ergonomics and design; especially in the issues of reducing both errors and accidents and the prevention and / or reduction of diseases in the occupational field. In addition, with the systematization of methods in research involving eye tracking, the understanding of user interface interaction can be improved (Reyes, 2017).

1. INTRODUCTION

Nowadays, the visual style of user interfaces has evolved along with technology in recent years; how can we forget when web interfaces began with hypercontrasting colors that "damaged the retina" the instant you saw them; and then moved on to a more "minimalist" style, where the background is white and its characters are black, known as light mode; and ending in what is now commonly called "modern design": black backgrounds with white characters, better known as dark mode; design that is considered a fashion-driven practice (Pan, 2015).

Based on the aforementioned supports, is that preliminary results are presented by implementing in a pilot test the analysis from the usability, through oculomotor movements (fixation times, saccades and pupil diameter), the effects that have on readability, readability and visibility in reading; using as a stimulus object for the test the information presented in health advertising with smoking issues existing in the official web pages of the Mexican Federal Government (Ministry of Health), with two visual representations of user interfaces: In light mode and dark mode; and intercalating the environmental lighting in two levels, simulated within a controlled place: daylight and night light (light and dark); levels that were simulated within the test laboratory of the Behavioral and Health Research Center in the University Center of the Valleys; counterbalancing both factors to rule out any type of bias both in the reading and in the participants.

In this test, the instrument used was a high-cost eye tracker of the Tobii brand, the X2-30 model, with which precise and quantifiable data were obtained; in addition to a final interview, to obtain subjective data from the participants.

With this part of the research, in its piloting it was possible to identify that the dark mode is the one that most favors reading, in terms of "ease" and "speed"; and that, although the user mentions that he has understood what he has read, there are always physiological quantitative metrics (oculomotor movement) that can confirm or annul what the users affirm qualitatively in their own words.

2. OBJECTIVE

Analyze the effects on legibility, readability and visibility in the reading of health advertisements with smoking issues on the official website of the Mexican Federal Government with user interfaces in light mode and dark mode and with two levels of illumination; through oculomotor movements measured with an eye tracker.

3. DELIMITATION

The pilot test was conducted at CUVALLES of the University of Guadalajara (University Center of the Valleys, by its acronym in Spanish); in the testing laboratory of the Behavioral and Health Research Center in the University of Guadalajara, in Ameca, Jalisco. The sample population consisted of two people: one 27 and the other 37 years old, both women, Mexican, non-smokers, experienced Internet users and familiar with both interface modes, with normal visual acuity. These tests were conducted in July 2022.

It should be noted that for the final protocol of this research, the research population will consist of 20 subjects, 10 of whom will be chronic smokers and 10 non-smokers. The inclusion criteria of the participants will have to be Mexican citizens, men or women between 25 and 40 years of age, who can read and write; and people with any visual impairment will be excluded; including people who have corrected to normal vision (use of glasses or some type of contact lens, eye surgery, etc.), people with strabismus, who consume some type of psychotropic, who have any other mental illness and/or psychological disorder and people who suffer from claustrophobia.

The protocol aims to analyze the effects on the three ergonomic factors in reading (legibility, readability, visibility) in official health advertising in smokers and non-smokers. For future studies, some measures can be omitted and/or replaced according to interest.

4. METHODOLOGY

In this test an analysis was made within the Human Computer Interaction (HCI) system, measuring oculomotor parameters such as fixation duration and saccade amplitude; parameters that are considered as indicators of cognitive load (Crosby et al., 2001); and fixation durations are considered as indicators of readability in texts (Rello, 2016). All the data obtained were of a quantifiable nature.

Having as tasks for the participant to read the information and observe the images to understand the message; obtaining through the eye tracker areas of interest or "target words" that the participant had to "find"; search technique used in research with reading and that analyzes the factors of text comprehension (readability) not related to the visual qualities of the text (Beier, 2009).

4.1 Participants

The participants who participated in this pilot test met the strict inclusion requirements: they had to be able to read and write, be Mexican nationals, be between 25 and 40 years of age, gender was indistinct as well as whether or not they were chronic smokers, and they should not have any type of visual disability (even vision corrected to normal) or any type of mental disorder and/or illness.

The sample for this pilot test was only two people, since this test is part of a final research protocol. It should be noted that 5 to 10 participants are suggested for a pilot test, but because we are still in a period of pandemic COVID-19, it used only this number of participants for convenience, in order to advance and refine some aspects for the future adequacy of the project.

4.2 Setting

The study was carried out in a test laboratory within the Behavioral and Health Research Center in the University Center of the Valleys of the University of Guadalajara.

The laboratory has an area of 10.86 m2 (square meters): it is distributed with three pairs of fluorescent light lamps, cold light of 5,900 lm (lumens) each at a distance of 1.5 m (meters) approximately from the ceiling to the table; which reach, all turned on at the same time, 15,900 - 16,200 lx (lux); sufficient amount of lux (15,000 lx, approximately, for daylight) which, as mentioned by Mur (1985), is the amount of lux that is reached at the highest point of daylight, taking into account the geographical area where we are located: Guadalajara; therefore, said amount of luxes were the ideal and the necessary ones to be able to simulate daylight for the realization of this study.

4.3 Materials and equipment

4.3.1 Stimulus object

The stimulus object used for this test was the health advertisement in both visual representations in the user interface (Fig. 1, Fig. 2). Each participant was presented with the same images and the same information; the only change was "background color":

Fig. 1: Image of the interface in light mode

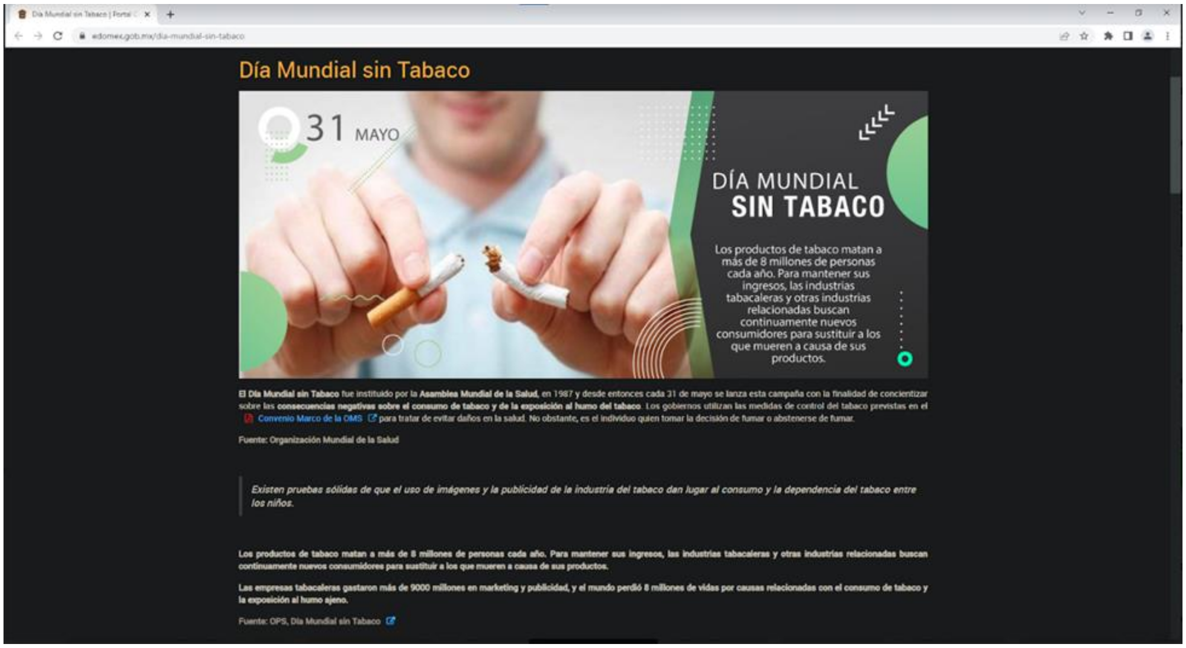

Fig.2: Image of the interface in dark mode

4.3.2 Visualization

The visualization of the user interfaces was on a desktop computer with a 27" (inches) screen with a Full High Definition (Full HD) resolution of 1920 x 1080 (pixels); non-reflective of 250 nits, with the maximum brightness level of the screen.

It should be noted that the distance between the participants, the screen and the eye tracker was between 63 and 65 cm.

4.3.3 Recording

Both video and sound were recorded throughout with two different devices: a digital voice recorder with high-sensitivity microphones, for sound; and a high-end smartphone for video.

4.3.4 Eye tracking

Gaze tracking was measured with a high-cost Tobii brand eye tracker, model X2-30 Compact.

4.4 Timing

Participants had only 60 seconds to view and read each of the images: 60 seconds for the dark mode interface and 60 seconds for the light mode interface.

4.4.1 Breaks

At all times there were breaks, some longer than others, and the breaks that were taken were: first to accustom the participant to the change in lighting, whether it started with a lot of light or with little light; the next was during the change from one interface to another, with the same purpose: to get used to the change in lighting; and the last was to end the test and return to the adaptation of the pupil to the exterior light; and while this break was taking place, a short interview of only three questions was given to each of the participants. Rest times were approximately 30 to 120 seconds, depending on the case.

4.5 Research design

The way in which the images were presented to the participants, were following the research design proposed for the final protocol (Tab. 1): Factorization of Variables with Counterbalancing:

Tab. 1: Research design

	ADVERTISING			
GROUPS	DAY	NIGHT		
1	A	B	LIGHT MODE	BACK
2	A	B	DARK MODE	GRO
3	B	A	LIGHT MODE	UND
4	B	A	DARK MODE	

A: First conditions with which the participant will start
B: Last conditions with which the participant will end

4.6 Protocol

The test was divided into two experimental series counterbalancing the factors of light/dark interface and day/night illumination: where participant #1, and following the research design, started with the interface in light mode and daylight level; and ended with the interface in dark mode and no light; and participant #2 started with the interface in light mode and no light; and ended with the interface in dark mode and daylight.

At the end of the test, and as previously commented, a simple series of questions, three only, were applied (Fig. 3) to know the user's experience in their participation in the study and also to obtain some other data that may go unnoticed in the user in front of their experience both in the test in general, and in each of the interface modes.

1. Did you manage to read everything?
2. From what you read, what did you understand?
3. Do you have any general comments? On any topic: some annoyance, some suggestion, something you want to add, etc.

Fig. 3: Questions to finalize the test

The duration of the test was approximately 15 minutes and only a single application per participant was necessary; they received instructions before the test and training before starting; and at all times the COVID-19 sanitation protocols recommended by the Health Situation Room (2022) were respected: use of masks, minimum distance of 1.5 m from person to person, use of antibacterial gel and disinfection of the test area between one participant and another.

5. RESULTS

5.1 Participant #1

Participant #1, and following the research design, started with the interface in light mode and daylight level; and ended with the interface in dark mode and no light.

Two videos were recorded directly with the eye tracker: one video for each of the modes; the first video (light mode/daylight) lasted 61.335 seconds and the second video (dark mode/no light) lasted 61.213 seconds.

From the first video, the image shown below (Fig. 4) is the one showing all the gaze tracking that was obtained directly from the eye tracker:

Fig. 4: First image shown to participant #1

From this first part of the test (light mode/daylight) the eye tracker obtained 2,247 events, of which: 435 were fixations, grouped in 98 moments; where the slowest fixation was 394 ms (milliseconds) and the fastest was 61 ms; thus giving an average fixation time of 153 ms (Fig. 5).

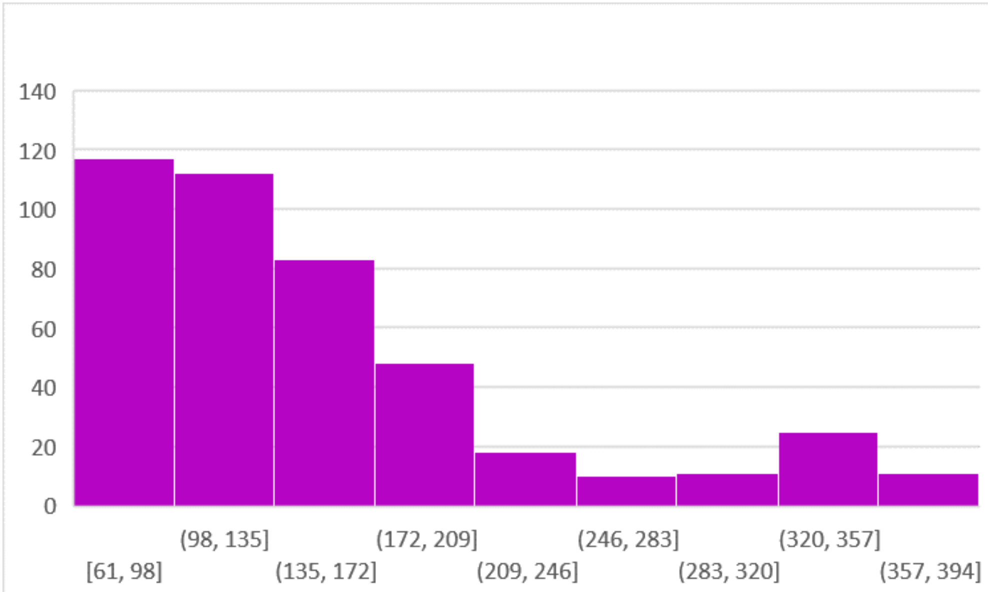

Fig. 5: Fixing times and number of fixations

Also, 1,408 saccades were obtained, grouped in 387 moments; where the slowest saccade was 586 ms and the fastest was 25 ms; thus giving an average of 158 ms of saccade time (Fig. 6).

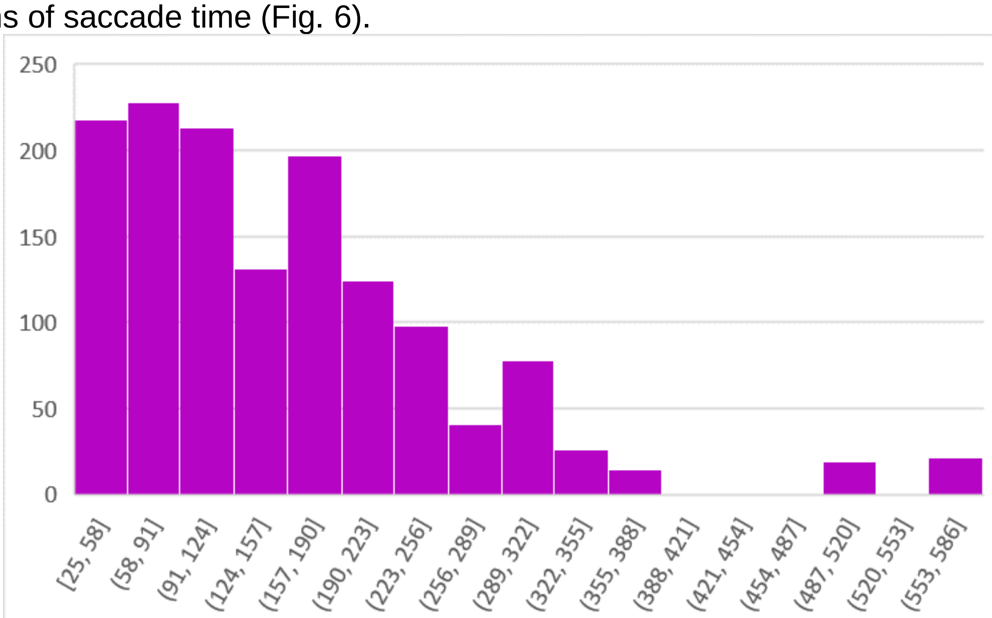

Fig. 6: Saccade times and number of saccades

And finally, 404 unclassified movements were obtained.

Pupil size started at 3.25mm in the left eye and 3.50mm in the right eye; and ended at 3.00mm in the left eye and 2.80mm in the right eye; thus giving an average pupil dilation of 2.92mm in the left eye and 2.98mm in the right eye.

From the second video, the image below (Fig. 7) is the one showing the entire gaze tracking that was obtained directly from the eye tracker:

Fig. 7: Second image shown to participant #1

In the second part of the test (dark/night) the eye tracker obtained 2,180 events, of which: 432 were fixations, grouped in 83 moments; where the slowest fixation was 412 ms and the fastest was 61 ms; thus giving an average fixation time of 182 ms (Fig. 8).

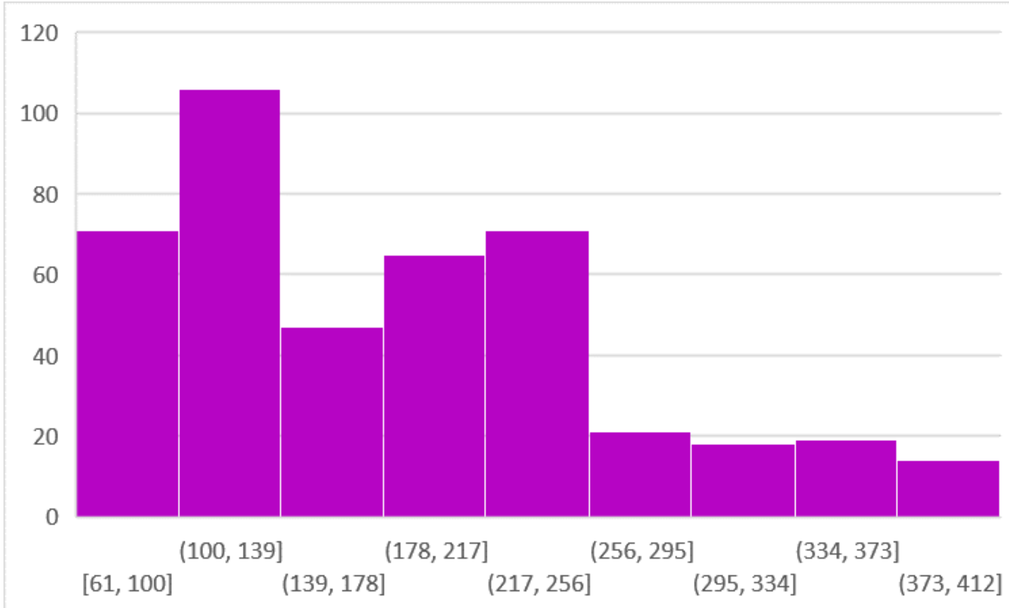

Fig. 8: Fixing times and number of fixations

Also, 1,313 saccades were obtained, grouped in 349 moments; where the slowest saccade was 480 ms and the fastest was 25 ms, giving an average saccade time of 169 ms (Fig. 9).

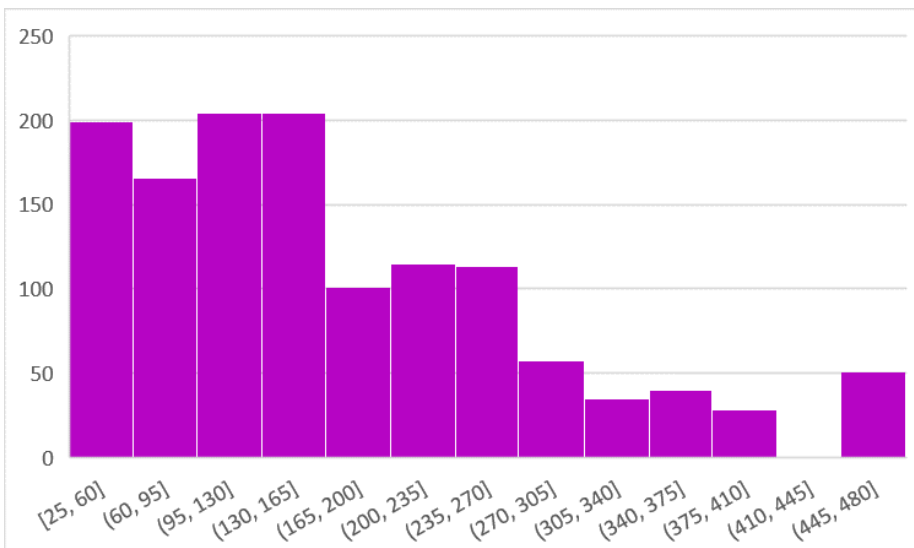

Fig. 9: Saccade times and number of saccades

And finally, 435 unclassified movements were obtained.

Pupil size started at 2.72mm in the left eye and 2.58mm in the right eye; and ended at 3.11mm and 3.41mm respectively; thus giving an average pupil dilation of 3.01mm in the left eye and 3.25mm in the right eye.

In the second part of the test, with the dark mode and without light, the participant was able to read most of the text.

5.2 Participant #2

Participant #2, started with the interface in light mode and no light; and finished with dark day mode and daylight.

Two videos were recorded directly with the eye tracker: one video for each of the trials; the first (light/night) lasted 61.345s and the second (dark/day) lasted 61.250s.

From the first video, the image shown below (Fig. 10) is the one showing all the gaze tracking that was obtained directly from the eye tracker:

Fig. 10: First image shown to participant #2

From this first part of the test (light mode/night light) the eye tracker obtained 2,057 events, of which: 1,463 were fixations, grouped in 163 moments; where the slowest fixation was 1,236 ms and the fastest was 60 ms; thus giving an average fixation time of 426 ms (Fig. 11).

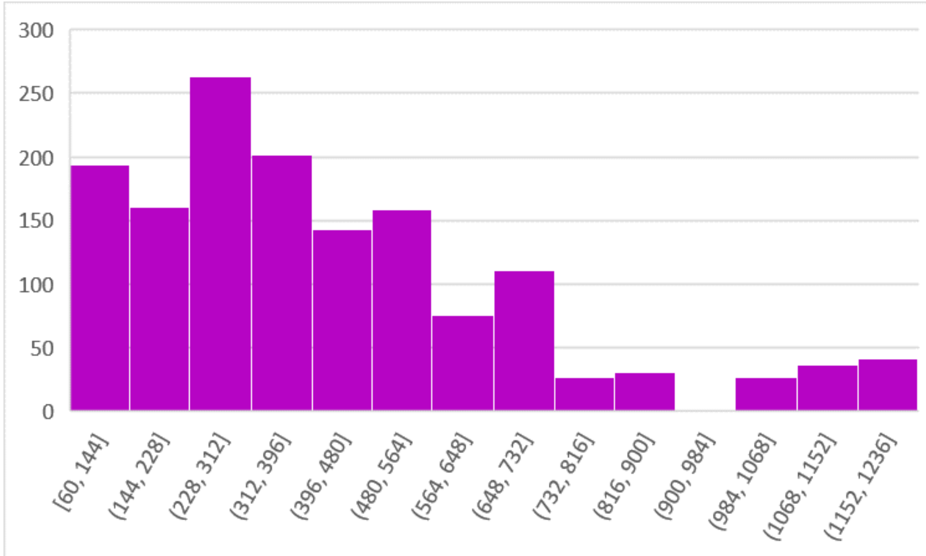

Fig. 11: Fixing times and number of fixations

Also, 338 saccades were obtained, grouped in 211 moments; where the slowest saccade was 243 ms and the fastest was 27 ms; thus giving an average saccade time of 67 ms (Fig. 12).

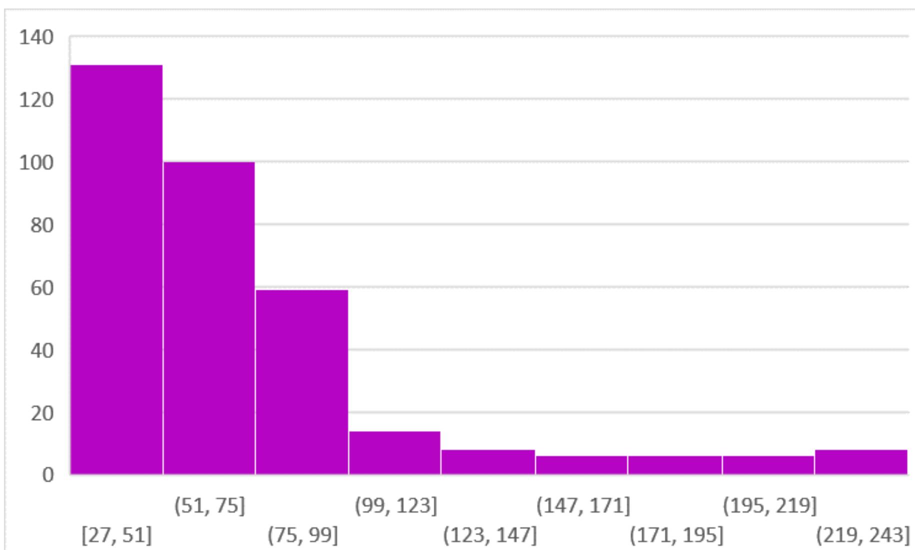

Fig. 12: Saccade times and number of saccades

And finally, 256 unclassified movements were obtained.

Pupil size started at 4.95mm in the left eye and 5.31mm in the right eye; and ended at 3.43mm and 3.42mm respectively; thus giving an average pupil dilation of 3.63mm in the left eye and 3.58mm in the right eye.

From the second video, the image below (Fig. 13) is the one showing the entire gaze tracking that was obtained directly from the eye tracker:

Fig. 13: Second image shown to participant #2.

In the second part of the test (dark/day) the eye tracker obtained 1,843 events, of which: 1,224 were fixations, grouped in 157 moments; where the slowest fixation was 1,219 ms and the fastest was 62 ms; thus giving an average of 424 ms fixation time (Fig. 14).

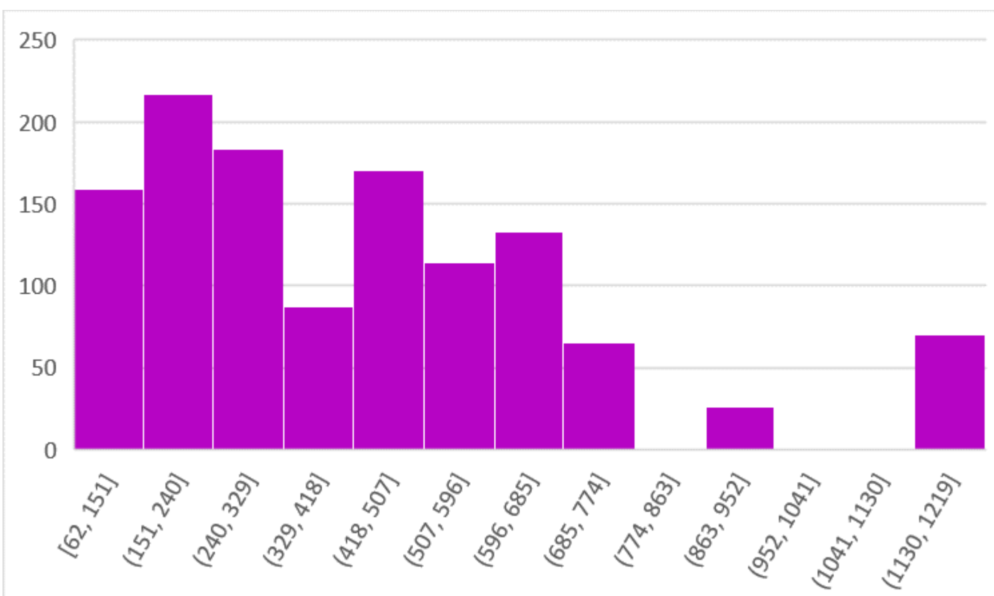

Fig. 14: Fixing times and number of fixations

Also, 307 saccades were obtained, grouped in 194 moments; where the slowest saccade was 197 ms and the fastest was 26 ms; thus giving an average saccade time of 69 ms (Fig. 15).

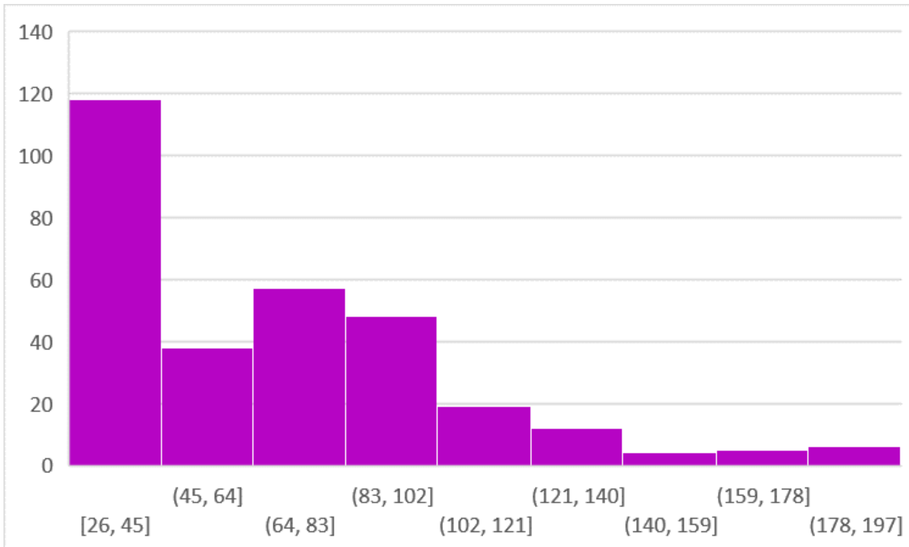

Fig. 12: Saccade times and number of saccades

And finally, 312 unclassified movements were obtained.

Pupil size started at 4.23mm in the left eye and 4.44mm in the right eye; and ended at 4.72mm and 4.40mm respectively; thus giving an average pupil dilation of 4.41mm in the left eye and 4.24mm in the right eye.

It is also noteworthy that, in the dark mode, the participant was able to read most of the text.

6. DISCUSSION

From the results obtained, and according to the information found in the literature where it is mentioned that fixations correspond with the desire to maintain the gaze on an object of interest; and saccades are considered manifestations of the desire to voluntarily change the focus of attention (Reyes, 2017); they are two main measurements of ocular behavior that provide valuable information in the participant: measures can be used in many ways to analyze particular aspects of ocular behavior (Ehmke & Wilson, 2007).

More specifically in eye tracking, fixations are referred to as a series of gaze points held in a constant direction that the participant observes toward a stationary target; and saccades are interpreted as the rapid oculomotor movements that occur between each of the fixations.

Eye fixations provide a deeper insight into participants' attention that can be measured in several ways: time from first fixation, duration of fixation, and total number of fixations (Poole & Ball, 2005). These numerical measures play a significant role in the interpretation of the user's eye behavior. In addition, these measures provide different explanations for the behavior: for example, a higher frequency of fixation on a particular object indicates an important object, while a long fixation duration suggests a difficulty in processing information (Goldberg & Kotval, 1999).

Thus, fixation/saccade ranks provide us with information about the participant's behavior; that is, whether he/she is processing information (which is elicited through fixations), or whether he/she is searching for something (which is elicited through saccades). Thus, a greater number of saccades indicates searching behavior (Goldberg & Kotval, 1999; Liversedge and Findlay, 2000; Poole et al., 2004).

What this means in a nutshell is that, if the saccades are short, it means that the participant is searching for information; and if they are long, it means that a good connection is being made between word and word. On the other hand, in the fixations, if they are short, it means that the participant is having ease in reading the text; and if they are long, it means that the participant is having difficulty both reading and comprehending the text. And finally, there is pupil dilation, in this case, measured through the diameter; since this, and according to some studies, can be used as an indicator of cognitive workload (Bailey et al., 2007; King, 2009): which means that if the pupil is dilated, the cognitive load and processing are high.

Which can be better explained with the following table (Tab. 2):

Tab. 2: Representation of the measurement of saccades and fixations with respect to the duration of each of them and their score

-	+	
Saccades	**Fixations**	L x - E x
Fixations	**Saccades**	L ✓ - E ✓
L ✓ - E x	L x - E ✓	

- = Less long (shorter duration)
+ = Longer (longer duration)
L = Reading measured through the saccades
E = Understanding measured through fixations
✓ = Positive score
x = Negative score

Having mentioned all of the above, and taking into account the data obtained in this test, it could be observed that participant #1, both in the first part of the test and in the second part, obtained more saccadic movements than fixations. But on the other hand, participant #2, both in the first part of the test and in the second part, obtained more fixations and fewer saccades. Participant #1's saccades were much longer than her fixations; and participant #2's fixations were much longer than her saccades. And the pupillary dilation in participant #1 in the first part of the test decreased .25 mm and .70 mm in the left and right eye, respectively; and in the second part increased .40 mm and .85 mm; and in participant #2 in the first part of the test she considerably decreased her pupil size: 1.50 mm and .90 mm; and in the second part of the test one eye increased pupil size and the other had a barely perceptible decrease: the left right pupil increased .50 mm and the right pupil decreased .04 mm.

In addition, in both participants #1 and #2, the dark mode interface favored reading (regardless of the number of saccades and/or fixations); since in both participants reading was more fluid; in both cases they were able to read a greater number of words in the same amount of time.

Concerning participant #1 eye-tracking performance having: +saccades/-fixations the result could be related with her positive scores in reading and understanding; on the other hand, participant #2 having: +fixations/-saccades could be related with negative scores in reading and understanding. However, it is necessary to increase the number of participants and improve the methodology to better understand the relation of the variables involved in this study.

And finally, in the final interview answers, both participants agreed that with the interface in dark mode they were able to read the information "faster"; both gave their answer about "what they understood" of all the information they read and both also agreed that, in neither part of the test, they were able to read the information completely; which tells us that 60 seconds are not enough to read the complete information of the advertisement.

7. CONCLUSIONS

Taking into account all the information described above, it can be said that the oculomotor movements are quantitative metrics, which offer more precise data about what is actually happening in the cognitive process of the person, because it is not enough that they mention that they understood something if in the end the results may be different.

Another fact to consider is that pupil dilation, although it is closely linked to cognitive processes, and for obvious reasons to light, can also be closely related to other external agents, especially to emotions or to what the participant is feeling and/or experiencing when seeing and reading the information in the advertisement.

And finally, we also have to take into account that both participant #1 and participant #2, the dark mode interface favored reading much more than the light mode; since, in both cases, they were able to read more text, regardless of the number of fixations and saccades they obtained in the eye-tracker test.

However, regardless of the level of ambient illumination, viewing the interface in dark mode was always in second place, so it cannot be ruled out that the favoring of "faster" reading was due to a bias of memory and of already knowing what the text said. For this reason, and for future work, the order of the series of both factors (interface/lighting) must be balanced, as described in the research design, in order to avoid this type of bias in reading.

Therefore, legibility was reflected and measured through the number and size of saccades; readability was through the number and size of fixations; and visibility in pupil size.

So, up to this point of the research, the recommendation would be, for reading, the interfaces in dark mode are the ones that favor it more, on the other hand, the least recommended in this case, would be the reading with light mode in places where there is little or no light; since the other conditions (light mode/daylight - dark mode/daylight) do not present physiological alterations (in the eyes) as drastic as if it was presented in the condition of light mode/night light.

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ERGONOMIC DESIGN OF THE PRODUCTION AREA OF A BIOINSECTICIDE BASED ON ENTOMOPATHOGENIC FUNGI AND PLANT EXTRACTS AT THE TECNOLOGICO NACIONAL DE MEXICO CAMPUS GUASAVE

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Resumen El presente proyecto muestra información de una investigación que se desarrolló con la finalidad de generar un diseño ergonómico del área de producción de un bioinsecticida a base de hongos entomopatógenos y extracto de vegetales en el Tecnológico Nacional de México campus Guasave.

"Ergonomía es la disciplina científica que trata de las interacciones entre los seres humanos y otros elementos de un sistema, así como, la profesión que aplica teoría, principios, datos y métodos al diseño con objeto de optimizar el bienestar del ser humano y el resultado global del sistema". (EIA, 2000).

EL diseño ergonómico del área de producción de un bioinsecticida a base de hongos entomopatógenos y extracto de vegetales ayudo de manera significativa a mejorar el proceso en las operaciones y las condiciones de trabajo, seguridad, control de inventario, reducción de tiempo, logrando un mejor manejo en esa área. Sé evalúo las condiciones de trabajo del proceso de producción de bioinsecticida, Se realizó la toma de datos durante 3 semanas para presentar la propuesta de diseño.

Palabras clave: Bioinsecticida, análisis de trabajo, Diseño ergonómico

Relevancia para la Ergonomía: El diseño de los espacios de trabajo es esencial en la productividad de los procesos. La aportación de la ergonomía garantiza la optimización de los recursos y la optimización de los sistemas Hombre- Máquina. Generando un sistema más eficiente en sus operaciones, cuidando la seguridad y salud del trabajador.

Abstract: The present project shows information from a research that was developed with the aim of generating an ergonomic design of the production area of a bioinsecticide based on entomopathogenic fungi and plant extracts at the Tecnológico Nacional de México campus Guasave.

"Ergonomics is the scientific discipline that deals with the interactions between human beings and other elements of a system, as well as the profession that applies theory, principles, data and methods to design in order to optimize the well-being of human beings and the overall performance of the system". (EIA, 2000).

The ergonomic design of the production area of a bioinsecticide based on entomopathogenic fungi and plant extract helped significantly to improve the process in the operations and working conditions, safety, inventory control, time reduction, achieving a better management in that area. The working conditions of the bioinsecticide production process were evaluated. Data was collected for 3 weeks in order to present the design proposal.

Keywords: bioinsecticide, job analysis, Ergonomic Design

Relevance to Ergonomics: The design of workspaces is essential in process productivity. The contribution of ergonomics guarantees the optimisation of resources and the optimisation of Man-Machine systems. Generating a more efficient system in its operations, taking care of the safety and health of the worker.

1. INTRODUCTION

Sinaloa is the main producer of grains and vegetables in Mexico, due to the great variety and quality of foods derived from the field, which are recognized nationally and internationally. The agricultural leadership of our state is based on the production of crops such as corn, wheat, potatoes, squash and many others. This makes it one of the most representative activities of our region. (CODESIN, 2020).

In the state of Sinaloa there is a total of 1,626,551 hectares planted in which the grains that stand out are corn, beans, sorghum, wheat, for legumes beans and chickpeas and for vegetables white onion, tomato and others. Guasave has approximately 200,000 hectares of irrigated land, making it the municipality with the largest planted area in Mexico. It produces a wide range of crops such as corn, wheat, beans, rice, cotton, chickpeas and vegetables (Reho, 2015).

Within the federative entity, contamination is part of food production, due to the use of agro-inputs for the elimination of pests, such as the whitefly. Based on this, a bioinsecticide based on entomopathogenic fungi and vegetable extracts was developed at the Instituto Tecnológico Superior de Guasave, taking care of good practices, safety and health of workers.

The Society of Ergonomists of Mexico AC (SEMAC, 2020), points out that ergonomics in human factors, is the scientific discipline related to the knowledge of the interaction between human beings and other elements of a system, and the profession that applies theory, principles, data and methods to design seeking to optimize human welfare and the execution of the Global System.

However, through the efforts it is seen that within the bioinsecticide production processes in laboratories and experimental field there are risks and musculoskeletal injuries that are present.

Musculoskeletal injuries have a huge and growing impact worldwide, from the perspective of productivity and economics of the industry. In Mexico, musculoskeletal pathology is one of the main causes of morbidity, as established by evidence according to IMSS statistics for 2011, where it is reported that the number of occupational hazards in total was 536,322 cases (IMSS, 2014).

It is known that, in Mexico, for 2016, the IMSS registered 12 thousand 622 cases of occupational diseases, of which 4 thousand 683 (37.1%) were musculoskeletal, placing them among the groups of occupational diseases with the highest rate of occurrence. The above, is equivalent to 2 out of 5 cases of work-related diseases related to this type of diseases (Work, 2017).

In this study, an ergonomic design of the production area of a bioinsecticide based on entomopathogenic fungi and plant extracts was carried out to reduce musculoskeletal injuries and risks to which the worker is exposed when performing his activity.

The production processes involve two male workers between the ages of 25 and 35, with an 8-hour workday; in general, they perform 10 to 20 operations per day. Part of the process is carried out in the laboratory and the other part in the experimental field area of the institute.

The environmental conditions to which they are exposed, one part of the day in a controlled thermal environment at 23 to 25 degrees Celsius and the other in the experimental field with a temperature between 38 to 42 degrees Celsius and 30% humidity. Other conditions considered in the proposal were that the heights and spaces assigned for operations do not comply with the official Mexican Standards of the Ministry of Labor and Social Prevention (STPS). Ergonomic evaluation methods were applied, such as the Rapid Upper Limb Assessment Method (RULA).

2. OBJETIVE

Ergonomic design of the production area of a bioinsecticide based on entomopathogenic fungi and plant extracts at the Tecnológico Nacional de México campus Guasave.

3. DELIMITATION

The project is established at the scale level of the experimental phase production quantity of the bioinsecticide based on entomopathogenic fungi and plant extracts, considering scaling up according to the demand and needs of the product.

4. METHODOLOGY

The study was carried out in several stages:

1.- To elaborate a current diagnosis of the production process of the bioinsecticide. Through the identification of STPS Standards and ergonomic principles.

2.-. To carry out evaluations for the identification of musculoskeletal injuries and cumulative trauma disorders through ergonomic evaluation methods.

3.- Design the production area with ergonomic and safety conditions in the production process.

5. RESULTS

This project was developed in two phases, the first one was the production of the biorational insecticide and the other one was mixtures with vegetables and application.

The first phase consists of carrying out the production process of the biorational insecticide made from entomopathogenic fungi in the laboratory, which is divided into 3 parts: preparation of the inoculum, liquid fermentation and solid fermentation.

In the part of liquid fermentation and solid fermentation, it was detected that the operations that are carried out in the laboratory, only good practices and the use of personal protective equipment have to be taken care of. However, there are activities that last 2 or 3 hours and the heights of the tables or equipment are not within the reach of the operator, presenting inadequate postures, doing the activity continuously for 5 hours.

Figure 1. Station 1 Preparation of liquid fermentation

Figure 2. Station 2 of the Bioinsecticide production process.

In the processing of vegetable extract liquid, it was detected that the operations carried out in the experimental field do not use personal protective equipment and the distribution of operations are not oriented to the flow of the production process, generating downtime and unnecessary movements. However, there are activities that last 2 or 3 hours and the heights of the tables or equipment are not within the reach of the operator, presenting inadequate postures, doing the activity continuously for 5 hours, as well as the temperatures to which they are exposed is 38 to 42 degrees Celsius causing fatigue and physical exhaustion.

Design of the work environment based on standards

Based on what is stipulated in the NOM regulations of the STPS, the conditions with which the facilities must have are reflected, as well as the details of each of the areas of the production line, giving a reference for the proper design.

Lighting

NOM-025-STPS-2008 Standard NOM-025-STPS-2008 Minimum lighting levels are 20 lux outdoors. Based on the activities performed in the laboratory and in the experimental field where natural light is used.

Noise

NOM-011-STPS-2001 standard regarding safety and hygiene conditions in workplaces where noise is generated; the following table shows that work can be performed for a period of 8 hr with a maximum level of 90 dBA. See table 1

Table 1. Permissible Exposure Limits

dBA	Time
90	8 hr
93	4 hr
96	2 hr
99	1 hr
102	30 min
105	15 min

Material handling and storage

Standard NOM-025-STPS-2008 Regarding the handling and storage of materials, a visual inspection and functional test of the machinery must be performed at the beginning of each workday, as applicable, to verify the proper condition and operation of the elements. Have emergency stop devices for the machinery, and warnings about its maximum load capacity and delimit to prevent access to the machinery operation areas to workers or persons not involved in the material handling work, as well as to keep these areas free of obstacles. As well as ensuring that the worker uses personal protective equipment.

Results of Corlett & Bishop Method and Rula Method

Through the application of the Corlett & Bishop method in the elaboration of a biorational bioseticide, the activities carried out in the production process present a record of cumulative trauma disorders (CTD'S), pain and discomfort in: neck, legs, upper, middle and lower back. Presenting postural problems during the work period.

In the sowing method with device presents a record of cumulative trauma disorders (CTD'S), aches and pains in: neck, upper back, upper, middle and lower back. It does not present postural problems during the work period.

The application of the Rula ergonomic evaluation method indicates that the posture of station 1 generates a level 4 result (prompt investigation, future change).

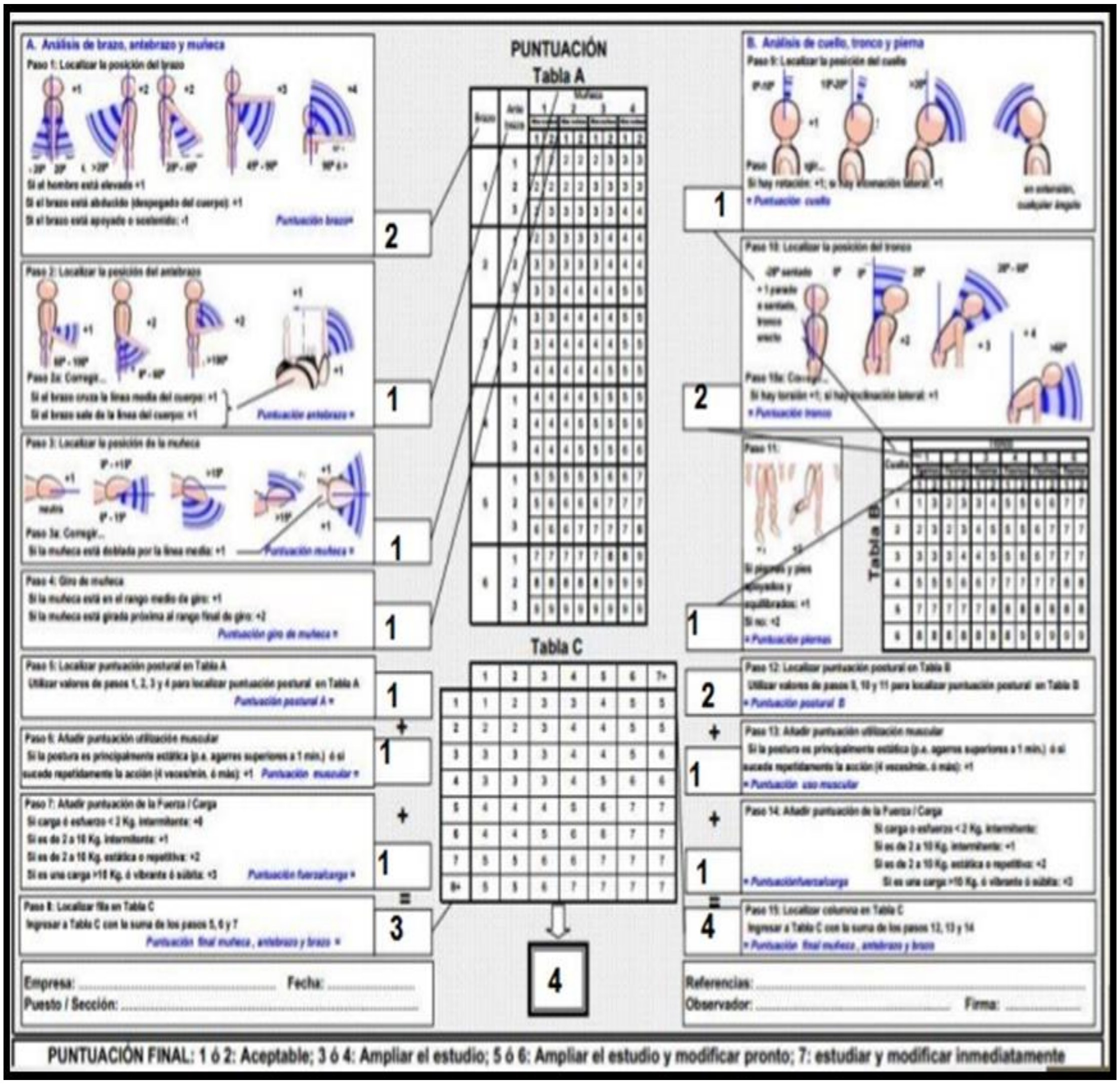

Figure 3 Application of the RULA method in station 1.

For station 2 it generates the result of level 6 (Early investigation and immediate change).

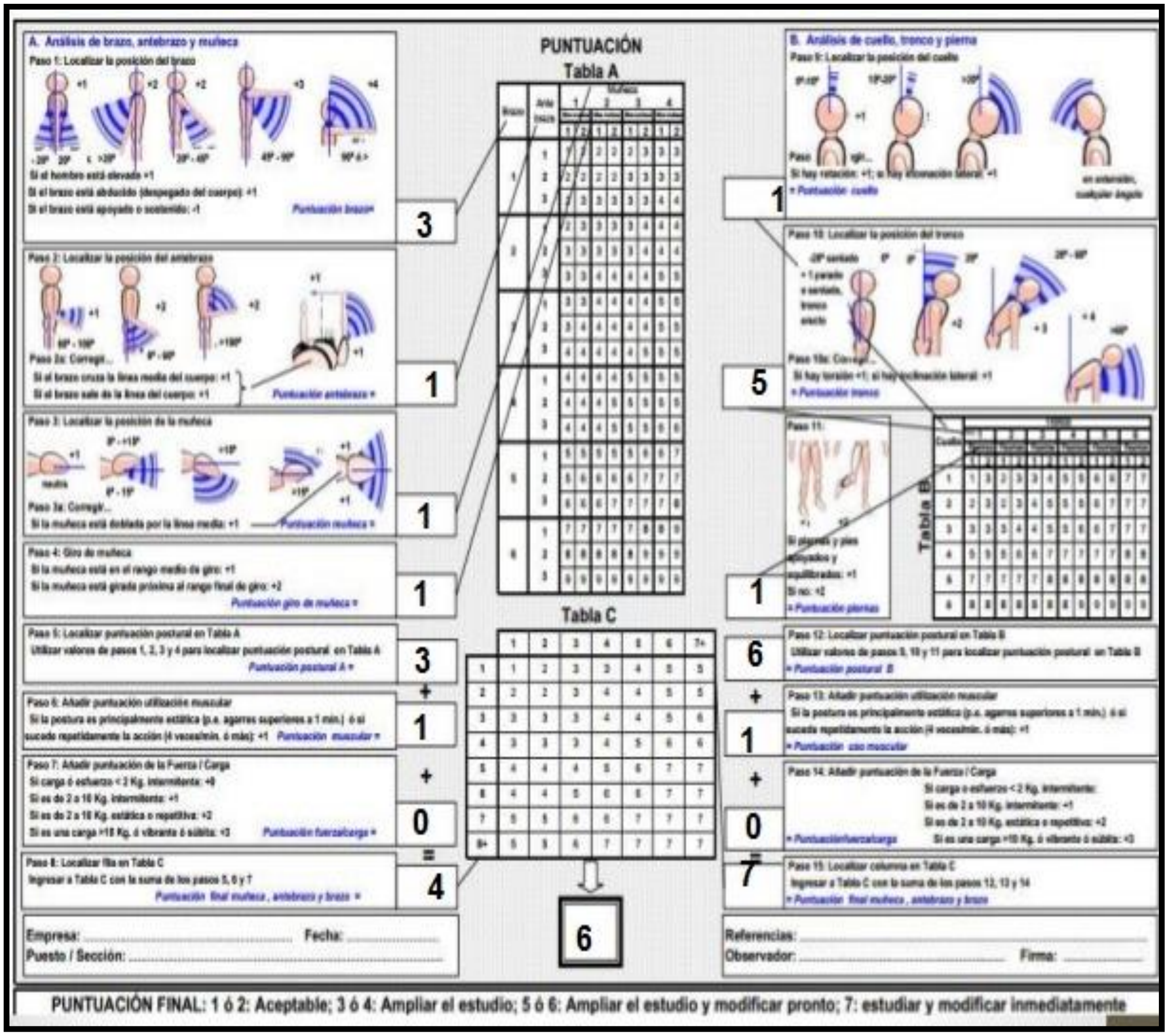

Figure 4 Application of the RULA method in station 2

Design of work areas

Based on the results of the ergonomic evaluation methods, a proposal for the redesign of workstations in the area of liquid processing of vegetable extracts is required.

The plant needs identified were as follows:
The physical space for the allocation of machinery and equipment needed was:

Table 2.Physical space required

	Length	x	width=	Scuare meter x	Stations of number	Total of scuare meter
Shredder	1		0.50	0.50	1	0.50
Drying table	3		0.60	1.8	1	1.8
Weighing machine	0.40		0.30	0.12	1	0.12
Barrel 200L	0.57		0.57	0.32	2	0.64
Tinaco	1.5		1.5	2.25	1	2.25
Tina/tarja	1.3		0.5	0.65	1	0.65
				Total of scuare meter =		5.96
				Scuare meter of 150%=		8.94

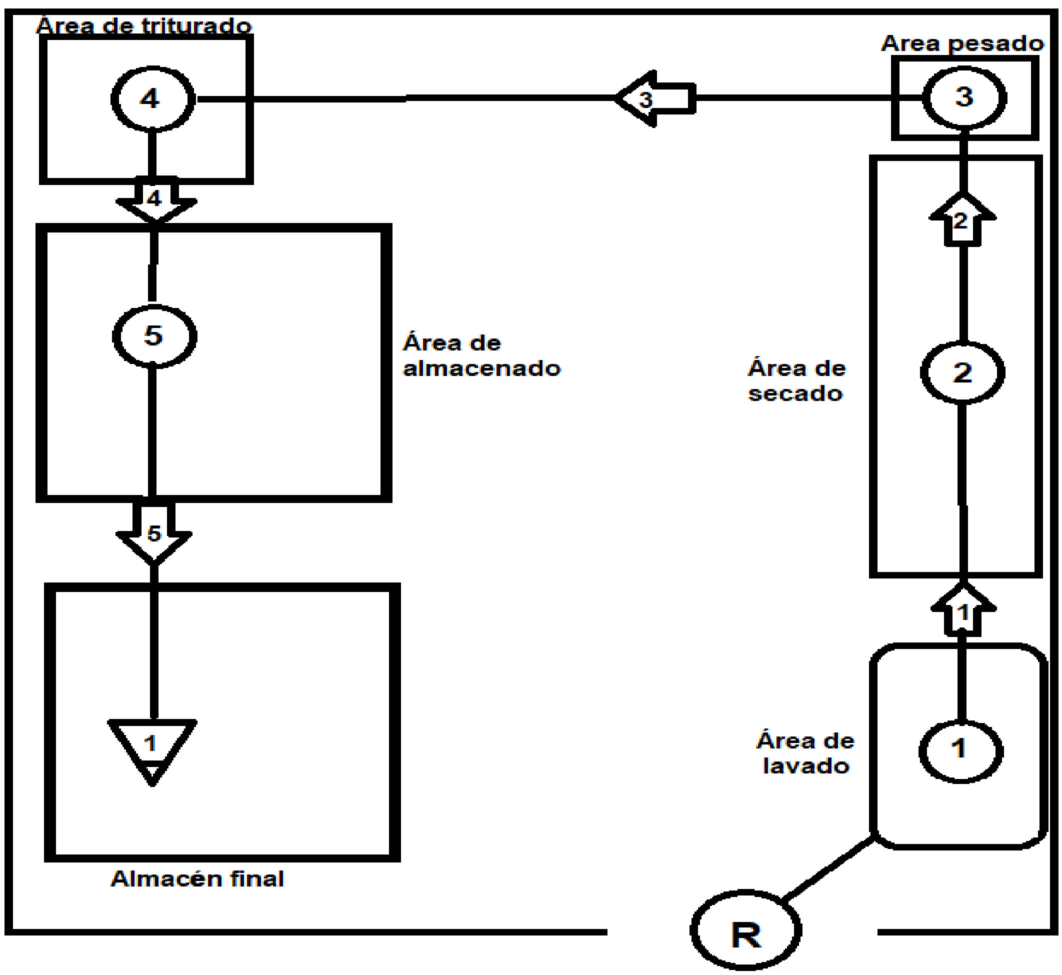

Figure 5. Overall plant flow diagram

6. CONCLUSIONS

The analysis of ergonomic conditions allows detecting the risk factors that workers are exposed to when performing operations in the agricultural field. Worker productivity is affected by environmental conditions, temperature, humidity and inadequate work methods.

Based on the results of the Corlett & Bishop method, only 3 cumulative trauma disorders (neck, upper back and lower back) are identified as permissible indicators for station 2. The RULA method detects a level 6 for the activity of vegetable extraction and for station 1 of the laboratory it yields a result of level 4, indicating that the operations performed in the extraction of vegetables have a higher risk. Generating representative musculoskeletal injuries in the workers in the future.

An investigation was carried out in which the ergonomic principles were identified based on what is stipulated in the norms of the Secretary of Labor and Social Welfare, which must be taken into account in production systems similar to the one we intend to carry out, where the different important aspects to take into account when designing the workstations are shown, having an adequate work environment is important not only from the point of view of the workers, but also for the company to improve their time and use of its resources.

A pilot test of the bioinsecticide production process was carried out in the space that is intended for this process to be carried out. This test was used to study different issues of the production line, such as the postures present when performing the activities in order to detect which of these are considerable risk for the worker, as well as the time spent in the different operations, to have a precedent and to obtain the standard times for each of the operations.

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COMPARATIVE STUDY OF ERGONOMIC POSTURAL ASSSSMENT TOOLS FOR SCULPTORS

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Resumen: Los desórdenes musculoesqueléticos (DM) se consideran las enfermedades más prevalentes a nivel mundial. Los DM relacionados con las tareas laborales representan la mayoría de las patologías ocupacionales, que resultan en restricciones laborales, días de trabajo perdidos y en otras ocasiones el retiro temprano de los trabajadores. La adopción eficiente de posturas mejora el desempeño en el trabajo y reduce los DM. En el trabajo de escultores existen factores de riesgo de DM. Para conocer las causas los DM y reducir su incidencia, es necesario identificar los factores de riesgo que intervienen en su manifestación. En esta investigación se han empleado dos procedimientos de evaluación postural: Rapid Upper Limb Assessement (RULA) y OWAS (Ovako working assessment system) para evaluar en el ambiente de trabajo, el riesgo postural de tres tareas: cernido, amasado y modelado de 39 escultores de la ciudad de Hermosillo, Sonora. El objetivo de este trabajo es determinar si existen diferencias entre los dos métodos para determinar el de nivel de riesgo ergonómico de las tareas de los escultores. Se planteó una prueba de hipótesis sobre la igualdad de medias en los niveles de riesgo generados por los dos procedimientos. Los resultados revelan que no existe suficiente evidencia estadística para rechazar la hipótesis de igualdad de medias de niveles de acción entre ambos métodos por lo que ambos procedimientos pueden emplearse indistintamente para evaluar las tareas de cernido, amasado y modelado de los escultores.

Palabras clave: Postura, estudio, escultores.

Relevancia para la ergonomía: Existen diferentes opciones para realizar evaluaciones posturales, el procedimiento presentado en este trabajo ofrece una opción para tomar una decisión sobre el método a emplear.

Abstract: Musculoskeletal disorders (MD) are the most prevalent disease worldwide. Work-related MD accounts for most occupational pathologies, resulting in work restrictions, lost workdays, and at other times early retirement of workers. Efficient posture improves work performance and reduces MD. Risk factors for MDs exist in the work of sculptors. To know the causes of MD and reduce its incidence, it

is necessary to identify the risk factors involved in its manifestation. In this research, two postural assessment procedures have been used: Rapid Upper Limb Assessment (RULA) and OWAS (Ovako working assessment system) to evaluate the postural risk of three tasks in the work environment: sifting, kneading, and modeling of 39 sculptors in the city of Hermosillo, Sonora. The objective of this work is to determine if there are differences between the two methods to define the level of ergonomic risk of the sculptors' tasks. A T-student test was used to determine if the two sample ergonomic risks means are equals. The results reveal that there is not enough statistical evidence to reject the hypothesis of equality of means of action levels between the two methods so that both procedures can be used indistinctly to evaluate the sifting, kneading, and modeling tasks of the sculptors.
Key words: Risk, assessment, postural, visual artists.
Relevance for ergonomics: There are different options to perform postural evaluations, the procedure presented in this paper offers an option to decide on the method to be used.

1. INTRODUCTION

Globally, musculoskeletal disorders (MD) are considered an occupational health problem in industrial and manual labor sectors (Rahman, Khan, Rahman, & Biswas, 2019). Musculoskeletal diseases are a health concern in developed and developing countries (Jadhav, Arunachalam, & Salve, 2019). Oakman et al. (2019), indicate that problems in the musculoskeletal system have an impact on the health of workers. The Occupational Safety and Health Administration (Occupational Safety and Health Administration, OSHA, 2021) notes that musculoskeletal problems affect worker performance. According to the Health and Safety Executive (HSE, 2021), in 2020, musculoskeletal disorders accounted for 30% of occupational illness cases, and 27% of the causes of lost workdays. In the United States of America, the Bureau of Labor Statistics (Goode, Newnam, & Salmon, 2019) states that MD accounts for 31.8% of occupational illnesses and injuries. On the other hand, Davis & Kotowski (2015), indicate that diseases of the musculoskeletal system are work-related and prevalent in many occupations. Dianat et al, (2020) indicate that they are a prevalent health condition among manual workers. Furthermore, Mrunalini & Logeswari (2018) point out that sculptors belong to an informal labor sector suffering from musculoskeletal system diseases. Several proposals have emerged to identify ergonomic risk factors of MD. Among them, are the observational and automated observational methods (Chen et al., 2018). Observational methods to assess risk factors include the Rapid Entire Body Assessment (REBA) method (Hignett & McAtamney, 2000), Rapid Upper Limb Assessment (RULA)(McAtamney & Nigel Corlett, 1993), and the Ovako Working Posture Analysis System (OWAS) method (Karhu, Kansi, & Kuorinka, 1977). Bodin et al., (2020) indicate that to know the causes of MD and reduce its incidence, it is necessary to identify the risk factors involved in its manifestation.

2. OBJETIVE

In this research, two postural assessment procedures have been used to to evaluate in a laboratory environment, the postural risk (three different tasks: sifting, kneading, and modeling) of 39 sculptors from the city of Hermosillo, Sonora. The observational methods are the Rapid Upper Limb Assessment (RULA) and the OWAS (Ovako working assessment system). The objective of this study is to determine if there are differences between the two methods to determine the ergonomic risk level in the sculptor tasks.

2.1 Delimitation

The present study aims to conduct a comprehensive procedure to decide in regard to the postural assessment to be used in the context of the sculptor's job.

3. METHODOLOGY

3.1 Participants

Fifty professional sculptors from the city of Hermosillo, Sonora, Mexico were recruited for the development of this research. Thirty-nine sculptors were selected, all of whom met the following inclusion criteria: no history of MD development, not being pregnant, and not being under medical prescription. The selected sculptors decided to participate voluntarily in the experimental process. The demographic data of the sample considered in this study are as follows: Sex, age, mass index and marital status. The work characteristics investigated were the following: work experience, work stress, other work activity besides sculptor, and difficulty in performing the work.

3.2 Consent to participate

Workers who met the selection criteria were asked to participate in this study, and 100% (N=39) of them stated that they agreed to do so. The study was approved by the Ethics Committee of the Asociación de Artistas Plásticos de Sonora. The researcher conducted a session to present the methodology and purpose of the study. Participants were free to withdraw from the study at any time and those who chose to do so were provided with the results of the study. During the initial visit, it was found that the workers were unaware of the occupational risk factors in their workplace.

3.3 Postural assessment methods

Establishing which ergonomic methods are suitable for identify risk factors associated with MD depends on the accuracy required to assess the task demand

and the risks associated with it. There are several procedures for assessing the risks, which are divided into the following groups:
- Methods that assess job demand using a checklist or questionnaire.
- Methods that assess the demand by considering the whole body.
- Methods that only consider the upper limbs of the body.
- Methods that consider the different parts of the body.

Among the methods that assess the upper limbs are RULA (Rapid Upper Limb Assessment), REBA (Rapid Entire Body Assessment), OWAS (Ovako Working posture assessment) (Karhu et al., 1977), LUBA (Postural loading on the upper body assessment) (Kee & Karwowski, 2001). Two procedures were chosen for this research: RULA and OWAS, since sculptors perform their tasks imposing a greater postural load on the upper limbs of the body. It is desired to compare both methods in terms of the levels of action they suggest when evaluating the task.

3.4 Description of the sculptors' tasks

The work schedules of the sculptors were carefully observed for one week, before starting the data acquisition process. The work schedule of the sculptors is from 3:00 to 9:00 p.m. for five consecutive days a week. The first task performed by the workers is to sift the ceramic to separate foreign materials, which is then hydrated. This sifting work is exhausting. Once the ceramic powder is hydrated, the mixture is deposited in piles of plaster to reduce the humidity, after which the sculptors begin the kneading process to eliminate air bubbles and prepare the models. Afterwards, the molds are made, which are then dried and prepared for casting with slip that is prepared and poured into them. Finally, the molded pieces are removed from the molds and air-dried, and then baked in an oven. After baking, the pieces are painted and baked again to cure them.

3.5 Postural assessment

In this study, the postural assessment was performed using the Rapid Upper Extremity Assessment (RULA), which included the following: identification of the most demanding postural tasks through video and digital photography resources (Video camera 4K 10X optical zoom camera ORDRO Ultra HD Wi-Fi video camera). The body posture and limb angle of the movement were observed, and several repetitions performed by sculptors were observed, and the RULA rating for each body part was determined, according to the method instructions. Finally, the results were grouped into tables and converted into RULA scores, which were grouped into corresponding action level categories. The RULA assessment was first performed to identify the tasks with the highest postural risk, then the RULA assessment was implemented for the selected tasks.

For the OWAS method, all observed postures were coded using a four-digit rating corresponding to back, arms, legs, and load supported. A total of 84 code combinations results from all the elements considered. The load supported is considered according to different categories: < 10 kg, between 10 and 20 kg and > 20 kg. The risk of the different postures is categorized in four categories based on the increase of postural stress on the body: the first one corresponds to a normal posture without additional requirements for ergonomic evaluation, the second one corresponds to postures with some adverse effects and requirements for ergonomic intervention actions, the third one considers postures with relevant effects on the musculoskeletal system and ergonomic actions as soon as possible and the fourth one for postures with very large effects and requirements for urgent ergonomic intervention.

3.6 Experimental design

The positions of the arm, back, legs and load supported were examined for the 39 workers in the three tasks considered in this study, using the OWAS method; the dependent variable being the level of action considered in the method. On the other hand, the forearm, arm, wrist, neck, back and leg positions were considered as independent random variables for the RULA method, and the dependent variable is the corresponding action level according to the table of ratings of the procedure. The participants performed the three tasks, and each was assessed with both methods. Table 1 shows the correspondence between independent variables for both methods, and a set of example values are shown in the table to show how a data set is generated for a single intervention in a specific task:

Tabla 1
Independent variables and associated risk levels

RULA scores																	
Sifting						Kneading						Modelling					
Group A			Group B			Group A			Group B			Group A			Group B		
Forearm	Arm	Wrist	Neck	Back	Leg	Forearm	Arm	Wrist	Neck	Back	Leg	Forearm	Arm	Wrist	Neck	Back	Leg
2	1	1	2	1	1	5	2	2	4	1	1	3	1	1	3	2	1
RULA score				3		RULA score				7		RULA score				3	
RULA action level				2		RULA action level				4		RULA action level				2	

OWAS scores											
Sifting				Kneading				Modelling			
Back	Arms	Legs	Load	Back	Arms	Legs	Load	Back	Arms	Legs	Load
4	2	2	1	4	2	1	3	1	2	2	1
OWAS action level		2		OWAS action level		3		OWAS action level		1	

This data set is generated for the 39 sculptors in the three tasks evaluated, resulting in 117 data sets with the configuration presented in the table. The postures of the segments indicated in the table were evaluated for each task and each sculptor, generating a total of 3510 data.

3.7 Statistical analysis

The data obtained for the different postures were evaluated with a normality test using the Kolmogorov-Smirnov (k-S) test. Student's t-tests were performed with a significance level =0.05 to compare the means of the dependent variables in each of the postures evaluated with respect to the methods considered: RULA and OWAS.

To establish the differences between the means of the values of the dependent variables in both methods, the action levels for the OWAS method were regrouped to homogenize the data to compare the results of action levels for both methods. The analyses were performed using SPSS V 24 software.

4. RESULTS

In this research, 3510 postures corresponding to the following body segments were studied: back, arm, legs, forearm, wrist, neck, in addition to the external load supported by the body, for three tasks of the sculptors: sifting, kneading, and modeling. The corresponding action levels were determined for the RULA and the OWAS methods, and the data were statistically processed to compare the action levels between the two methods and for each task to determine if there is statistical evidence to say that the means of action levels between the RULA and REBA methods are equal at a significance level of =0.05.

4.1 Demographic and occupational characteristics of the sculptors

The sample consisted of 39 professional sculptors working in six workshops in the city of Hermosillo, Sonora, Mexico, who belong to the Association of Plastic Artists of Sonora. The demographic characteristics of the sculptors are shown in Table 2:

Table 2 Demographic characteristics of sculptors

Characteristics	Variables	Value
Age (years)		
	Mean	37.23
	Range	24-62
	Standard deviation	11.10
Sex (%)	Women	9 (30%)
	Men	70 (70%)
Body index mass	Mean	27.83
(kg/m^2)	Range	23.71-34.31
	Standard deviation	3.89
Marital status (%)	Married	26 (66.67%)
	Single	13 (33.33%)

According to Table 2, the age of the sculptors is in the range of 24 to 62 years (with a mean of 37.23 years and a deviation of 11.10 years), 30% of the participants are women, their mass index is in the range of 23.71 to 34.31 kg/m2.

4.2 Statistical analysis

This section presents a summary of the results of the statistical analysis, which will allow us to draw conclusions regarding the objectives set.

4.2.1 RULA and OWAS action levels

The action levels determined for each of the evaluated tasks are shown in Figure 1, we observe that for the modeling tasks the OWAS and RULA method have equal values of action levels. The action levels are very different in the kneading task; for action level 3, OWAS presents a considerably higher frequency. The task that presents more consistencies in the action levels suggested by the methods is the modeling task, being the sifting task in which the apparent differences are greater.

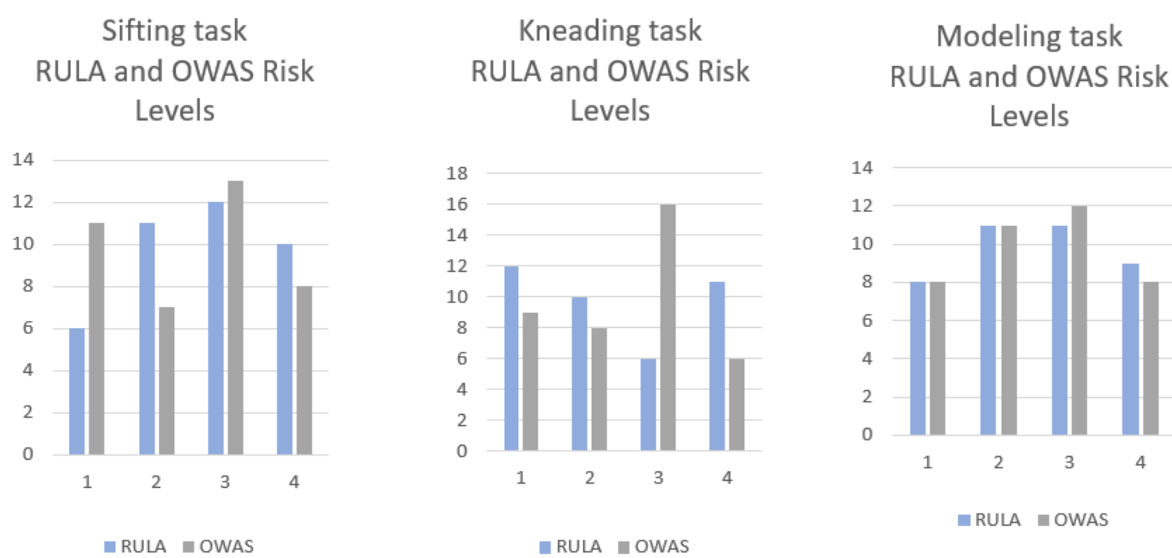

Figure 1 RULA and OWAS risk levels

4.2.2 Normality of data and T-student's test

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The normality test was performed on the data set according to the Kolmogorov-Smirnov (K-S) test, in which the hypothesis of data normality was accepted, according to the results shown in Table 4:

Tabla 4
RULA y OWAS action levels (K-S test)

Method	n	Mean and standard deviation	p
RULA	117	2.401 ± 1.145	0.000
OWAS	117	2.307 ± 1.133	0.000

Based on the results obtained, it is feasible to perform a T-student test to compare the means of action levels of the RULA and OWAS methods.

4.2.3 T-Student Test

In this study, the MD risks of the sifting, kneading, and modeling tasks of a sculptor were evaluated, for each of them the postures of the forearm, arm, back, legs, neck, trunk and wrists were considered. Two methods were used: RULA and OWAS with the purpose of establishing if there are differences between both methods, in terms of the level of action with which they qualify a task. Table 5 shows the results of the T-Student test from which the means of the action levels in the three sculptor tasks are compared, with a significance level = 0.05.

Table 5 T-student test

Tasks	RULA ACTION LEVEL		OWAS ACTION LEVEL		
	Mean	Standard Deviation	Mean	Standard Deviation	T-test*
Sifting	2.641	1.135	2.564	1.071	0.426
Kneading	2.282	1.191	2.205	1.196	1.596
Modeling	2.526	1.056	2.371	1.255	0.000

*Two tail T-test, α=0.05

The results reveal with a significance level of 0.05, that there is not enough statistical evidence to reject the hypothesis of equal means for this test, so that both methods are consistent with each other for the three tasks evaluated and therefore can be used interchangeably to perform postural risk factor assessments. Similar studies have been conducted, for manual tasks (Chiasson, Imbeau, Aubry, & Delisle, 2012), (Chung, Lee, Kee, & Kim, 2002) (Chung, Lee, & Kee, 2003), (Hellig, Mertens, & Brandl, 2018). The results reveal in these cases, the consistency between methods when manual tasks are evaluated.

5. CONCLUSIONS

The MD risk factors of 39 sculptors from six workshops in the city of Hermosillo, Sonora, were determined according to the RULA and OWAS methods. The body regions evaluated were the arm, forearm, back, legs, trunk, neck, as well as external load. A total of 3510 postures were identified and evaluated according to the guidelines of the RULA and OWAS methods. The action levels required by each method were determined for each of the three tasks evaluated, which are sifting, kneading and shaping. Four categories of risk levels were considered for each method. The means between the two procedures for the three tasks were compared using a T-student test. The results revealed that there is not enough statistical evidence to reject the hypothesis of equality of means, therefore, both methods are adequate to evaluate this type of tasks. From the results obtained we can conclude that, although the statistical tests reveal that there are no differences in the averages of action levels suggested by the RULA and OWAS methods, according to the results, a consistency in results was obtained only in the modeling activity, which is one of the activities with the lowest postural load, in relation to the other two, which are kneading and sifting. It is possible that these differences in the kneading and sifting tasks are related to the fact that the postural loads of both are greater, in addition to the fact that the extra load is different in both cases, since in sifting the external load supported is less than the external load supported in the kneading process. In a future study, it would be convenient to analyze all sculpting tasks to make inferences with a broader spectrum of postures.

Conflict of interest: None to report.

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EVALUATION OF BACK POSTURE AT A WORKSTATION IN THE HOME OFFICE MODALITY

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RESUMEN Una de las principales partes del cuerpo que se ven afectadas por malas posturas es la espalda debido a no se cuentan con sillas adecuadas para el personal que realiza labores de oficinas; hoy en día la modalidad de trabajo HomeOffice ha tomado mucha popularidad diferentes empresas y a menudo suele pasar por desapercibido el hecho de que el trabajador realice sus labores desde casa con una posición de la espalda incorrecta. Por este motivo en el presente documento se busca evidenciar y evaluar una mala postura de la espalda de un trabajador, el cual utiliza una silla convencional. El análisis se realizó mediante el uso del Software Ergonautas, específicamente ocupando el método ROSA. Se encontró que el trabajador corre un riesgo con la posición actual que tiene al momento de desarrollar sus actividades, por lo cual se concluye que es requerida una acción para mejorar la postura y así evitar cualquier tipo de trastorno musculoesquelético relacionado con una mala postura de la espalda.

Palabras clave: Trabajo en casa, Método ROSA, Ergonomía, Desórdenes musculoesqueléticos

Relevancia para la ergonomía: La modalidad de trabajo HomeOffice ha tenido un incremento considerable en estos últimos años debido a la pandemia, esto provoca que los empleados que llevan a cabo su trabajo desde casa, salgan de la visibilidad de la empresa por lo cual es más difícil supervisar que cuenten con equipo adecuado para una correcta postura de la espalda y sufran alguna lesión, es por esta razón que se debe realizar un análisis y poder eliminar cualquier riesgo ergonómico que puedan correr los trabajadores.

ABSTRACT One of the main parts of the body that are affected by poor posture is the back due to not having adequate chairs for the staff that performs office work; Today the HomeOffice work modality has become very popular in different companies and the fact that the worker carries out his work from home with an incorrect back position often goes unnoticed. For this reason, in this document we seek to demonstrate and evaluate the poor posture of the back of a worker, who uses a conventional chair, the analysis was carried out using the Ergonautas Software, specifically using the ROSA method. It was found that the worker runs a risk with the current position that he has at the time of carrying out his activities, for which it is concluded that an action is required to improve posture and thus avoid any type of musculoskeletal disorder related to poor posture of the worker back.

Keywords: HomeOffice, ROSA Method, Ergonomics, Musculoskeletal disorders

Relevance for ergonomics: The HomeOffice work modality has had a considerable increase in recent years due to the pandemic, this causes employees who carry out their work from home to leave the visibility of the company, which is why it is more difficult to supervise that they have adequate equipment for a correct posture of the back and suffer an injury, it is for this reason that an analysis must be carried out and any ergonomic risk that the workers may run can be eliminated.

1. INTRODUCTION

According to the International Ergonomics Association (2000), ergonomics "is the scientific discipline concerned with understanding the interactions between humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design to optimize human well-being and overall system performance".

Ergonomics takes into consideration physical, cognitive, social, organizational, and environmental factors, but, with a "holistic" approach, in which each of these factors should not be analyzed in isolation, but in their interaction with each other.

According to Forbes magazine (2021) and according to a study by Adobe Forrester, 67% of the world's workforce has turned the home office into a working modality and another 39% of companies state that they will adopt telework on a permanent basis.

From this arises the need to start paying much more attention to the different workplaces that adopt this modality, prepare special courses for the staff that will develop their activities in this way, and talks to them about possible ergonomic risks they may run.

In this case, a risk factor for the health of a worker in the office sector will be addressed. These factors are related to the tools that the worker uses, such as keyboard, mouse, monitors, desk, and chair, among others. The main obstacle is the design of the equipment used by the worker, as well as the position he/she adopts. This means that having a chair and a desk that are not ergonomically adapted to the work to be performed can directly affect the worker's health, specifically in the back area. All this is analyzed using the Rapid Office Strain Assessment (ROSA) method, which is especially aimed at evaluating ergonomic situations in office workstations (Sahlabadi, Karin, Khatabakshs, & Soori, 2020). This is in order to find possible risks to the operator's health and to find some actions that can be improved so that the worker has an adequate workstation and tools. It was decided to address this issue in the HomeOffice modality, since as the personnel is working outside the company's facilities, certain situations that affect the worker may go unnoticed.

Figure 1 shows how the worker is currently working, using a chair that is not ergonomic for a day's work.

2. OBJECTIVE

To evaluate the level of risk that the employee runs with the back position in which he/she finds himself/herself with the chair shown in Figure 1, and to be able to determine or recommend some alternative to improve the position.

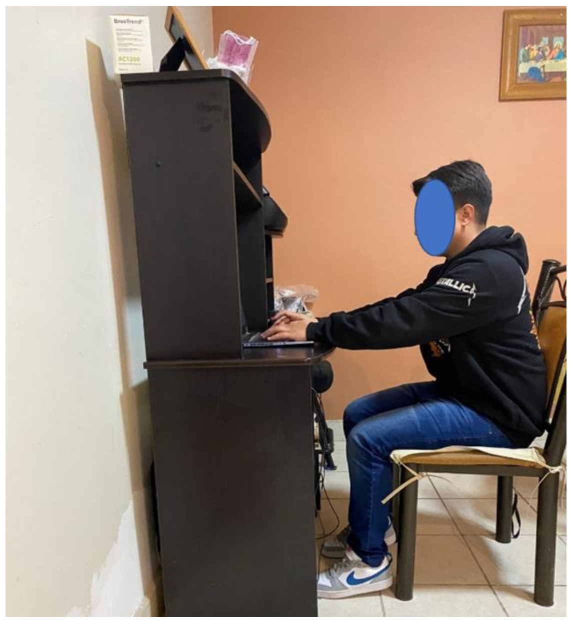

Figure 1. The incorrect posture adopted by the worker

3. DELIMITATION

This project is applied to employees who are working in HomeOffice mode, directed to the Post Marketing area of the company Hillrom, which carries out its activities in this modality already mentioned. The project analyzes only the risk factors that affect the back posture of one of the employees.

4. METHODOLOGY

The methodology used is the Plan-Do-Check-Act (PDCA) cycle, which is coupled to the project, since it complies with the guidelines of this methodology.

According to the European School of Excellence (2019), the PDCA cycle, in ISO 9001, is one of the most used methodologies in quality management; and is used, among other issues, to plan the execution of activities, standardize and control processes and always focus on customer satisfaction. The PDCA cycle consists of four phases: Plan, Do, Check, and Act (Gorenflo and Moran, 2009; Realyvásquez Vargas et al., 2018), which are mentioned continued below (Mutafelija and Stronberg, 2013).

Figure 2 shows graphically the steps of this methodology and what each stage consists of. The following is a detailed description of how these stages of the PDCA methodology are carried out.

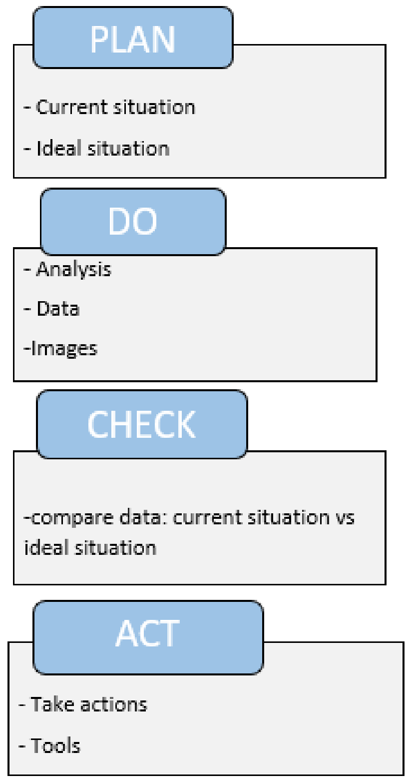

Figure 2. PDCA methodology

4.1 Plan

It is necessary to analyze the posture of the worker to evaluate if there is a risk to the worker's health, then with the results obtained from the analysis, we can determine if the worker runs a risk of working with the equipment that has, in this case, a conventional chair, and with this to determine what improvements or equipment is right for the worker.

To perform the ergonomic risk analysis, we will use the Ergonautas software, based on the ROSA method, with this we will be able to have results to be able to obtain a conclusion and have some recommendations.

4.2 Do

To perform the analysis, as already mentioned, the ROSA method will be used in the Ergonauts software, in which the employee's data is entered, such as height, age, weight, name, and position, among other data necessary to obtain a complete evaluation. In addition, a photo of the employee is included, which will be taken in profile sitting at the workstation, so that the software can analyze the angles of the body and thus obtain the results and determine the level of risk caused by the posture.

The results will be in the ROSA method score which can go from 1 to 10 and in turn a level of risk.

4.3 Check

At the moment of having the results, it is important to verify them, in order to determine the ergonomic risk, the Ergonauts software itself shows if there is a risk, so a score of the ROSA method is obtained, in addition to this, it provides a work risk level and indicates if the work risk is low, medium or high.

4.4 Act

In this case, we will only make recommendations based on the results obtained, since at this time we do not have the resources to carry out major actions, so only a few recommendations will be made.

5. RESULTS

Based on the data provided on the dimensions of the workspace, handling of work tools, the distance between operator-machine, and postures in which the worker performs the activities, the Ergonauts software provided results that facilitated decision making in order to conclude and recommend some improvement to prevent an ergonomic risk.

Figure 3 shows the results obtained after performing the analysis, in which the ROSA method score obtained is 9, the work risk level is 4, which is extreme, and the action level indicates that action is urgently needed.

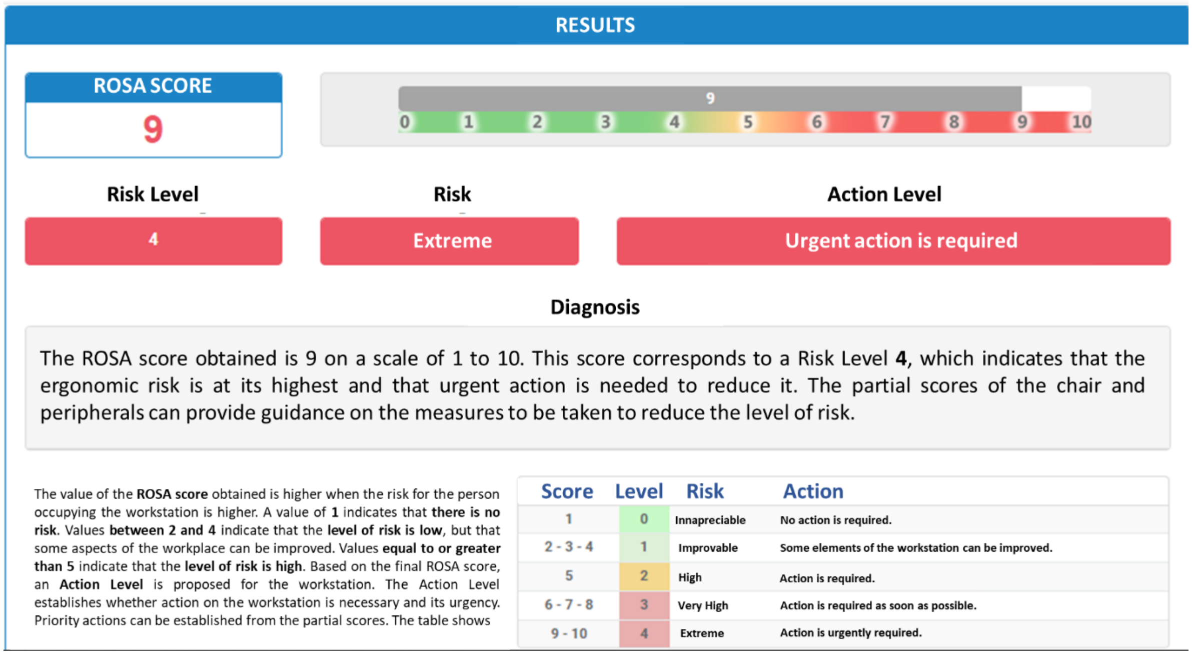

Figure 3. ROSA score

Figure 4 shows the results of the application of the pink method in the use of the operator's chair, giving a score of 9, indicating that the risk is too high in this evaluation and that action is urgently needed.

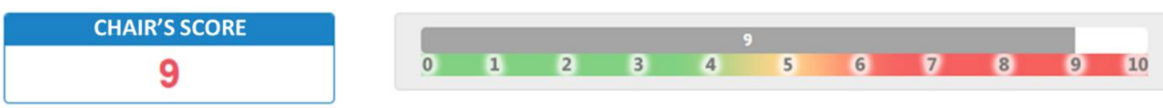

Figure 4. Chair's score

Similarly, Figure 5 shows the score for the use of the screen and peripherals, indicating a score of 1, which indicates a minimum risk for the operator.

Figure 5. Display and peripherals score

6. CONCLUSIONS AND RECOMMENDATIONS

Once the results of the analysis of the ROSA method were presented, we proceeded to improve the employee's work equipment. It was found that improving the employee's chair improves the ergonomics of the personnel and reduces the risk of back problems.

As can be seen in Figure 6, the chair used by the employee at his workstation is a conventional chair, whose function is not for work or for sitting for long periods of time, since it does not have a height adjustment or backrest adjustment. All of this causes the employee's workday to be very tiring and causes back discomfort.

As can be seen in Figure 6, the chair recommended for HomeOffice work is a special office chair, since its main function is to protect the employee's back, provide support in the lumbar area, avoid muscle fatigue, a chair that helps to take care of the worker's health.

Another recommendation is to extend this research to a larger sample size, which is more representative, at least of the students of a certain institution, a certain city, a certain country, or a certain level of studies.

Figure 6. Current chair and recommended chair.

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ERGONOMIC EVALUATION IN A GLASS INDUSTRY IN SAN LUIS POTOSÍ

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Resumen:La identificación de los factores generadores de riesgo disergonómico impacta en la salud y desempeño de los trabajadores. Es por tanto, que se realizó un estudio de las condiciones laborales, el nivel de riesgo y posibles afectaciones en el personal de una empresa del sector vidriero en México, porque se han observado exigencias fisiológicas importantes en la ejecución de las tareas diarias, por lo que requiere una corrección inmediata. **Objetivo:** Evaluar los factores de riesgo ergonómico en una industria vidriera de San Luis Potosí. **Metodología:** Estudio de caso efectuado de junio a septiembre de 2021 en el que se utilizó el método de LEST, NIOSH, RULA, ROSA y OCRA según el tipo de exposición y actividades de los puestos de trabajo. **Resultados:** Se observó que el 73 % de los puestos de trabajo cuentan con condiciones de nocividad para el trabajador, principalmente por una carga física, manejo manual de cargas y posturas forzadas. El método RULA evidenció que el 80 % de los puestos operativos se ubicaron en un nivel elevado lo que amerita tomar acciones para evitar lesiones musculoesqueléticas. Los puestos de trabajo con mayor exposición a movimientos repetitivos con riesgo inaceptable en el 75 % de ellos fueron los mecánicos electricista, de máquinas, reparador de molde y tornero, de servicio y energía, así como el operador empacador, lubricador, operador de silos y refractorista. En el caso del personal administrativo el 33 % presentó riesgo medio y 67 % riesgo alto. **Conclusiones:** Existen condiciones con oportunidades de mejora que son necesarias corregirse como son: la distribución de espacios, el uso continuo del manejo manual de cargas sumado a posturas forzadas que ya han impactado en la zona lumbar, hombros, cuellos y brazos.

Palabras clave: ergonomía, industria vidriera, postura forzada, manejo manual de carga.

Relevancia para la ergonomía: Evaluación global de puestos de trabajo, evaluación en industria vidriera para corregir las afectaciones en el sistema músculo esquelético. Propuesta de alternativas de control para los trabajadores del sector vidriero.

Abstract: The identification of ergonomic risk generating factors has an impact on the health and performance of workers. Therefore, a study of the working conditions, the level of risk and possible affectations in the personnel of a company in the glass sector in Mexico was carried out, because important physiological demands have been observed in the execution of daily tasks, which requires immediate correction. Objective: To evaluate the ergonomic risk factors in a glass industry in San Luis Potosí. Methodology: Case study carried out from June to September 2021 in which the LEST, NIOSH, RULA, ROSA and OCRA methods were used according to the type of exposure and activities of the workstations. Results: It was observed that 73% of the workplaces have harmful conditions for the worker, mainly due to a physical load, manual handling of loads and forced postures. The RULA method showed that 80 % of the operational workstations were at a high level, which warrants taking action to prevent musculoskeletal injuries. The jobs with the highest exposure to repetitive movements with unacceptable risk in 75 % of them were the electrical

Keywords. ergonomic, glass industry, forced posture, manual load handling.

Relevance to Ergonomics: Global evaluation of jobs, evaluation in the glass industry to correct damage to the musculoskeletal system. Proposal of control alternatives for workers in the glass sector.

1. INTRODUCTION

Working conditions are key elements in the study of workers' health and can be decisive so that work activity in practice is an ordeal when it should be the opposite (Naranjo, 2011). In addition to this, the consequences presented by both the worker and his family and his social environment are added, in addition to the economic costs for the companies, the city and the country where they are located; since these costs impact from monetary losses for compensation, costs of medical care, lost working days (including training and training of new personnel) and the interruption or stoppage of the production process; These costs represent up to 3.94% of the world's Gross Domestic Product (ILO, 2019).

In the Mexican legislation it is established from the Political Constitution of the United Mexican States in its sixth title in article 123 in which it is mentioned that every person has the right to a decent and socially useful job; as well as in its section XIV, where it states that employers will be responsible for work accidents and occupational diseases of workers, suffered by reason or in the exercise of the profession or work they perform; and section XV, where it states that the employer will be obliged to organize the work in such a way that it results in the greatest guarantee for the health and life of the workers (DOF, 2021).

Likewise, in the Federal Labor Law, article 132 refers to the obligations of employers with which they must comply with the provisions of the labor standards that are applicable to their company, in addition, they must inform their workers of the information on the risks and dangers to which they are exposed.

On the other hand, there is the Federal Regulation on Safety and Health at Work in which ergonomic risk factors are defined as those that may involve physical effort, repetitive movements or forced postures at work.

Every company must evaluate the disergonomic risks to which its work personnel may be exposed to take preventive measures. Sánchez (2016) mentions that in Mexico there is little evidence of the application of the LEST method, even though it is a good tool to carry out a complete ergonomic analysis.

Due to the above, a case study was carried out in a company in the glass sector in Mexico.

2. OBJETIVE

Evaluate the ergonomic risk factors exposed to the operative and administrative personnel of a glass industry in San Luis Potosí, Mexico.

3. METHODS

The following methods were used: LEST method for the global evaluation of working conditions, the use of specific methods such as the RULA method for postural overload; the ROSA method for office work and the OCRA Check-list method for activities with repetitive movements.

Process

1. The global evaluation of working conditions was carried out with the LEST method to analyze the agents and factors to which the workers are exposed, to know the main areas, the activities that are carried out and the jobs with the greatest exposure criticality.
2. Selection of ergonomic evaluation methods. Once the positions that are exposed to forced postures, repetitive movements and manual handling of loads were identified, the recordings of the representative activities were made.
3. Analysis of the results. With the help of four analysts, the materials were distributed to review the exposure conditions. From this, the RULA method was considered for positions with postural load exposure characteristics. Those who handle loads used the NIOSH method and the reference guide of NOM-036-1-2018. Those who were exposed to repetitive movements, the

OCRA method was used and finally for the administrative staff, the ROSA method was applied.

4. Graphic representation. With the use of excel, a database was generated to obtain the descriptive statistics of the results of the applied methods.

4. RESULTS

1.1 Recognition of the workplace

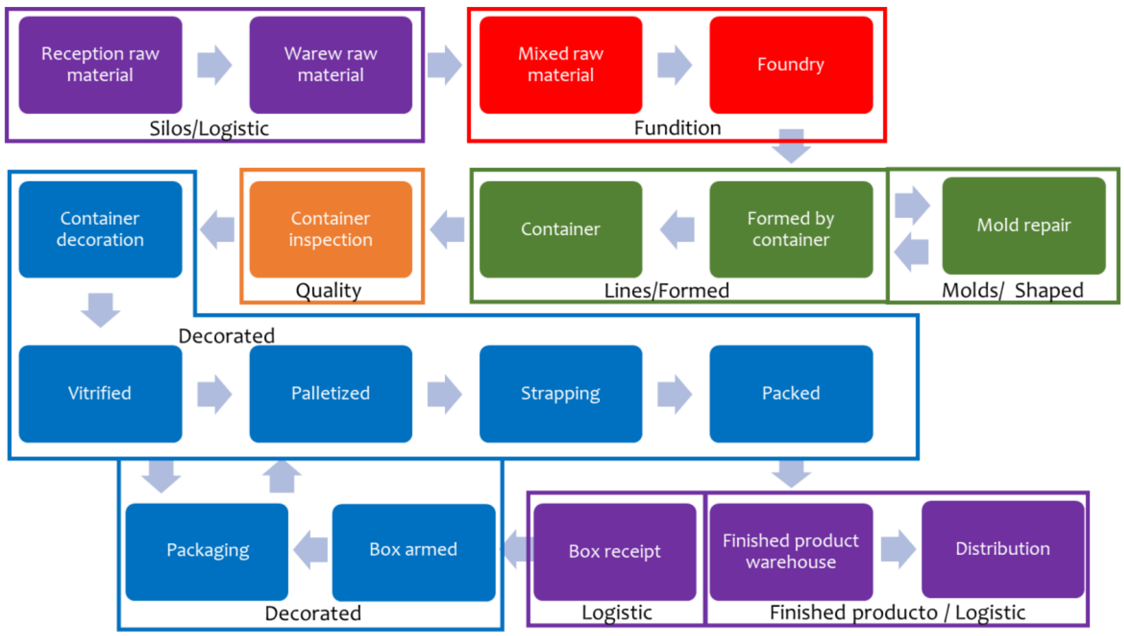

Figure 1. Sensory recognition on the workplace

Figure 1 shows the process of the glass industry, which begins with the reception of raw materials by rail and land, they are stored in two batteries of silos which are distributed to the four foundry furnaces that the organization has. The raw materials used to make the finished product are silica sand, sodium carbonate and calcium carbonate. To obtain the finished product, the vitreous mixture is prepared and sent to the foundry furnaces at a temperature of 1500°C.

The formation of the container begins with the feeding of the molten glass to the forming machines, which is fed to them in the form of candles. Once the containers are formed, they are gradually cooled by means of air and are tempered in annealing ovens. At the exit of these ovens, the containers are sprayed with a liquid solution that gives them lubricity on the walls for proper handling of them during their transportation.

The containers are inspected in automated equipment to rule out defects in the product so that later the containers arrive at decorating machines where the

labels are printed, the label printing process is carried out by means of screen printing and the paint used is of a low-point ceramic type. of fusion.
Once the labels have been printed, the containers are sent to ovens to vitrify the label on the container, this is done at a temperature of 640°C and is gradually cooled to room temperature.

Throughout the manufacturing process, the containers are subjected to different quality inspections and the non-conforming product is rejected. The rejected product is sent through the belts to the silo batteries, where it is stored for its addition to the glass mix formulation.

The container that meets the quality criteria is packed in cardboard boxes or palletized in bulk, being stored until the customer demands it. The shipment of the finished product is carried out by forklift and is sent to the client by land or rail, as appropriate, that is, by trailers or vans, respectively.

2.1 Evaluation of working conditions

Table 1. Results of the LEST METHOD.

Department	Workstation	Activity	LEST Overall evaluation of the job				
			Physical loacl	**Physical environment**	**Mental load**	**Psychosocial aspects**	**Work times**
Quality	Quality technician	Various quality tests	15	3.7	4	2.7	7.5
	Reviewer of various	Check for imperfections in the bottles	3.5	10	3.7	2.6	7.5
Decorated	Electrician mechanic	Give preventive and corrective maintenance to decorating machines	2	10	3.5	3.2	7
	Decorating machine operator	Operate the decorating machine	12.5	3.1	4.3	2.7	7.5
	Cashier operator	Operate and stock the box erecting machine	18.5	10	4	2.7	7.5
	Packer operator	Operate the packing machine	15	10	3.78	2.7	7.5
Formed	Machine mechanic	Give preventive and corrective	10	5	3.1	3.9	7

		maintenance to forming machines					
	Lubricator	Lubricate forming machines	10	10	5.7	3.2	7.8
	IS Machine Technician	Operate IS machine	10	10	4.2	3.8	7
	Mold repair mechanic and turner	Give corrective and preventive maintenance to molds	5	10	2.7	3.3	7
Fundition	Refractorist	Maintain ovens	10	10	5.7	3.9	7
Logistic	Silo Operator	Download transport raw material	6	10	2.8	3.3	8
	Technician of parts and spare parts	Dispatch and reception of materials	14.5	10	4.2	4.5	7.5
	Finished Product Forklift	Storage and shipment of finished product	14.5	10	3.2	4.2	7.5
Services and energy	Services and energy mechanic	Give preventive and corrective maintenance to pumps, fans and lighting	10	5	5.28	3.41	7.5

It was observed that in 11 (73%) jobs the physical load (static and dynamic) refers to harmfulness for the worker, and corrective actions are required; This qualification is mainly associated with the handling of loads and the postures acquired by the worker, such as sitting or standing with the arms raised above the shoulders or in extension, and the trunk leaning.

In the physical environment variable, it was observed that 73% of the jobs refer to harmfulness for the worker, mainly attributed to the physical load previously presented and to the temperatures of the work environment. It is observed that no job posts presented fatigue discomfort, or any discomfort associated with the total duration of the set of interventions per hour and the average duration of the operations carried out by the worker.

Regarding the psychosocial factors, no job post presented high scores that suggest improvements to provide more comfort to the worker. In the working time variable, breaks, work pace and hours worked are considered; It is observed that 1

(6%) job post presents a risk of fatigue, especially associated with the hours of the working day, because the pace of work is continuous and with rest periods. The results are summarized in Table 1.

3. 2 Ergonomics risk by workstation.

Table 2. Ergonomics risk by workstation.

Department	Workstation	Activity	Ergonomic risks			
			Postural overload	Manual handling of loads	Repetitive movements	Office activity
Quality	Quality technician	Various quality tests	X	X		X
	Reviewer of various	Check for imperfections in the bottles	X			
Decorated	Electrician mechanic	Give preventive and corrective maintenance to decorating machines	X	X	X	
	Decorating machine operator	Operate the decorating machine	X	X		
	Cashier operator	Operate and stock the box erecting machine	X	X		
	Packer operator	Operate the packing machine	X	X	X	
Formed	Machine mechanic	Give preventive and corrective maintenance to forming machines	X	X	X	
	Lubricator	Lubricate forming machines	X	X	X	
	IS Machine Technician	Operate IS machine	X	X		X
	Mold repair mechanic and turner	Give corrective and preventive maintenance to molds	X	X	X	

Fundition	Refractorist	Maintain ovens	X	X	X	
Logistic	Silo Operator	Download transport raw material	X	X	X	
	Technician of parts and spare parts	Dispatch and reception of materials	X	X		X
	Finished Product Forklift	Storage and shipment of finished product	X			
Services and energy	Services and energy mechanic	Give preventive and corrective maintenance to pumps, fans and lighting	X	X	X	

Subsequently, a specific method was applied for the ergonomic evaluation in each job according to the activity carried out, to carry out a personalized analysis in each one of them, whose results are summarized in Table 2.

Each job is presented for which it was determined if there were ergonomic risk factors, specifically physical ergonomics, such as: manual handling of loads, postural overload, repetitive movements, or those with office activities. In addition to the specific methods according to the ergonomic risks observed in each job, the LEST method (Working Conditions Analysis Method of the Laboratoire de Economie et Sociologie du Travail) was carried out to perform a global evaluation of the job of work.

It is observed that in all the jobs evaluated postural overload was found, so its evaluation was carried out with the RULA (Rapid Upper Limb Assessment) method to evaluate postural overload. In those positions where manual handling of loads was observed, the evaluation was carried out with the applicable reference guide of NOM-036-1-STPS-2018, Ergonomic risk factors at work-Identification, analysis, prevention, and control. Part 1: Manual handling of loads; while in the activities where repetitive movements are performed, the evaluation was carried out with the OCRA Check List method; and for those positions with office activities, the ROSA method (Rapid Office Strain Assessment) was carried out for a more specific evaluation.

2.3 Postural overload

The postural overload identified in all the workstations was evaluated with the RULA method, which considers the position of the neck, trunk, upper and lower limbs, as well as the forces exerted, grip and muscle activity.

In each job, the postures adopted by the worker were evaluated and the angles of each body segment were measured to assign scores and obtain the corresponding result.

It is observed that in 12 (80%) of the jobs it is suggested to have action to avoid musculoskeletal injuries due to postures; since 5 (33%) of the positions present high risk and 7 (47%) very high.

This type of risk is mainly attributed to raising the arms above shoulder level, maintaining flexion, turning, or tilting the trunk.

The preponderant posture that was observed in most of the jobs was the flexion of the neck, flexion, or inclination of the trunk forward, these postures favor musculoskeletal injuries in the spine, which is further increased with the torsion or rotation of the trunk, so it should be considered as a priority for the implementation of improvements.

2.4 Manual handling of loads

Table 3. Activities with manual handling of loads according to workstations.

Department	Workstation	Activity	Manual handling of loads				
			Raise lower	Transport	Teamwork	Push and pull	
						Without auxiliary equipment	With auxiliary equipment
Quality	Quality technician	Various quality tests	X	X			X
Decorated	Electrician mechanic	Give preventive and corrective maintenance to decorating machines					X
	Decorating machine operator	Operate the decorating machine		X			
	Cashier operator	Operate and stock the box erecting machine	X			X	X
	Packer operator	Operate the packing machine	X				
Formed	Machine mechanic	Give preventive and corrective maintenance to forming machines	X	X			X
	Lubricator	Lubricate forming machines	X	X			X
	IS Machine Technician Mold repair mechanic and turner	Operate IS machine Give corrective and preventive maintenance to molds	X	X			X
	Machine mechanic	Give preventive and corrective maintenance to forming machines	X				X

Fundition	Refractorist	Maintain ovens	X	X		X	
Logistic	Silo Operator	Download transport raw material	X	X			
	Technician of parts and spare parts	Dispatch and reception of materials		X			
Services and energy	Services and energy mechanic	Give preventive and corrective maintenance to pumps, fans, and lighting	X	X			X

In each department, the jobs that presented ergonomic risk factors were identified; Those where manual handling of loads is carried out were selected for the application of the Analysis of ergonomic risk factors due to manual handling of loads referred to by NOM-036-1-STPS-2018, Ergonomic risk factors at work- Identification, analysis, prevention and control. Part 1: Manual handling of loads. Table 3.

15 jobs were identified where cargo handling activities are carried out; the most frequent activity in the workplace was lifting and lowering loads, followed by transporting loads and handling loads with auxiliary equipment.

The production area is where there are more positions with manual handling of loads.

Once the activities carried out in the workplace that entail exposure to ergonomic risk factors due to manual handling of loads were identified, an analysis was carried out taking into account:

1. The job.
2. The characteristics of the activity.
3. The description of the task that involves manual handling of loads.
4. Occupationally exposed personnel.
a. Number of workers in the job.
b. Age of the workers.
5. Manual load handling activity.
a. Activities of lifting or lowering loads.
b. Transport cargo.
c. Team cargo handling activities (2 or more workers).
d. Push and pull loads.
Yo. With use of auxiliary equipment.
ii. No use of auxiliary equipment.
6. Load weight in Kg.
7. Frequency with which the activity is carried out.
8. Duration time of each activity.
9. Workers' opinions on the demands of the operation.

According to the type of load handling, a score was assigned in accordance with the provisions of NOM-036-1-STPS-2018, Ergonomic risk factors at work-

Identification, analysis, prevention and control. Part 1: Manual handling of loads, according to:
1. Load weight and frequency of activity.
2. Horizontal distance between the hands and the lower back.
3. Region of vertical lift.
4. Torsion and lateral flexion of the trunk.
5. Asymmetric load on the torso.
6. Postural restrictions.
7. Hand-load coupling (fastening elements).
8. Work pattern.
9. Transportation distance.
10. Work surface.
11. Obstacles on the route.
12. Communication, coordination and control (for work team loading activities).
13. Auxiliary equipment condition (for loading activities with auxiliary equipment).
14. Other environmental factors.

Considering in all cases, the routine work day and the worst scenario in each of them.

Each job position was analyzed observing the activities carried out during the working day, as well as the record of the workers' opinions on the demands of the operation to obtain data according to their perception when carrying out the activities, and observations related to the way of carrying out the activity or the handling of loads in each case.

3.1 Simple estimation of the level of risk of the activities identified

A simple estimation of the level of risk of jobs with manual handling of loads was carried out according to the type of activity, the level of risk was identified according to the score obtained from Appendix I - Estimation of the risk for lifting and transport of loads, and manual loading operations in a work group and to Appendix II - Estimation of the risk due to pushing and dragging loads with or without auxiliary equipment of NOM-036-1-STPS-2018, Ergonomic risk factors in the Work-Identification, analysis, prevention and control. Part 1: Manual handling of loads; According to the level of risk, the priority and the actions to be taken in each of them will be assigned.

Once the analysis was carried out, a score was obtained, indicative of the level of risk that the worker presents to present some musculoskeletal disorder according to the activity carried out; According to the level of risk, priority is assigned for the implementation of corrective actions and the necessary control measures are assigned, from monitoring to establishing an Ergonomics Program.

In the simple evaluation, it was observed that in 12 (80%) positions load handling is carried out, either lifting or lowering, transporting or handling loads with or without auxiliary equipment. In 9 (69%) jobs there was a medium risk level, 3 (23%) high risk and 1 (8%) very high risk, for which all deserve specific evaluation, to determine the level of risk for handling of loads.

There was no low risk level in any of the jobs.

3.2 Specific assessment of the level of risk

Table 4. Results by specific method of ergonomic assessment.

Department	Workstation	Activity	Evaluation methods			
			RULA Postural overload	NOM-036-STPS-2018 Manual handling of loads	Check List OCRA Repetitive movements	ROSA Office activity
Quality	Quality technician	Various quality tests	High	Medium	Does not apply	High
	Reviewer of various	Check for imperfections in the bottles	Aceptable	Does not apply	Does not apply	Does not apply
Decorated	Electrician mechanic	Give preventive and corrective maintenance to decorating machines	Very high	Medium	Optim	Does not apply
	Decorating machine operator	Operate the decorating machine	Medium	Medium	Does not apply	Does not apply
	Cashier operator	Operate and stock the box erecting machine	High	Medium	Does not apply	Does not apply
	Packer operator	Operate the packing machine	Very high	Medium	Medium	Does not apply
Formed	Machine mechanic	Give preventive and corrective maintenance to forming machines	Very high	High	Medium	Does not apply
	Lubricator	Lubricate forming machines	Very high	Medium	High	Does not apply
	IS Machine Technician	Operate IS machine	Very high	Medium	Does not apply	High
	Mold repair mechanic and turner	Give corrective and preventive maintenance to molds	High	Medium	Medium	Does not apply
Fundition	Refractorist	Maintain ovens	Very high	Very high	Medium	Does not apply
Logistic	Silo Operator	Download transport raw material	High risk	High risk	Medium	Does not apply
	Technician of parts and spare parts	Dispatch and reception of materials	Medium	High risk	Does not apply	Medium
	Finished Product Forklift	Storage and shipment of finished product	High risk	Does not apply	Does not apply	Does not apply

Services and energy	Services and energy mechanic	Give preventive and corrective maintenance to pumps, fans and lighting	Very high	Medium	High	Does not apply

The specific evaluation was carried out with the scientifically evaluated method of the NIOSH equation (National Institute for Occupational Safety and Health) as suggested by the standard.

It was observed that 2 positions presented a limited risk (RL), while in 6 positions there was a moderate increase in risk (IM), and in 5 positions there was a pronounced increase in risk (IA); These results are mainly due to the postures adopted by the worker while handling loads.

3.3 Repetitive movements

Eight jobs were identified in which repetitive movements are made during work activities, for which the OCRA Check List method, previously described, was applied, the results of which show that there is an unacceptable risk in six of them, because the movements repeated and in frequent cycles during the activity increase the risk of presenting musculoskeletal injuries, for which the recommendations are provided to: improve the position, provide medical supervision and training.

In a job it was found that the level of risk was considered optimal, this result is attributed to the rest periods and the time during the day where repetitive movements are not made, so the recommended activities focus on vigilance of the activity.

There is a job where an uncertain level of risk was presented, this result is mainly attributed to the postures that the worker adopts while performing repetitive movements, such as raising the arm or bending the trunk, so monitoring of the activity is recommended to improve the position, provide medical supervision and training the worker regarding the proper postures.

3.4 Office work

Three jobs were evaluated (quality technician, IS machine technician, parts and spare parts technician) where office work is carried out, and with the data collected on the seat and peripheral instruments used in the job, A specific evaluation of each of them was carried out.

The measurement with respect to the worker with the seat and the screen or other instruments, aims to avoid injuries due to maintaining the same posture in a sustained manner while carrying out the activity in the office, since in the case of an inadequate seat it can lead to that the worker acquires a posture that compromises blood circulation due to compression in the legs, or increases the risk of presenting musculoskeletal disorders due to the contracture of muscle groups for a prolonged period of time.

It was observed that only one of them presented a medium risk level, to which it is only recommended that some elements of the position can be improved.
There are two jobs where there was a high level of risk and action is required as soon as possible, especially because the position of the worker with respect to the work area is inadequate, either because of the seat (absence of backrest and armrests in two workstations or inadequate position of height, depth, or armrests of the seat); while in the rest of the posts only improvement actions are suggested.

5. CONCLUSIONS

There are conditions with opportunities for improvement where immediate action measures must be implemented to avoid adverse effects on the health of workers, so the following recommendations must be implemented:

1. Keeping work surfaces in good condition allows activities to be carried out without complicating the performance of tasks for each worker in their job.

2. In those activities where auxiliary equipment is used, knowing the specific weight of the load and the weight that the auxiliary equipment supports, as well as having a maintenance program and having it at hand in all cases is of the utmost importance to consider whether the equipment used is really the ideal and safe one in each case.

3. In those positions in which the level of risk is considered unacceptable, a modification in the characteristics of the procedure in each job must be considered, according to the needs and possibilities of the company.

4. Knows how to highlight that those jobs where ergonomic risks other than manual handling of loads were identified, such as postural overload and repetitive movements, should be considered for evaluation and thus avoid the development of musculoskeletal injuries in workers.

Surveillance of the general conditions of the job and the work environment (noise, lighting, vibrations, mental load, psychosocial factors, etc.) should also be considered, since this allows the risks inherent in each activity carried out to not be potentiated. by the worker.

Regarding postural overload, it is recommended to avoid forced postures and those postures where the trunk is tilted forward or the trunk is twisted, or the arms are raised, as they favor the appearance of musculoskeletal injuries. For this, it is recommended to provide training to personnel to minimize the inherent risk of handling loads in each work activity.

Health surveillance regarding the ability to manually handle loads is of the utmost importance to avoid workers with symptoms related to musculoskeletal disorders associated with manual handling of loads, such as low back pain, pain in the neck, knees, and arms, etc.

In all cases, it is necessary to implement control measures through an Ergonomics Program to give continuity to the improvements in a structured way.

5.1 Considerations

In accordance with the legislation, this analysis of ergonomic risk factors due to manual handling of loads must be available to workers who participate in or carry out manual handling of loads.

-Should be reviewed, updated, or modified when:

a) The conditions in which the activity is carried out are modified, and/or any alteration to the health of the occupationally exposed workers is detected or an occupational musculoskeletal disorder is present.

-It must be integrated into the diagnosis of safety and health at work, referred to in NOM-030-STPS-2009, or those that replace it.

6. CONFLICT OF INTEREST

The authors explicitly declare that there are no conflicts of interest with the study site that may have influenced the results obtained or the proposed interpretations.

7. REFERENCES

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ERGONOMIC EVALUATION AND ANALYSIS OF THE ACTIVITY OF CUTTING TORTILLA CHIPS IN A CORN PRODUCTS FACTORY

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Resumen: El objetivo de este proyecto de investigación es determinar el nivel de riesgo desarrollar desórdenes musculoesqueléticos dentro de una fábrica de productos de maíz en la tarea de corte de tortillas. Para ello, se ha decidido implementar los métodos de evaluación postural REBA y Suzanne Rodgers, con ello se logrará conocer la gravedad de lasituación con el proceso actual y además se podrán identificar las partes del cuerpo más afectadas que podrían desarrollar trastornos músculo esqueléticos. Finalmente, se pretende utilizar la información recopilada para tener una base que dé sustento y relevancia a las propuestas de mejora que se plantean para la estación de trabajo y en el proceso. La intención de esto es corregir y mejorar las malas posturas adoptadas por los operadores. Se espera que la implementación de estas propuestas de mejora beneficie no solo a los trabajadores en su salud, sino que también se perciba un mejor rendimiento, lo cual representaría beneficios para la organización directamente.

Palabras clave: REBA, Suzanne Rodgers, Desórdenes musculoesqueléticos, Análisis postural.

Relevancia para la ergonomía: El desarrollo de este trabajo contribuye a futuras investigaciones para determinar los problemas ergonómicos que existen dentro de este tipo de procesos, provocados por un mal diseño de herramientas.

Abstract: The purpose of this research project is to know the risk level to develop musculoskeletal disorders in the activity of cutting tortilla chips. For this, it has been decided to implement the postural evaluation methods REBA and Suzanne Rodgers, with this it will be possible to know the severity of the situation withthe current process and also be able to identify the most affected parts of the body that could develop skeletal muscle disorders. Finally, it is intended to use the information collected to have a basis that provides support and relevance to the improvement proposals that are proposed for the workstation and in the process. The intention of this is to correct and improve the bad postures taken by the operators. It is expected that the implementation of these improvement proposals

will benefit not only the workers in their health but also a better performance, which would represent benefits for the organization directly.

Keywords: REBA, Suzanne Rodgers, Musculoskeletal disorders, Postural analysis.

Relevancies for ergonomics: The development of this work contributes to future research todetermine the ergonomic problems that exist within this type of process, caused by poor tool design.

1. INTRODUCTION

According to the International Ergonomics Association, ergonomics is the scientific knowledge applied to ensure that work, systems, products and environments are adapted to the physical and mental capabilities and limitations of the individual (International Ergonomics Association (IEA), 2018).

This research is carried out in a corn products factory dedicated to produce and sell tortillas, tortilla chips and tostadas, this being its entire range of production. Such products are distributed in the different commercial chains of convenience stores in the cities of Tijuana, Playas de Rosarito and Tecate, Baja California (B.C.).

The tortilla production process comprises the tortilla cutting task. In this activity, for each cut performed, the operator on shift must place approximately two and a half kilograms of tortillas on the cutting table, which is specifically designed for this task.

The problem lies in the effort that the operator makes to press the lever to cut the tortillas, since most of the movement occurs with the arms above shoulder height. The operator performs this activity repetitively during the eight-hour workday. The postures adopted by the operator are shown in Figure 1.

Figure 1. Postures adopted by the operator during the tortilla cutting task.

This research is focused on physical ergonomics, where it is intended to perform the relevant analysis to subsequently apply methodologies that facilitate obtaining recommendations for improvement and that can benefit the worker's health and well-being.

2. OBJECTIVES

2.1 General Objective

The general objective of this research is to know the risk level to develop musculoskeletal disorders in the activity of cutting tortilla chips.

2.2 Specific Objectives

The specific objectives of this project are as follows:

- To apply an ergonomic analysis in the activity of cutting tortilla chips using the Rapid Entire Body Assessment (REBA) and Suzanne Rodgers method.
- To identify the main risk factors in the activity.
- To propose recommendations for improvement in the activity of cutting tortilla chips, based on the results obtained.

3. LITERATURE REVIEW

The term musculoskeletal disorder (MSD) denotes health problems of the locomotor system, i.e., muscles, tendons, skeleton, cartilage, the vascular system, ligaments and nerves. MSD identifies a large number of conditions that result from trauma to the body, either in one minute or significantly over a period of time. This encompasses all types of ailments, from mild and transient discomfort to irreversible and disabling injuries (Malca-Sandoval, 2017).

The present study is carried out with a descriptive type of research, in which the activity of cutting tortilla chips is evaluated, in order to identify the main ergonomic risk factors and avoid musculoskeletal injuries in the operators. For the development of the ergonomic evaluations, the Suzanne Rodgers and REBA methodologies were used, due to the postural effort that occurs during the execution of the task during the workday.

It is intended to apply the methodologies in order to obtain a more complete analysis of the results for the proper study and recommendations. In the next sections a brief description of these methods is provided.

3.1 REBA Method

The REBA method is a tool used for postural analysis of workstations (Kim, Hwang, Jin, Tchounwou, & Kee, 2022). It is based on the division of the human body into segments that can be coded individually. This methodology divides the body into different postures, for which it establishes two large groups: Group A, which involves the trunk, neck and legs; and Group B, where the arms, forearms and wrists are involved (Amri & Putra, 2022). REBA provides a system of scales and combinations for activities such as quick changes, static or dynamic loading, unstable postures and the engagement or grip in the handling of tools or controls (Diego-Mas, 2015).

These combinations are established in tables that give an index in each of the groups and to which a factor for strength or load and another factor for the characteristics of the activity performed must be added, thus establishing the index that will indicate the level of action associated with a level of risk of suffering musculoskeletal injuries (Rodríguez, Aravena, Vargas, & Cachutt, 2007).

3.2 Suzanne Rodgers Method

The method of ergonomic analysis Suzanne Rodgers has the objective of analyzing muscle fatigue (Antonio-Benito, Franco-Austria, & Martínez-Hernández, 2021). It consists of studying three points: the level of effort; the duration of effort; and the frequency of muscle activation. This method estimates the level of muscular fatigue in the following parts of the body: neck, shoulders, back, arms-elbows, wrists, hands-fingers, legs-knees, ankles, feet-fingers (Rodríguez et al., 2007).

There are three classifications for the level of effort: light, moderate or heavy; applied to each part of the body. The duration of effort is understood as the time that a muscle remains continuously active and is classified as: duration of less than 6 seconds; between 6 and 20 seconds; and more than 20 seconds. Frequency is classified into three categories: less than one repetition per minute; 1 to 5 repetitions per minute; and 5 to 15 repetitions per minute (Mishra & Satapathy, 2021). The change priority of an activity is established according to the combination of three factors (Rodríguez et al., 2007).

4. DELIMITATION

The ergonomic analysis is carried out with the personnel in charge of cutting tortilla chips at the corn products factory in the city of Tijuana, B.C.

5. METHODOLOGY

This section briefly explains the method that will be carried out for the development of this research project. Next, Figure 2 shows the general sequence of steps for the application of the methodologies.

The first step is to obtain direct information from the worker in the form of an interview, followed by an initial observation of the workstation. Once this is done, we proceed to implement the REBA and Suzanne Rodgers ergonomic analyses, respectively. The REBA method is applied by using the online software available in Ergonautas(Diego-Mas, 2015), whereas the Suzanne Rodgers method is applied using the Software of Excel®. This makes it possible to detect the risk factors in the evaluated activity. Finally, the corresponding results are analyzed, which will be used to propose recommendations for improvement, as indicated in the specific objectives of the research.

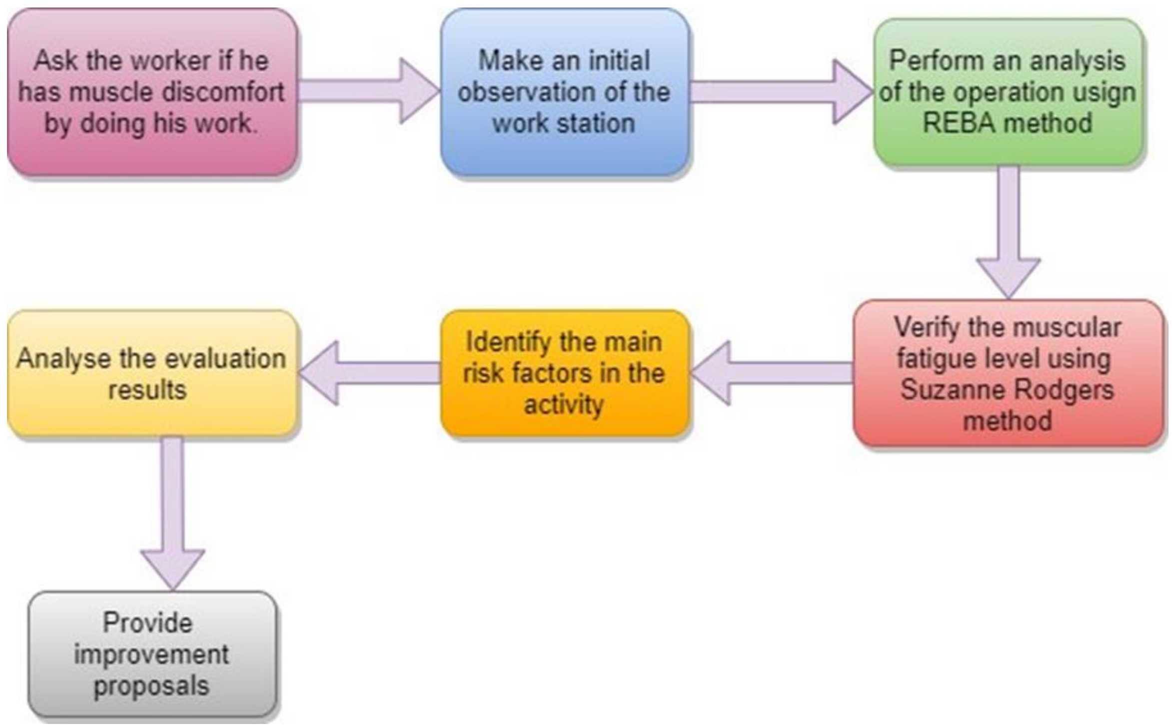

Figure 2. Steps to apply the methodology

6. RESULTS

Tables 1-8 below present the results obtained from the REBA evaluation for each of the groups A and B.

6.1 Results of group A: legs, trunk and neck

Table 1 shows that a score of 2 was obtained for the neck, since it had a flexion greater than 20°. For the trunk, a score of 3 was obtained, because it had a flexion between 20° and 60°, and it was also in torsion. In the case of the legs, a score of 1 was obtained for both, since the weight of the body was equally distributed.

With these values, a score of 4 was obtained for both sides of group A.

Table 1. Scores for parts of group A

Body part	Score
Neck	2

Trunk	3
Legs	1

6.2 Results of group B: arms, forearms and wrists

Table 2 shows the results of the evaluation of the parts of group B. As can be seen, a score of 4 was obtained for the left arm, since it was flexed between 45º and 90º, in addition to the shoulder being elevated. Similarly, a score of 5 was obtained for the right arm, because it was flexed more than 90º and the shoulder was elevated. In the case of the forearms, a score of 1 and 2 was obtained for the left and right forearms, respectively. In the case of the left forearm, it was flexed between 60º and 100º, while the right forearm was flexed more than 100º. Finally, in the case of the wrists, a score of 2 was obtained, since both were in flexion/extension between 0º to 15º, and with lateral deviation.

Table 2. Scores for parts of group B

Body part	Score	Body part	Score
Left arm	4	Right arm	5
Left forearm	1	Right forearm	2
Left wrist	2	Right wrist	2

With this, a score of 5 was obtained for the left side and a score of 8 for the right side.

6.3 Results of strength and muscle activity

Table 3 shows the results of forces and muscular activity by the worker that add scores to the different groups. As can be seen, there were significant changes in posture or posture remained unstable. In addition, the force exerted by the worker was greater than 10 kg, and a regular grip was exercised.

Table 3. Results of strength and muscle activity

Muscular and forces activities	Score
Major posture changes or unstable postures occur (group C)	+1
The load or force is more than 10 kgs (group A)	+2
Regular grip (group B)	+1

Adding the results of Table 3, the final results shown in Table 4 were obtained. Note that for the left side the final result was 10, while for the right side it was 11.

Table 4. Score by group

Left side	Score	Right side	Score
Group A	7	Group A	7
Group B	6	Group B	9
Partial C	9	Partial C	10
Final score	10	Final score	11

The values obtained in the final score indicate high and very high risk for the left and right sides, respectively. The left side indicates a score of 10, on a scale of 1 to 15, with an action level of 3, indicating a high risk and action is needed as soon as possible; while the right side indicates a score of 11 with an action level of 4, indicating a very high risk and action is needed immediately.

On the other hand, Table 5 shows the evaluations and results obtained by the Suzanne Rodgers method. Based on the scores obtained and their respective evaluations, it is determined that the parts of the body that have a high level of muscular fatigue and high priority for modification are the shoulders and back; and as moderate priority the neck, arms and elbows.

Table 5. Scores obtained by the Suzanne Rodgers Method

Region	Effort		Duration	Frequency	Evaluation
Neck	2		2	2	Medium
Shoulder	L	3	2	2	High
	R	2	2	2	Medium
Back	3		2	2	High
Arms/Elbow	L	1	1	2	Low
	R	2	2	2	Medium
Wrist/Hand/Finger	L	1	2	2	Low
	R	1	2	2	Low
Legs/Knee	L	1	1	2	Low
	R	1	1	2	Low
Feet/Fingers	L	1	1	2	Low
	R	1	1	2	Low

7. CONCLUSIONS AND RECOMMENDATIONS

The objective of the methodology implemented was to know the risk level to develop musculoskeletal disorders in the activity of cutting tortilla chips. The information collected about the activity evaluated allowed to have a broader picture of the risks and problems that exist in this activity.

By using the REBA and Suzanne Rodgers evaluation methods, it was possible to know in more detail which parts of the body are most affected and also to know the severity of the situation with the current workstation.

Finally, based on this, it was concluded that the most affected body parts in the operators are the shoulders and back, which are the most affected.

In addition, thanks to REBA, two evaluations were obtained; for the left and right side of the worker, with scores of 10 and 11, respectively, indicating that the risk is very high and that it is necessary to take immediate corrective actions.

The recommendations to reduce the ergonomic risks of physical nature of this task would be mainly to redesign the machine, for one that is made based on measures and scopes that take into account the highest percentage of the male population in Mexico.

Subsequently, it is suggested to establish in a fixed way the hours in which the machine will be used for this activity, in order to establish breaks for the operator and also to propose the alternation of this task with another worker, with the intention of decreasing the repetitiveness of the activity and reducing the fatigue caused by it.

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ERGONOMIC ANALYSIS OF A RESTAURANT EMPLOYEE USING 3D SSPP

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Resumen Las arduas actividades a realizarse en los restaurantes, en ocasiones han provocado que las personas que desempeñan en este tipo de empresas se adapten a los equipos, instrumentos y maquinaria de trabajo que se manejan; a los espacios que se transitan; a las alturas a las que deben acceder; y a las cargas de los objetos que deben manipular; lo que puede generar problemas músculo esqueléticos y lesiones. Esta investigación presenta el análisis postural realizado a un empleado de un restaurante que lleva a cabo diversas actividades en el área de cocina y se centra en la relación que tiene la ejecución de sus tareas con el desgaste físico y otras afectaciones ocasionadas por malas técnicas, posturas incorrectas y sobrecargas asociadas a sus labores. El estudio se realizó desde una perspectiva analítica, experimental y cuantitativa, con el apoyo de un sistema lógico y determinístico, mediante el software 3D SSPP versión 7.1.3. Los resultados obtenidos muestran los riesgos de lesión a los que está expuesto el empleado al realizar sus tareas y cómo se podrían mejorar estas condiciones. Esta investigación indaga sobre el potencial del uso de software comercial como apoyo para realizar la evaluación ergonómica de un puesto de trabajo en una MIPyME

Palabras clave: Ergonomía, Salud ocupacional, Evaluación del trabajo, MIPyME.

Relevancia para la ergonomía: La presente investigación demuestra la importancia del análisis postural en empleados de restaurantes, para identificar y reducir el riesgo de que puedan padecer algún tipo de lesión musculoesquelética.

Abstract: The arduous activities to be carried out in restaurants have sometimes caused the people who work in this type of companies to adapt to the equipment, instruments and work machinery that are handled, to the spaces that are transited, to the heights to which they must access, and the loads of the objects to be handled, which can lead to musculoskeletal problems and injuries. This research presents the postural analysis carried out on a restaurant employee who undertakes several activities in the kitchen area, and focuses on the relationship between the execution of their tasks and other effects caused by bad techniques, incorrect postures and overloads associated with their work. The study was conducted expressly from an analytical, experimental and quantitative perspective, with the support of a logical and deterministic system, using the 3D SSPP software version 7.1.3. The results obtained show the risks of injury to which the employee is exposed when performing their tasks and how these conditions could be improved. This research investigates the potential of using commercial software as a support to perform an ergonomic evaluation of a job in MIPyMEs

Keywords. Ergonomics, Occupational health, Job evaluation, MIPyME.

Relevance to Ergonomics: This research demonstrates the importance of postural analysis in restaurant employees to identify and reduce the risk that they may suffer some type of musculoskeletal injury.

1. INTRODUCTION

The application of ergonomics in manufacturing processes consists of the implementation of ergonomic principles and the analysis of human factors to the design of tasks, with the aim of optimizing the well-being of workers and guaranteeing the expected performance in the process (Peruzzini, et al., 2019). However, these principles should not be limited to the industrial sector, other sectors, such as services, also present risks to the health of their employees that can affect business results. For example, a study conducted in Korea identified that female employees in the hotel and restaurant sector were, in relation to the other sectors, those who were at greater risk of presenting MSDs (Park, et al., 2018).

In Mexico, there are few studies of the impact on the health and well-being of restaurant employees related to the activities associated with their positions. That is why this research focuses on the postural analysis of a job in a restaurant and focuses on the relationship between the movements of the activities that a worker performs with her physical wear and other musculoskeletal effects caused by inadequate techniques, postures and loads. To this end, a study of its activities was carried out with an analytical perspective and later experimental and quantitative, with the support of a logical and deterministic system.

1.1 Brief history of ergonomics

According to Cajal (2020), the origin and history of ergonomics is located at the beginning of human activity, thought and directed to goals. Since the beginning of humanity on the face of the Earth, it has had the need to adapt the environment where it is located to, firstly, ensure its survival and, secondly, to have greater comfort by relying on what was within its reach. The evidence that has been found in different places indicates that, at first, the materials used to develop tools were stones, sticks and bones with which spears, arrows and bows were made, among others.

In relation to the development of the concept of ergonomics, it is known that in Egypt there are records of occupational diseases caused by climatic conditions, efforts and postures that affected monument builders. In Rome, since Roman law gave responsibilities to the masters over their workers, employers were required to take into account the minimum safety conditions, recommending the use of animal bladders placed in front of the nose to avoid breathing the dust. At a closer stage, it was in 1923 when the Central Institute of Labor was created in the Soviet Union, in charge of the scientific organization of work. In 1930, the Russian scientists Behteriov and Viaszeitechov pursued with ergology (thus the term was used in the former USSR, together with that of ergonomics) the objective of investigating the characteristics of workers in relation to work. The history of modern ergonomics begins in the 40s, when it emerges as a scientific discipline (Cajal, 2020; Cruz & Garnica, 2010). In the United States it is called human engineering or engineering of human factors and arises as an applied technique since 1943; later the Society of Human Factors was founded; although the term "ergonomics" was first used in England in the late 1940s. It was not until the period between 1981 and 1984 that the first set of ergonomic standards, requirements and indicators necessary to create and modernize the technique was developed.

Since then, ergonomics works as an adaptation of technology through the application of engineering to the needs of the worker, being increasingly necessary and more feasible, thanks to technological advances. In particular, the development of applications that can facilitate job analysis and reduce the time to implement improvements (Molina, et al., 2019).

1.1.1 Case Study

The arduous activities to be carried out in the restaurant Rincón Cachanilla, have caused that the people who work in this company have adapted to the work teams, to the instruments that are handled, to the spaces that are transited and to the heights and loads of the objects. The situation has remained the same and under the same conditions due to the economic dependence of employees to keep their work.

The conditions to which workers are exposed require that tasks be performed in a way that great bodily efforts are made day after day. This situation may be affecting your health, causing problems in various parts of the body that over time will develop into injury or illness. That is why it is considered important to carry out the postural analysis of the activities of the position and determine how the impact on the well-being of employees could be eradicated or improved.

In general terms, the problem to be solved can be summarized as follows: the performance of the employees of the Rincón Cachanilla restaurant is not optimal, due to unnecessary efforts that cause irritability, mistakes in their activities, physical pain that results in absences and early wear and tear throughout the working day. All of the above leads to poor service, loss of customers and profits.

2. OBJECTIVES

The general objective seeks to demonstrate that the current posture is harmful to some parts of the body and, through the 3DSSPP software, to show that it is possible to improve the physical health and performance of the worker with an adaptation to the equipment and facilities and with it, improve the postures that the employee adopts in his daily activities.

There are two specific objectives, namely:

1. Using the 3D SSPP software determine what damage is causing the position of the position.

2. Propose an improvement that leads to better performance and provides healthy working conditions.

3. METHODOLOGY

An evaluation of the different jobs of the restaurant was carried out, through observation and interviews; and one was chosen as a case study to perform the analysis. According to Hernández-Sampieri (2014), the case study is a methodological tool that uses quantitative, qualitative or mixed research techniques to analyze a holistic unit in depth, in order to respond to the problem statement, test hypotheses and develop some theory.

Once the case study was chosen, the Cornell University survey (Hedge, A. & Cornell University, 2010) was applied, which consists of obtaining information on the frequency of pain or discomfort per unit of time. This instrument seeks to identify the level of discomfort and know if there is an interference or relationship with the loss of skill of the worker in his work, for each important part of the body. Figure 1 shows the questionnaire.

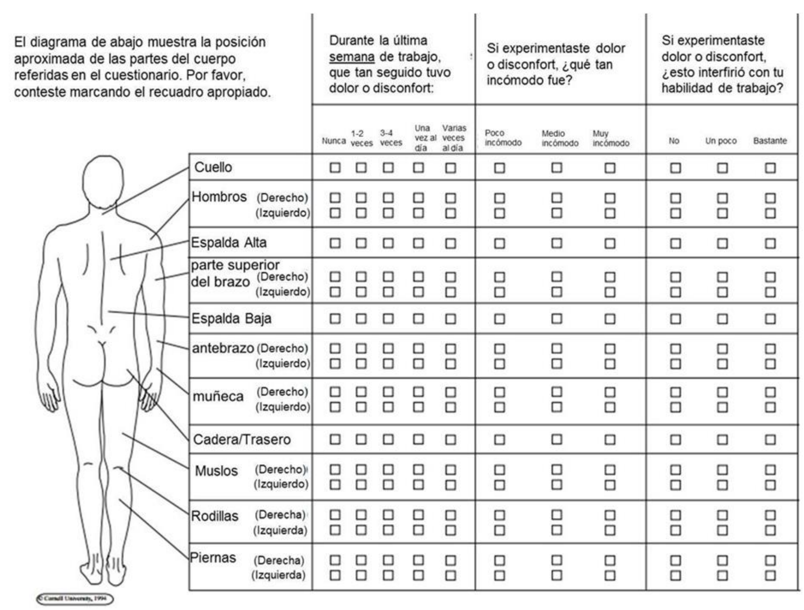

Figure 1. Cornell's questionnaire

The next step was to enter the anthropometric data of the selected employee: sex, anthropometric measurements based on coordinates of X, Y and Z for each part of the body and the adjustment of the angles to establish the posture to be evaluated. This activity was carried out in the 3DSSPP (software predicts static strength) software of the University of Michigan and the Center for Ergonomics. The loads of both hands with their respective angle of inclination were also introduced and the type of movement that was performed with each hand was determined. The worker was asked for his weight and height. Figure 2 shows the screenshot of the anthropometric program data.

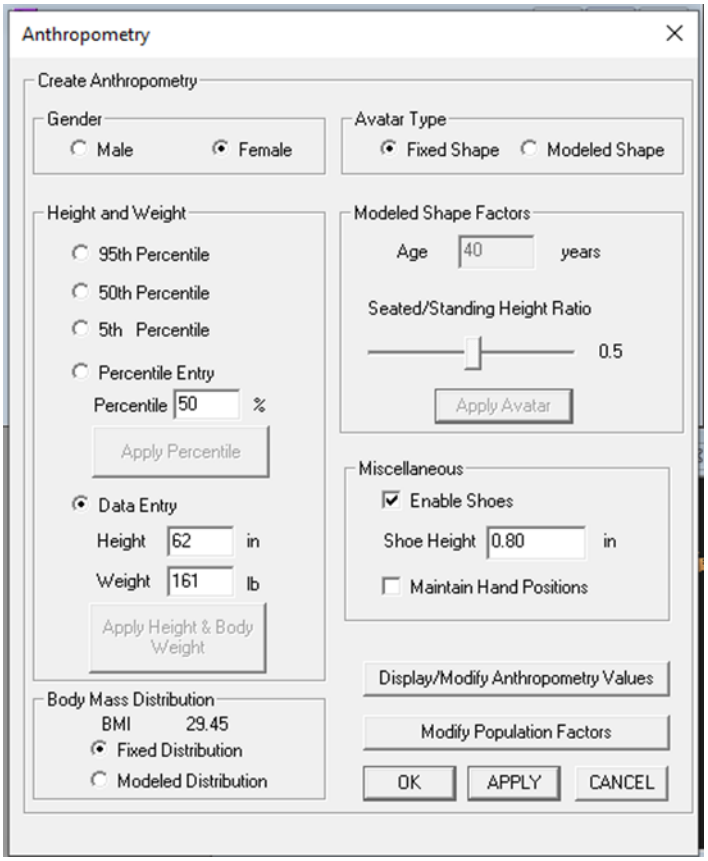

Figure 2. Anthropometry of the employee entered in 3DSSPP

In addition, illustrative photographs were taken, such as the one shown in Figure 3.

Figure 3. Image of the employee in the position to be analyzed

With this information, the avatar for the evaluation of the posture in the application was generated, as shown in Figure 4.

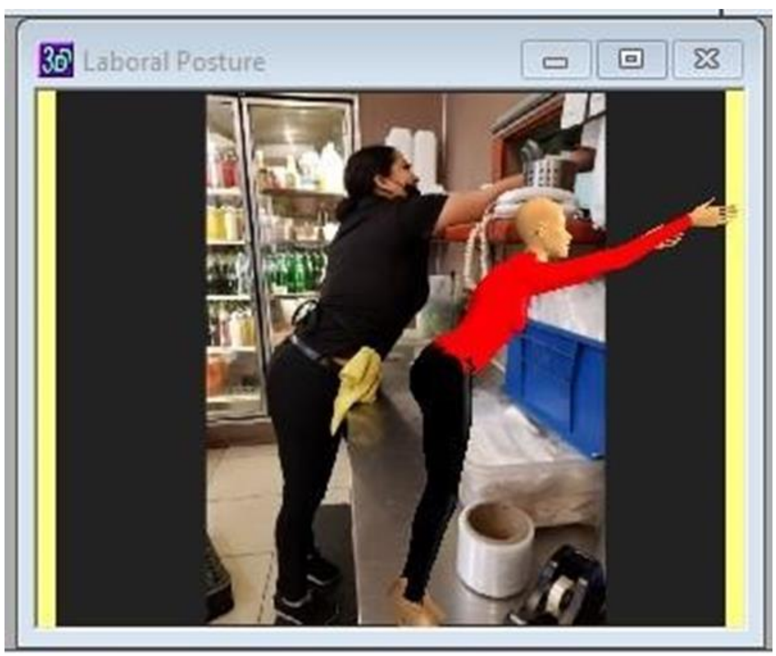

Figure 4. Work posture in 3DSSPP

4. RESULTS

The Cornell questionnaire identifies that the worker reports that the back interferes with his ability at work and that he experiences pain several times a day, not only in the back, but also in the legs. The worker indicates that his shoulders and wrists present discomfort once a day. Figure 5 shows the results.

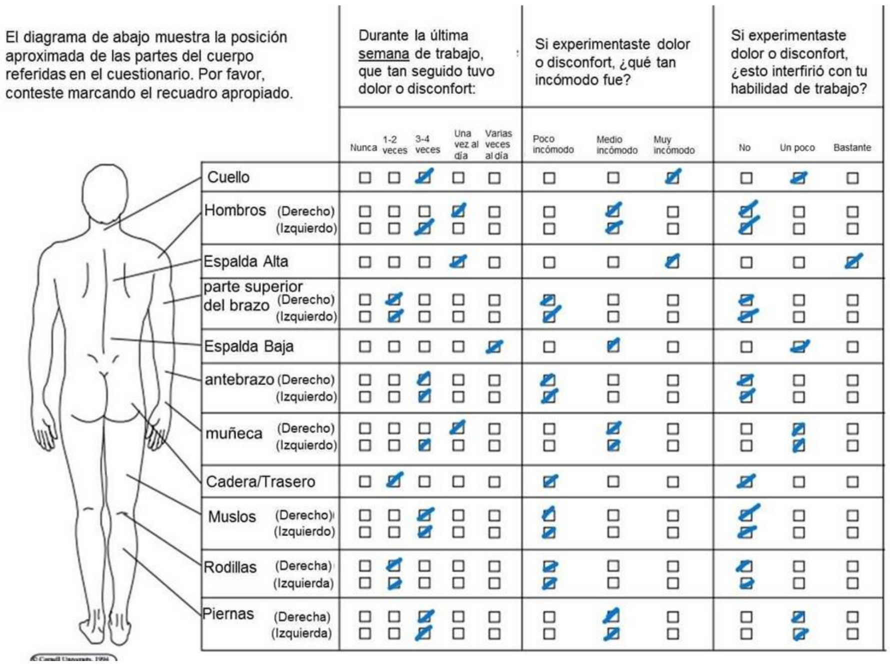

Figure 5. Employee-resolved survey

On the other hand, the software shows on the work posture screen, that the knee and ankles are the parts of the body that are in the critical area, which means that they are receiving maximum effort from the body, that is, that area is being punished (see figure 6).

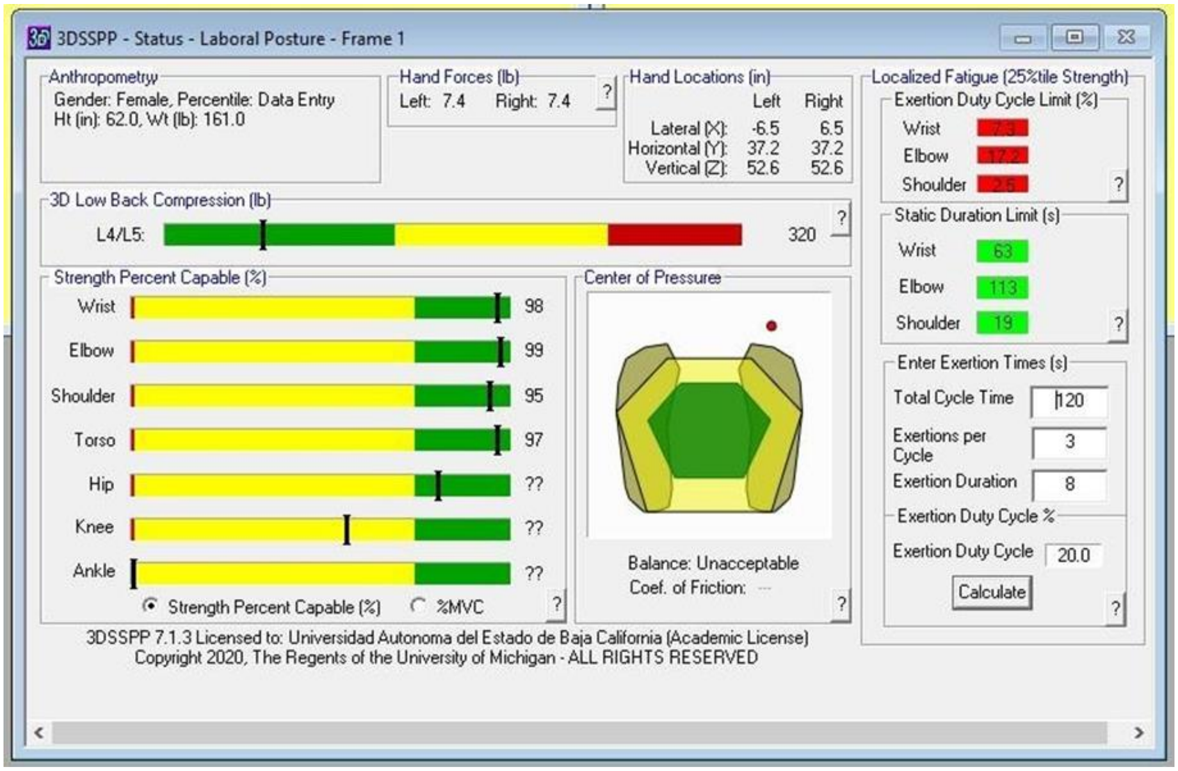

Figure 6. Laboral posture screen

On the standing balance report screen, the yellow dot indicates the center of gravity which, for the case evaluated, turns out to be critical; and the red dot indicates the stability/balance of the body, which appears in the range of unacceptable (Figure 7).

When the human body is unbalanced, it is more susceptible to damage and to receiving blows with greater damage to the spine, and if its center of gravity is not within the limits, it can fall, which indicates that, in the attempt to regain balance, the worker will force more the parts of his body on which it rests or is supported. The employee proved to be in both situations, as he stays around 3 minutes in that position.

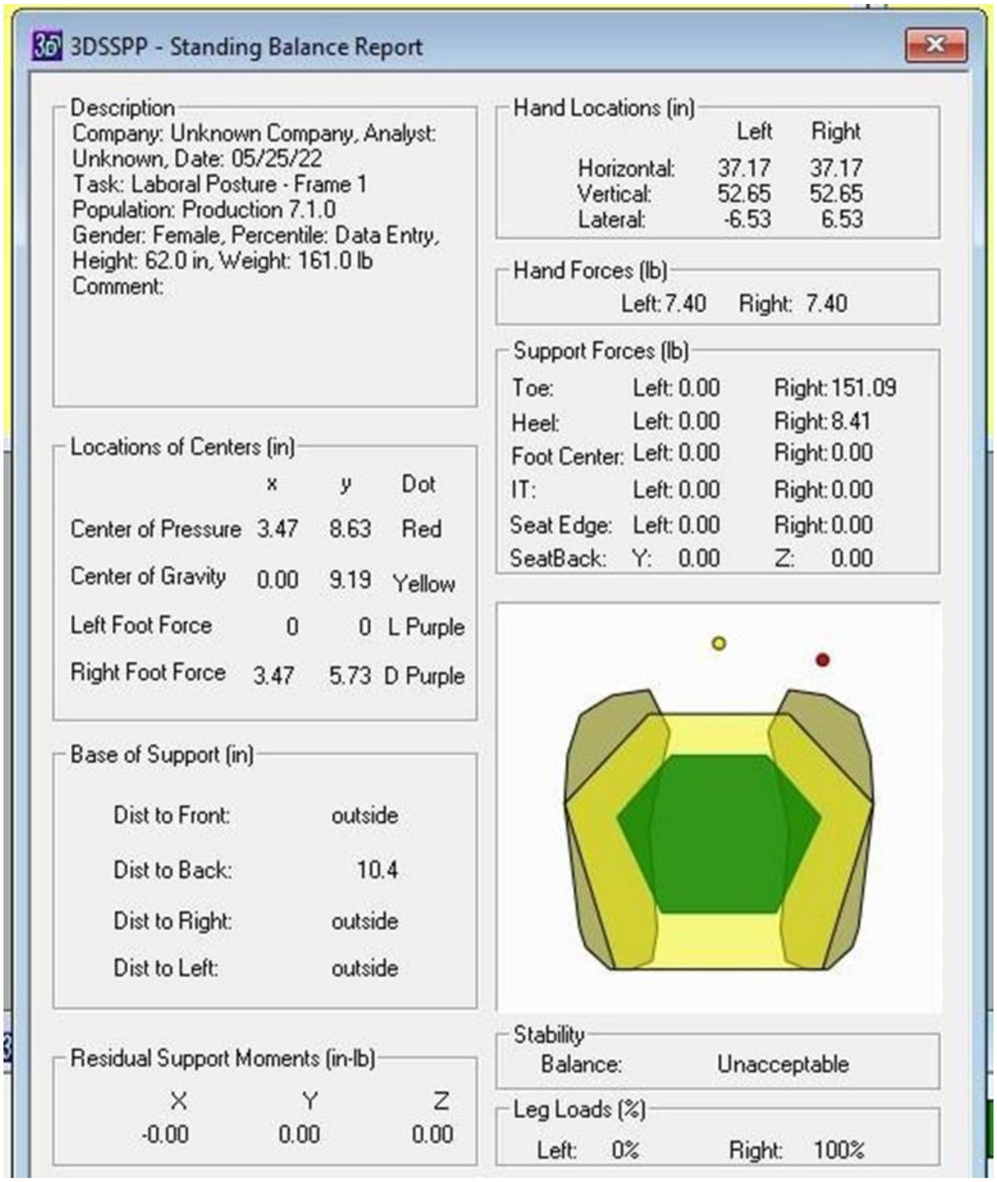

Figure 7. Standing Balance Report Screen

Finally, in the localized fatigue report screen, it was identified that both wrists, elbows, shoulders and torso present fatigue, which can be seen in Figure 8.

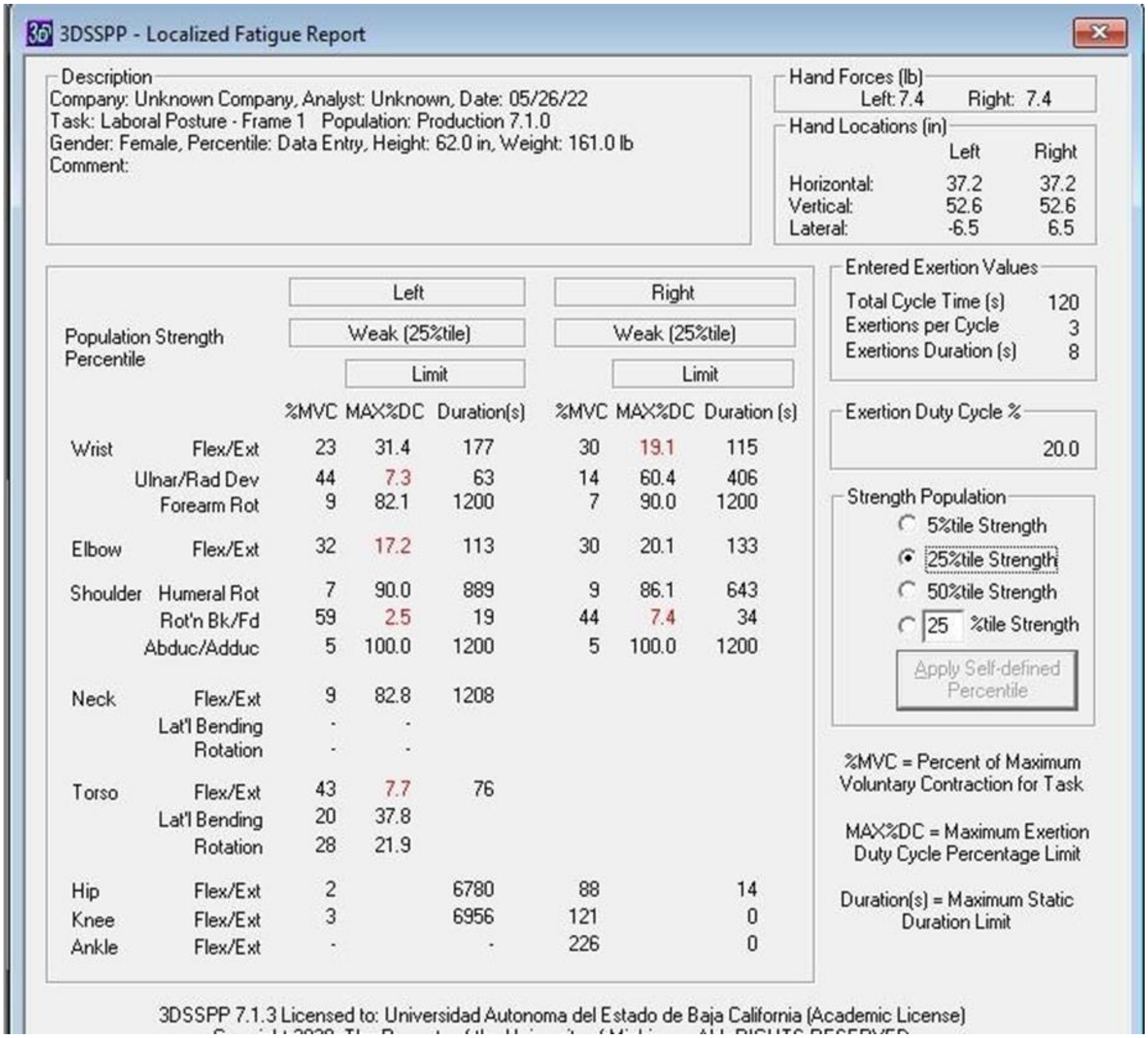

Figure 8. Localized Fatigue Report Screen

5. CONCLUSION

Thanks to the analysis carried out, it is possible to understand the fact that workers who do not have an ergonomic workplace have a low performance. This is due to the early fatigue of the joints, which result from maintaining an uncomfortable posture for prolonged periods and, in turn, this lack of comfort influences the mood of the joints throughout the day.

It was possible to identify that the equipment and accessories are placed in very high positions for people of average height and even more for people of short stature. For example, the height of the service window is very high for people of average size, as it was designed for people over 175 cm in height. The risk of injury is increased because you have to lift objects and push them with your hands with an angle of entry, at the same time. This can lead to a twisting of the wrists.

Because equipment replacement is expensive, the company should look to adapt the facilities to workers so that they can more easily access the equipment. It is recommended to use a staircase of 3 steps with the corners covered under the service window that connects to the kitchen. The staircase is closed and covered with sponge and with the corners protected, to avoid getting stuck between the spaces of the staircase and avoid bumps with the edges. It is also suggested to adapt an anti-skid surface, to avoid slips and falls of employees, which will make access to the window for the different percentiles better and the manipulation of objects is from top to bottom and not punish the shoulders. People's quality of life will increase radically as they will not subject their spine to high strains and their ankles will not suffer.

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ERGONOMICS IN E-SPORTS. A RISK FACTOR ANALYSIS

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Resumen: Los *e-sports* (deportes electrónicos) son una nueva categoría de deportes con base en los videojuegos, que generalmente se practican a través de un ordenador. Estas actividades se encuentran al alza en el mundo deportivo de alto rendimiento, siendo capaces de capturar la atención de cada vez más personas, en ocasiones atrayendo a más espectadores que eventos importantes de los deportes convencionales. Si bien, se han detectado problemáticas que afectan a los videojugadores en estudios anteriores, la información existente en relación a la ergonomía es escasa. Basados en lo anterior, en este estudio se busca identificar, desde la perspectiva de la ergonomía, las condiciones en las que se realizan las actividades de los jugadores de *e-sports* y los factores de riesgo presentes. Con este propósito, se realizó un cuestionario en línea a jugadores de *e-sports* casuales y profesionales a través de redes sociales. Se analizaron el contexto y los hábitos de práctica, frente a posibles malestares musculoesqueléticos, percepción de desempeño y satisfacción con el fin de encontrar relaciones entre ellos. Se reportaron síntomas de malestar musculoesquelético en el cuello en más del 50% de los participantes. El 43.5% reportan baja satisfacción en relación al mobiliario con el que cuentan. El 30.6% reporta estrés producido por la presión en el desempeño.

Palabras clave: *E-sports*, satisfacción, desempeño, estrés, síntomas musculoesqueléticos

Relevancia para la ergonomía: Gracias a su semejanza a los estudios relacionados en el ámbito ICH (Interacción Humano-Computadora), la naturaleza y condiciones de la actividad (sedentarismo, exigencia en el rendimiento, movimientos repetitivos), los *e-sports* se convierten en un área de interés para la ergonomía. Ya que, además de haberse encontrado una falta de estudios relacionados en el área (Lipovaya et al., 2019), se trata de un campo de investigación relativamente nuevo. Por lo tanto, un estudio desde la perspectiva de la ergonomía puede servir como un parteaguas para futuras investigaciones relacionadas. Igualmente, puede ayudar a tomar en cuenta consideraciones para futuros diseños de estaciones de juego / trabajo. Finalmente, los deportes electrónicos se encuentran en rápido crecimiento, por lo tanto, se considera que en el futuro habrá una mayor cantidad de personas envueltas en estos. De este modo, con aportaciones de la ergonomía en el ámbito, será posible reducir los factores de riesgo y estrés para las siguientes generaciones de jugadores, y así impactar positivamente su desempeño, satisfacción y bienestar.

Abstract: E-sports (electronic sports) are a new category of video game-based sports, generally played on computers. These activities are on the rise in the high-performance sports world, capturing the attention of more and more people, and sometimes attracting more spectators than major conventional sports events. Although problems affecting gamers have been detected in previous studies, the existing information regarding ergonomics is scarce. Based on the above, this study seeks to identify, from the perspective of ergonomics, the conditions in which the activities of e-sports players are performed and the present risk factors. For this purpose, an online questionnaire was conducted on casual and professional e-sports players through social networks. The context and practice habits were analyzed against possible musculoskeletal discomfort, performance perception, and satisfaction to find relationships between them. Symptoms of musculoskeletal discomfort in the neck were reported in more than 50% of the participants. 43.% report low satisfaction with the furniture they have. 30.6% reported stress produced by performance pressure

Keywords. E-sports, satisfaction, performance, stress, musculoskeletal symptoms.

Relevance to Ergonomics: Thanks to their similarity to studies in the HCI (Human-Computer Interaction) field, the nature and conditions of the activity (sedentary, demanding performance, repetitive movements), e-sports become an area of interest for ergonomics. Since, in addition to having found a lack of related studies in the area (Lipovaya et al., 2019), it is a relatively new field of research. Therefore, a study from an ergonomics perspective can serve as a milestone for future related research. Likewise, it may help to take into account considerations for future gaming/workstation designs. Finally, e-sports are rapidly growing, thus, it is considered that in the future there will be a greater number of people involved in them. And, with contributions from ergonomics in the field, it will be possible to reduce the risk and stress factors for the next generations of players and thus impact their performance, satisfaction, and well-being.

1. INTRODUCTION

E-sports (electronic sports) are a new category of video game-based sports, generally played on a computer (Figure 1). These activities are on the rise in the high-performance sports world, being able to capture the attention of more spectators than some major events of more standardized sports, such as the NBA finals and the baseball world series (Emara et al., 2020). defines them as "an area of sports activities in which people develop and train mental or physical skills with the use of information and communication technologies".

E-sports players are constantly under high levels of demand, because it is a highly competitive activity. They require an outstanding performance that allows them to fulfill what is required of them, whether it is winning or excelling within their team. Just as in conventional sports, athletes are required to engage in arduous and long practice sessions and are exposed to various risk factors that can take them out of the scene, or have a negative effect on their performance and, more importantly, on their health. Some of the risks identified are related to repetitive movements. It has been recognized that a professional player can perform up to 500 APMs (actions per minute) compared to 10 APMs for a novice. In other words, the risks they face are more similar to those of an office worker than those of a soccer player (Zwibel et al., 2019).

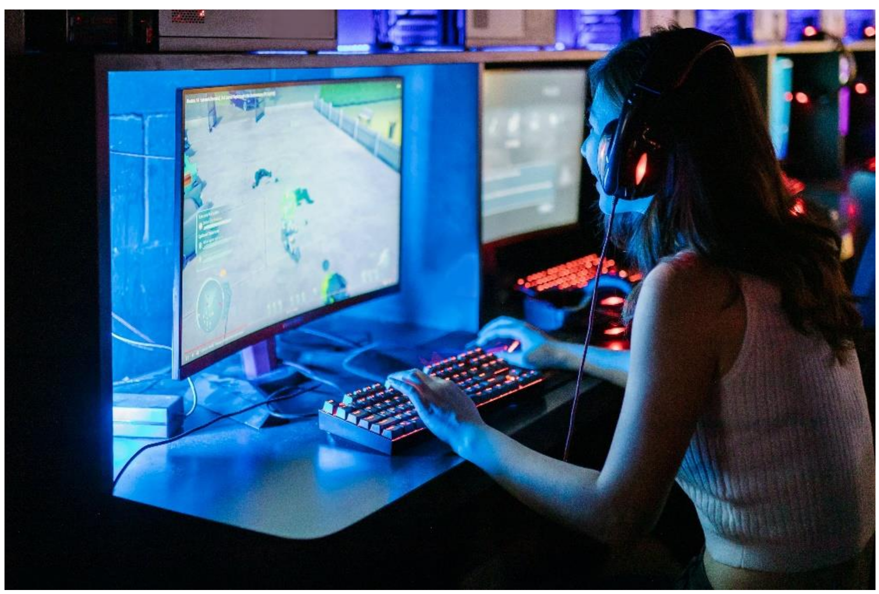

Figure 1. Activity to be evaluated. Practice. (Source: RODNAE Productions from Pexels: https://www.pexels.com/es-es/foto/mujer-jugando-tecnologia-moderno-7915437)

From the ergonomics point of view, some risk factors can be recognized, such as those reported by Emara et al. (2020): prolonged inadequate postures, repetitive micro-trauma, psychosocial, vision, and sleep problems. However, the existing information related to ergonomics is scarce, so it is important to carry out studies related to this new area of interest.

Motivated by this, this article describes, from the perspective of ergonomics, some of the conditions under which e-sports players practice and report musculoskeletal complaints, as well as their perception of performance and satisfaction.

2. OBJECTIVES

2.1 General Objective

From an ergonomics perspective, identify the conditions in which e-sports players' activities are performed and their possible relationship with musculoskeletal complaints, perception of performance, and satisfaction.

2.2 Specific Objectives

1. Identify the most prevalent musculoskeletal symptoms in players.
2. Identify factors that generate stress in players.
3. Identify the relationship between performance and satisfaction with the practice habits recognized by players.

3. METHODOLOGY

3.1 Delimitation and participants

Performance, satisfaction, stress, and musculoskeletal symptoms of casual or professional e-sports players, aged 17 years and older, from Mexico (51), Canada (1) Argentina (4), Chile (4), Paraguay (1), and Uruguay (1).

3.1.1 Inclusion criteria

Players of different competitive video game genres. Not necessarily professional and of indistinct gender. There's not any kind of impediment if a player practices on a console or a computer.

3.1.2 Exclusion criteria

Players who play on a mobile device or an entirely portable console are left out of the study. Similarly, gamers playing on an arcade machine are not considered in this study.

3.2 Scenario

A scenario in variable conditions. A protocol of conditions to conduct the online survey was not established, because it is a virtual questionnaire that could be answered in different places.

3.3 Materials

Mobile device, either tablet or cell phone; laptop or desktop computer to answer the questionnaire. Since it is an online questionnaire, it can be answered on any device, and it was not necessary to have an account to access it.

3.4 Instrument

An online questionnaire with 39 items consisting of the following categories: general data, demographic data, gaming mode, gaming schedules, gaming place data, warm-up and stretching routines, stress and risk factors, musculoskeletal symptoms, and perceived relationship between satisfaction and performance with the conditions in which the activity is performed.

3.5 Research design

Single-group cross-sectional descriptive.

3.6 Procedure

An informed consent form was attached at the beginning of the questionnaire, which the participants had to accept to access it.

The questionnaire was sent to participants using social networks and instant messaging services. It was active to be answered online from February 14 to March 10, 2022. The time it took participants to answer the questionnaire was around 12 minutes.

3.7 Issues running questionnaire

There is missing data for 2 participants in the item referring to the main screen size, and for 4 participants in the questions referring to the perceived relationship between satisfaction and performance with the conditions in which the activity is carried out.

3.8 Analysis

Once responses were no longer accepted, the results were entered into a database in *IBM SPSS Statistics*.

A descriptive analysis was performed for the demographic data, and responses for the time-related items (practice, rest, and experience). Finally, frequency analyses were carried out to obtain the percentages of the other responses.

4. RESULTS

There were 62 participants aged between 17 and 34 years, with a mean age of 24.25 years. 48 were male, 12 were female, and 2 who did not go into detail regarding their gender.

61 players from Latin America participated (51 from Mexico, 4 from Argentina, 4 from Chile, 1 person from Paraguay, and 1 from Uruguay), and there was one participant from Canada.

There were 40 non-professional players. And in turn, 2 professional players, 6 players who used to play professionally, and 14 participants who wish to enter the professional scene participated.

The video game genres with the highest number of participants were First Person Shooter (39) and Multiplayer Online Battle Arena (36), both with more than 50% acceptance.

Table 1. Practice characteristics

TIME			
	Mean	**Standard Deviation**	
Practice (Hours per day)	2.8	1.783	
Rest (Minutes per day)	33.82	65.7	
Experience (Years)	7.56	4.356	
PREPARATION			
		N	**%**
Pre-warming		12	19.4
Stretching	Before	14	22.6
	During	13	21
	After	22	35.5
GAMING SCHEDULE			
		N	**%**
Morning		5	8.1
Afternoon		31	50
Night		57	91.9

Table 2. Gaming station details

SCREEN			
	Distribution	**N**	**%**
Number of screens	1	44	71
	2	17	27.4
	3	1	1.6
Display size (Inches)	14 – 17.5	15	24.2
	18 – 20	4	6.5
	21 – 23	6	9.7
	24 – 27	21	33.9
	28 – 29	3	4.8
	+ 29	1	1.6
	TV > 30	10	16.1
Distance (Centimeters)	< 30	4	6.5
	30 – 40	20	32.3
	41 – 50	15	24.2
	51 - 60	11	17.7
	+ 60	12	19.4
CHAIR TYPE			
		N	**%**
Gamer		17	27.4
Executive		13	21
Office		20	32.3
Other		12	19.3
GAMING TOOL			
		N	**%**
Mouse and keyboard		45	72.6
Gamepad		36	58.1
Fightstick		3	4.8
Steering wheel and pedals		3	4.8

Table 3. Musculoskeletal symptoms report

Body part	N	%
Neck	34	54.8
Upper back	28	45.2
Lower back	23	39.7
Hips	7	11.3
Shoulders	23	37.1
Elbows	4	6.5
Hands	22	35.5

Wrists	30	48.4
Arms	13	21
Forearms	4	6.5
Legs	3	4.8
Glutes	12	19.4
Knees	3	4.8
Feet	2	3.2

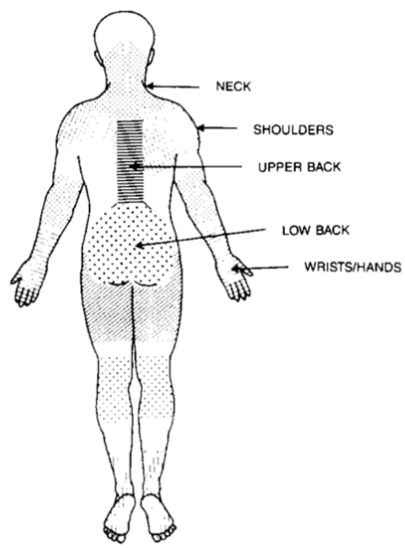

Figure 2. Location of the main complaints found. (Source: Edited figure of the human body presented by Kuorinka et al. (1987))

In terms of stress, 51 of the 62 participants admitted to feeling stress while playing for a variety of reasons. These causes were grouped based on their similarities and placed into the categories shown in Table 4.

Table 4. Stress causes

	N	%
Poor performance	19	30.6
Discomfort	2	3.2
Video game community	10	16.1
Technical issues	6	9.7
External interruptions	1	1.6
Defeat	9	14.5

Frustration	2	3.2
Clutch	1	1.6
Fatigue	1	1.6

Table 5. Participant's views about practice habits effect on performance

Practice habit	No effect	A little effect	A lot of effect	Total effect
Low practice time	14.5	25.8	33.9	21
High practice time	22.6	27.4	32.3	11.3
Deficient warm-up routine	37.1	45.2	8.1	3.2
Lack of preparation	17.7	38.7	29	4.8
Poor body posture	11.3	17.7	45.2	21
Personal routines	33.9	27.4	24.2	8.1
Repetitive movements	22.6	38.7	21	11.3
Furniture	8.1	22.6	38.7	25.8

Note: Values expressed as a percentage

Table 6. Participant's satisfaction levels according to their practice habits

Practice habit	Not satisfied	Slightly satisfied	Satisfied	Very satisfied
Practice time	4.8	35.5	50	4.8
Warm-up routine	14.5	38.7	29	9.7
Preparation	9.7	25.8	54.8	4.8
Body postures	21	48.4	24.2	1.6
Personal routines	14.5	43.5	29	6.5
Repetitive movements	11.3	33.9	45.2	3.2
Furniture	22.6	43.5	19.4	25.8

Note: Values expressed as a percentage

5. LIMITATIONS

The recruitment of participants was one of the main limitations in the development of this research. The aim was to have the participation of more professional players, since what has been reported in other articles in the field of e-sports evidences greater complications for them. Nevertheless, the results show some relevant data, particularly in the health care of the amateur population of this type of sport.

The means of application of the questionnaire made it difficult to collect information that could be useful. In addition, the need for a method that would allow a deeper understanding of some of the problems reported by the study participants became tangible.

6. DISCUSSION / CONCLUSIONS

It is possible to link the results obtained in this study with those found in previous studies. Primarily on musculoskeletal symptoms, since, research such as the one conducted by Lindberg et al. (2020) reports a 31.3% prevalence of back pain, 11.3% in neck pain, and 11.3% in shoulder pain, making them the main locations of complaints based on the responses of 188 danish e-sports players. And the one conducted by Difrancisco-Donoghue et al. (2019), which reports a prevalence of wrist (36%), hand (30%), and neck (41%) pain in 65 e-sports players from eight different universities in the USA. Compared to these two studies, the prevalence found in these body parts is higher. The location of the main complaints found in this study can be consulted in Figure 2.

The results obtained in terms of musculoskeletal symptoms are related to the nature of the activity, since it involves sitting for a prolonged time in front of a monitor with the eyes fixed on one point. However, there is a low report of affections in parts of the body such as the upper back and gluteus, where the prevalence of ailments is nil.

In terms of stress, the top three causes of stress in gamers are detecting poor performance on their part (30.6%), being defeated (14.5%), and interactions with other members of the video game community (16.1%). It is possible to link this last point to the research conducted by Adinolf y Turkay (2018), who detected what they called ''toxic behaviors'' within video game players, a term which encompasses all types of negative actions by the community, ranging from bad in-game behavior to verbal abuse. Adinolf and Turkay report that most of the reported toxicity generally stems from people's need to attribute failure to others.

Most of the participants play video games that have a competitive scene in a non-professional manner, which places them in the category of ''casual gamers'', which would explain why many of the practice habits are not taken seriously, such as resting, warming up, and stretching. There is a striking underreporting of these practice habits, even when the nature of the activity involves prolonged postures, repetitive movements in the upper extremities, and sedentariness.

Regarding the furniture on which they practice, the vast majority report the use of chairs with characteristics that allow certain margins of adjustment. However, it is necessary to analyze more directly whether these adjustments are adequate in terms of dimensions, in relation to the gamer’s body, and in relation to the other components of the station. Many of the participants are dissatisfied with the furniture they practice on. And at the same time, they consider that the furniture where they practice can affect performance, which indicates that it is likely that both factors are related to the gaming station. This possible relationship opens paths to identify the most suitable characteristics for this activity, considering well-being, satisfaction, and increased performance. We could also analyze the possible impact that an improvement in the station would have on decreasing the stress of the activity reported by the performance.

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ERGONOMIC ANALYSIS OF THE MATERIALS PRODUCTION PROCESS IN A CONSTRUCTION COMPANY IN GUASAVE, SINALOA.

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Resumen La empresa de construcción se encarga de la elaboración y venta de materiales en el municipio de Guasave, Sinaloa. Actualmente, es una de las empresas que cuenta con mayor calidad en el proceso y producto final, de los diferentes materiales, tales como: tabique, block y loseta. Se realizó un análisis ergonómico en el proceso de elaboración de materiales para construcción enfocado en problemas auditivos, lesiones musculoesqueléticas y condiciones ambientales, en las que se encuentran las personas que laboran ahí, y se determinó que es necesario hacer un análisis ergonómico para determinar posibles DTA en los operarios que se encargan del área de mezclado.

Palabras clave: Método RULA, Principios Ergonómicos, DTA, Materiales de Construcción.

Relevancia para la ergonomía: La ergonomía es la interacción entre los seres humanos y otros elementos de un sistema. Este estudio aporta información que contribuye a la mejora de las condiciones de trabajo del sector de construcción.

Abstract: The construction company is responsible for the production and sale of materials in the municipality of Guasave, Sinaloa. Currently, it is one of the companies with the highest quality in the process and final product of the different materials, such as: brick, block and tile. An ergonomic analysis was carried out in the process of manufacturing construction materials, focusing on hearing problems, musculoskeletal injuries and environmental conditions in which the people who work there are found, and it was determined that an ergonomic analysis is necessary to determine possible ATD in the workers who are in charge of the mixing area.

Keywords. RULA Method, Ergonomic Principles, ATD, Construction Materials.

Relevance to Ergonomics: Ergonomics is the interaction between human beings and other elements of a system. This study provides information that contributes to the improvement of working conditions in the construction sector.

1. INTRODUCTION

In Sinaloa, during 2021, the production value of the construction industry was 9,971 million pesos (MDP), 1,390 million more than in 2020. This was an increase of 16.2 per cent, higher than the national average of 13.4 per cent (CODESIN, 2021).
Based on the statistics of the Mexican Institute of Social Security of the year 2018 of Risks of work registered in the IMSS, it shows the top of accident rate by economic activity, by occupation, by unsafe act and physical risk, identifying that the construction sector is in the number 4 of accidents caused by dangerous postures or actions (SEPRESST, 2019).

Table 1. Accident rates by economic activity, by occupation, by unsafe act and by physical risk.

No.	Actividad Económica	Ocupación	Acto Inseguro	Riesgo Físico
1	Industrias de transformación	Trabajadores en actividades elementales y de apoyo	Falla al asegurar o prevenir	Métodos, materiales o procedimientos peligrosos
2	Comercio	Operadores de maquinaria industrial, ensambladores, choferes y conductores de transporte	Falta de atención a la base de sustentación o sus alrededores	Defectos de los agentes
3	Servicios para empresas, personas y el hogar	Comerciantes, empleados en ventas y agentes de ventas	Falla o acto inseguro de terceros	Peligros públicos
4	Industria de la construcción	Trabajadores auxiliares en actividades administrativas	Adoptar posiciones o actitudes peligrosas	Peligros por la colocación
5	Transportes y comunicaciones	Trabajadores artesanales	Uso inapropiado de las manos o de otras partes del cuerpo	Peligros del medio ambiente
6	Agricultura, ganadería, silvicultura, pesca y caza	Profesionistas y técnicos	Comportamiento inapropiado en el trabajo	Peligros ambientales de trabajo a la intemperie, diferentes a los peligros públicos
7	Servicios sociales y comunales	Trabajadores en servicios personales y vigilancia	Sin acto inseguro	Sin riesgo físico
8	Industrias extractivas	Funcionarios, directores y jefes	No usar el equipo de protección personal disponible	Protegido inadecuadamente

In the municipality of Guasave Sinaloa, the construction company is responsible for the production and sale of materials. This company has higher quality in the process and final product of the different materials, such as bricks, blocks and tiles. An ergonomic analysis was carried out in the manufacturing process of construction materials, focusing on hearing problems, musculoskeletal injuries and environmental conditions in which the people who work there find themselves, determining that it is necessary to carry out an ergonomic analysis to determine possible TCA in the workers who are in charge of the mixing area.

2. OBJECTIVE

To analyse the process of elaboration of materials of the construction company, such as brick, block and tile, to determine the musculoskeletal injuries and working conditions of the company.

3. DELIMITATION

The analysis refers to the ergonomic conditions in which the operators of the construction materials manufacturing company, located in the community of Guayparime, in the municipality of Guasave, in the state of Sinaloa, find themselves. Evaluating the postures of the workers in the activities they carry out, with the RULA method in a working day of 8 hours a day for 6 days a week. This company has 4 operators and five different areas: sieving, mixing, moulding, drying and storage.

4. METHODOLOGY

The study was carried out in several stages:

1. Carrying out a diagnosis of the company through tours, identifying the characteristics of the workers, work stations and the situation in which the company finds itself.
2. The work stations were analysed for a certain period of time, and the activities that present risk factors for the operator in the mixing area were identified, showing musculoskeletal injuries in the workers.
3. The applicable evaluation methods were RULA (work fatigue test), Corlett and Bishop (bodily discomfort) with which the risk run by the worker in his work area was evaluated, as well as the application of Mexican Official Standards (NOM).

5. RESULTS

After carrying out an analysis of the process of elaboration of construction materials, we identified an area of opportunity which has a negative impact on the operator, due to the fact that the work movements for mixing are inadequate, as the process requires it to be done manually in high temperature conditions, with inappropriate hearing conditions and at the same time exceeding the permissible load limits. The most problematic area is the Mixing area, where 2 male operators work, with an age range of 20 to 25 years old, with a working day of 8 hours for 6 days a week. The main activities are moulding products and transporting loads from the drying area and then to the warehouse.

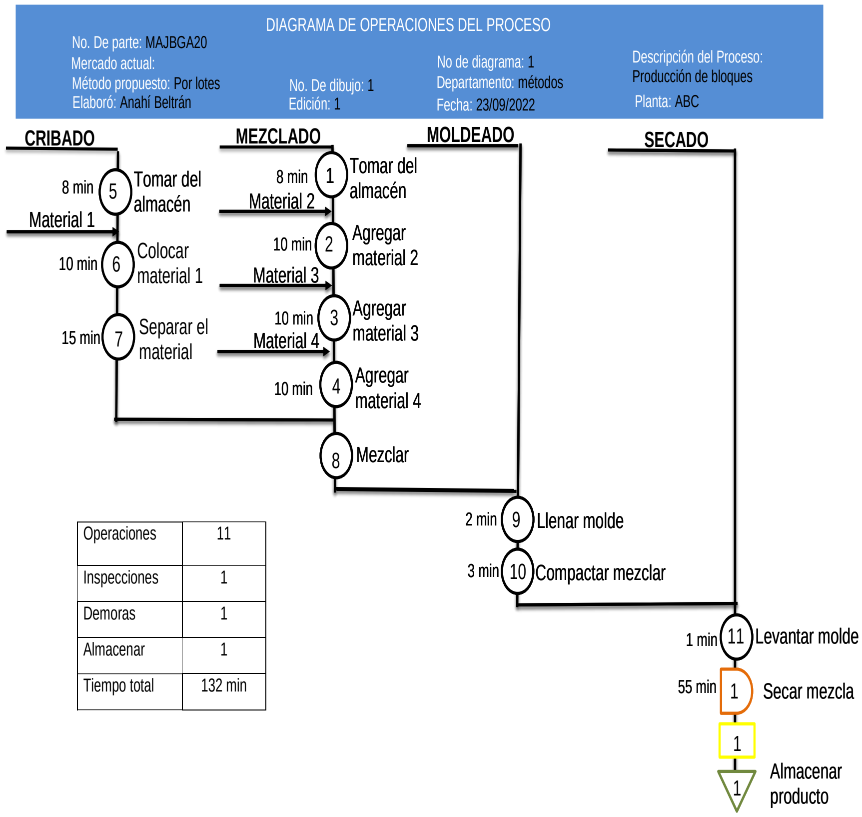


Figure 1 Process operations diagram

Figure 2. Photograph of Operator 1 and 2-product development.

5.1. Operator assessment

Método R.U.L.A. Hoja de Campo

Operador 1

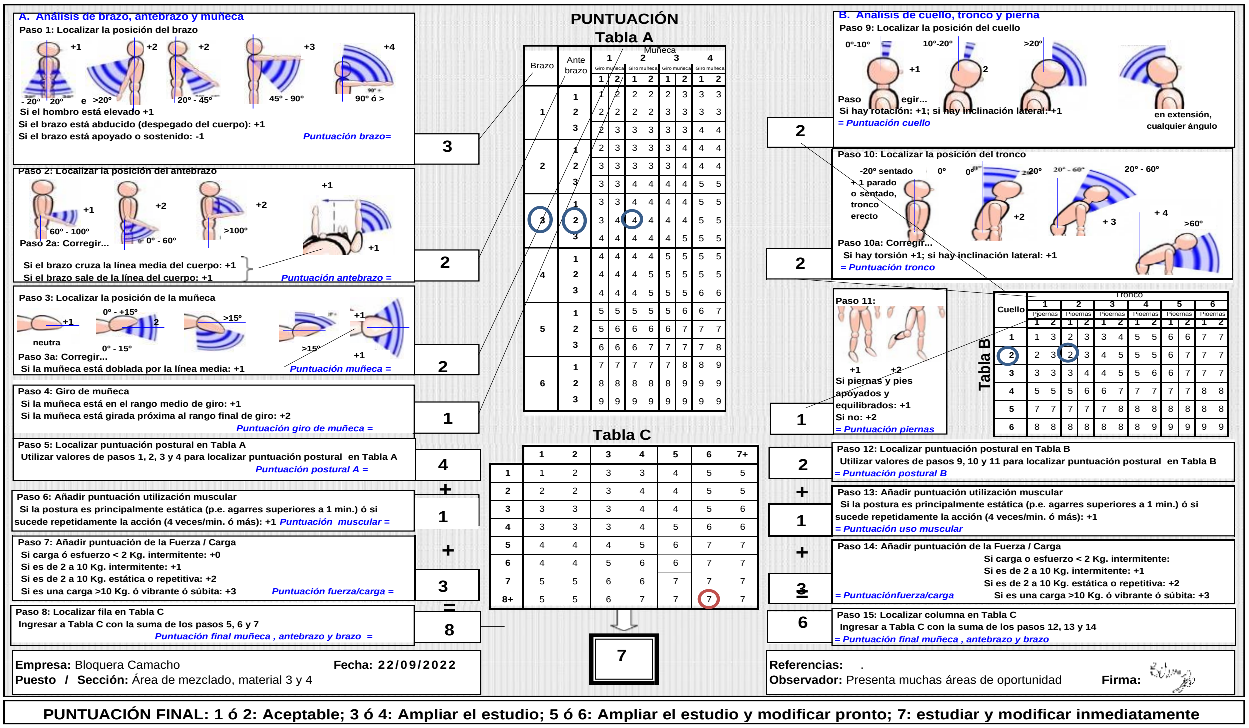


Figure 3. Application of the Rula Method Operator 1.

Operador 2

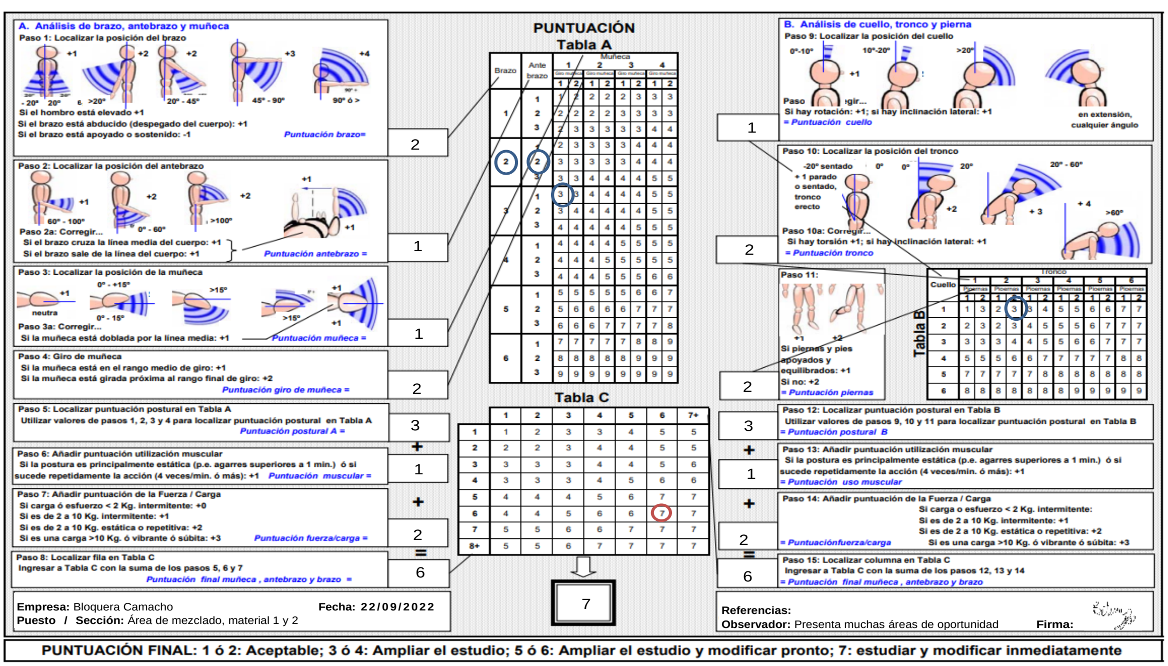


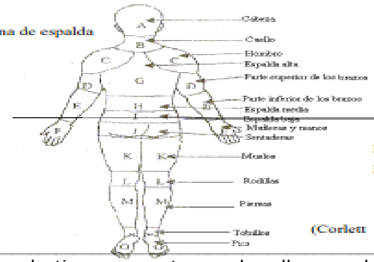
Figure 4. Application of RULA Method of Operator 2.

Operador 1

Mapa de molestias para las diferentes partes del cuerpo.

Marque con una cruz las partes del cuerpo donde sienta alguna molestia o dolor y numérelas en orden ascendente según su grado de molestia o dolor

Vista de una persona de espalda



M=Molestia
D=Dolor

(Corlett & Bishop, 1976)

Observaciones: La molestia se concentra en el cuello y espalda.

	ENTRADA							SALIDA						
A														
B								M						
C														
D														
E														
F														
G								M						
H								M						
I														
J														
K														
L														
M														
N														
O														

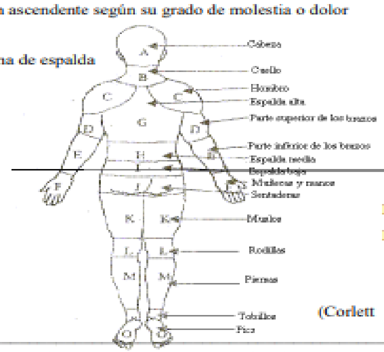
Figure 5. Application of the Corlett and Bishop Method of Operator 1.

Operador 2

Mapa de molestias para las diferentes partes del cuerpo.

Marque con una cruz las partes del cuerpo donde sienta alguna molestia o dolor y numérelas en orden ascendente según su grado de molestia o dolor

Vista de una persona de espalda



M=Molestia
D=Dolor

(Corlett & Bishop, 1976)

Observaciones: La molestia se concentra en los brazos.

	ENTRADA							SALIDA						
A														
B														
C								M						
D								M						
E								M						
F								M						
G														
H														
I														
J														
K														
L														
M														
N														
O														

Figure 6. Application of the Corlett and Bishop Method of Operator 2.

Table 1. Official Mexican standards applied to the production process

List of official Mexican Standards applied to the company's production process			
Company name: Bloquera Camacho			
Business: Company manufacturing and selling materials (block, partition, tile).			
Date: 09/22/2022			
Standard	**Yes**	**No**	**Observations**
Mexican Official Standard NOM-011-STPS-2001, Safety and hygiene conditions in workplaces where noise is generated.		**X**	The facilities do not have a mediator to reduce the noise generated by the machinery, nor do workers use personal protection.
Mexican Official Standard NOM-001-STPS-2008, Buildings, premises, facilities and areas in work centers-Safety conditions.		**X**	The company does not have safety conditions in any of its work areas.
Mexican Official Standard NOM-004-STPS-1999, Protection systems and safety devices for machinery and equipment used in the workplace.		**X**	The operators do not have any protection when using the machinery to carry out their activities.
Mexican Official Standard NOM-017-STPS-2008, Personal protective equipment-Selection, use and handling in the workplace.		**X**	The personnel do not have adequate protection for each of the activities they perform during their workday; they are tired.
Mexican Official Standard NOM-030-STPS-2009, Preventive occupational safety and health services - Functions and activities.		**X**	Employees do not have preventive health and safety services within the company.
Mexican Official Standard NOM-024-STPS-2001, Vibrations-Safety and hygiene conditions in workplaces.		**X**	Employees are exposed to high levels of vibration without any vibration.
NOM-016-STPS-1993, Relative to safety and hygiene conditions in workplaces regarding ventilation.		**X**	Personnel are exposed to high levels of humidity with no means of regulating ventilation.

6. CONCLUSIONS / DISCUSSIONS

The ergonomic analysis allows us to detect the risk factors to which the workers are exposed when carrying out operations. The temperature at which the work is carried out ranges from 42 to 48 degrees and a humidity of 70%, which generates low performance in the workers, presenting physical exhaustion, lack of concentration, fatigue from the second day of work, and for the mixing operations we can see that they are carried out with inadequate postures, developing cumulative trauma disorders. Neck, shoulders, arms, upper arms, knees, as well as lower, middle and upper back. Applying the RULA Method to the two operators indicates that there is a level 7 for each posture of analysis. Indicating that a change has to be made immediately and that a change in the working method has to be made.

A proposal to reduce the effect of the environmental conditions is to work at different times of the day when temperatures are not so high. This would also involve a rotation of activities. With regard to the design of the workstation, the workstation should be raised by 50 cm so that the workers can carry out the operations and not have to be in inadequate postures for a long time. Also take care that the Mexican Official Standards are met as being exposed to 90 decibels with rest periods as indicated in NOM-011-SPTS-2001, make the signage of spaces and conditions that marks the NOM-001-STPS-2010, the allocation of personal protective equipment to operators, NOM-017-STPS-2008 and the allocation of personal protective equipment is not present, as well as identify ergonomic risks at work.

With the application of the Corlett and Bishop Method, it was detected that physical fatigue is present from the second day of work, as well as discomfort at the end of the working day, and these are concentrated in the neck, upper, middle and lower back, arms, shoulders and wrists. A redesign of activities is suggested to take care of the physical and metal health of the two workers.

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EVALUATION OF THE DAILY ACTIVITIES OF PEOPLE WITH LIMB ABSENCE

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Resumen: Actualmente, son escasas las investigaciones realizadas para identificar las problemáticas en relación con las actividades diarias de personas con ausencia de extremidad. Los estudios se han enfocado en particular, en las características fisiológicas de las personas, así como las implicaciones biomecánicas del uso de prótesis. En este sentido se hace necesaria una perspectiva más cualitativa en la que se reconozcan las implicaciones que la ausencia de extremidad tiene en las actividades de la vida diaria.

En este artículo se exponen los resultados de una encuesta enfocada en identificar las problemáticas, desde la perspectiva de la ergonomía, en relación con una variedad de actividades diarias que van desde las básicas del hogar, hasta el trabajo y la socialización, así como la identificación de la experiencia que las personas han tenido con el uso o falta de prótesis.

Participaron 36 personas de población Latinoamericana (mayoritariamente mexicanos), todos de edad adulta y con ausencia de al menos una extremidad. Dicha encuesta fue dividida entre usuarios y no usuarios de Prótesis. Donde se pudo concluir que la mayoría de los usuarios de prótesis no requieren de asistencia para realizar sus actividades diarias, así como el uso de prótesis beneficia la satisfacción en la realización de las actividades diarias.

Palabras clave: Discapacidad, Extremidades Ausentes, Prótesis, Actividades Diarias.

Relevancia para la ergonomía: Para entender las actividades diarias de personas con ausencia de extremidad, la Ergonomía es un área fundamental, pues es una disciplina científica que se centra en la interacción entre las personas, y los demás

componentes de los sistemas, considerando sus propósitos. Entender las capacidades o limitaciones de las personas y cómo las características del sistema responden o no a ellas, es esencial para contribuir a construir escenarios más inclusivos.

En relación con los aportes de estos temas a la ergonomía, es importante mencionar que reconocer a las actividades diarias como escenario de análisis, amplía los espacios de trabajo de la ergonomía y muestra su importancia para mejorar cualquier actividad humana. Cabe resaltar que este análisis ha evidenciado también un tema que es muy propio de la ergonomía, como lo es el manejo manual de cargas, pero que ha sido muy poco considerado en poblaciones en condición de discapacidad. El resultado se puede traducir en la generación de conocimiento para sus futuras aplicaciones en el diseño de productos, espacios o servicios, tanto personales como laborales en los que se reduzca la exclusión a personas con ausencia de extremidad.

Abstract: Currently, little research has been done to identify the issues related to the daily activities of people with missing limbs. Studies have focused in particular on the physiological characteristics of individuals, as well as the biomechanical implications of the use of prostheses. This calls for a more qualitative perspective that recognizes the implications that limb absence has on activities of daily living.

This article reports the results of a survey focused on identifying the issues, from an ergonomic perspective, in relation to a variety of daily activities ranging from basic household activities to work and socializing, as well as identifying the experience that people have had with the use or lack of prostheses.

Thirty-six Latin American participants (mostly Mexicans), all of whom were adults and had at least one missing limb, participated in the survey. The survey was divided between prosthesis users and non-users. It was concluded that the majority of prosthesis users do not require assistance to carry out their daily activities, and that the use of prostheses benefits satisfaction in carrying out daily activities.

Keywords. Disability, Limbs Absence, Prosthetics, Daily Activities.

Relevance to Ergonomics: To understand the daily activities of people with missing limbs, Ergonomics is a fundamental area, as it is a scientific discipline that focuses on the interaction between people and the other components of systems, considering their purposes. Understanding the capabilities or limitations of people and how the characteristics of the system do or do not respond to them is essential to contribute to building more inclusive scenarios.

In relation to the contributions of these issues to ergonomics, it is important to mention that recognizing daily activities as a scenario for analysis broadens the working spaces of ergonomics and shows its importance to improve any human activity. It is worth noting that this analysis has also highlighted a topic that is very specific to ergonomics, such as the manual handling of loads, but which has been very little considered in populations with disabilities. The result can be translated into the generation of knowledge for future applications in the design of products, spaces,

or services, both personal and work-related, in which the exclusion of people without a limb is reduced.

1. INTRODUCTION

According to INEGI, disability is present in 5.7% of the population in Mexico, of which 41% indicate having mobility limitations (INEGI, 2021). Disability is defined by the World Health Organization as problems in the interaction between health conditions and environmental factors, resulting in physical restrictions in activities and participation in daily life.

According to the International Classification of Functioning, Disability and Health (WHO, 2001). Disability is an umbrella term for impairments, activity limitations or restrictions in social participation. Within disability, sensory, cognitive, and physical disabilities, among others, are recognized (WHO, 1980). Particularly in physical disability, in addition to wheelchair users, those who lack limbs due to the various difficulties that the environment presents are also considered.

The lack of limbs can be due to agenesis or amputation. Agenesis is defined as a congenital condition in which limbs do not develop properly. Amputation is understood as the removal of a body structure, mainly distal limbs such as arms and legs, either by trauma or surgery, in order to save the lives of people at risk from limb conditions (Erlt et al., 2021).

Few data on amputees in Mexico have been identified in the literature. In the book “Amputaciones, un reto para el Estado” (Vela et al., 2015), the National Academy of Medicine reports that on average 75 amputation interventions are performed per day and that approximately only 3% of amputees use prostheses; however, it does not report the reasons why people do not use them.

Current research reports that up to 75% of people with missing limbs report limitations in daily activities (Ebrahimzadeh et al., 2016). However, not enough information has been identified on the subject, so it is unclear which activities are most affected, as well as the possible relationship that the use of prostheses may have on performance and independence, leading to problems in interacting with the environment.

Some studies such as Yu et al. (2011) have focused on the physiological and health characteristics of individuals, as well as the use of prostheses in basic activities such as walking. However, there is little information related to the daily experience of people with limb absence, as well as information on the activities in which they recognize their limitations.

Based on the little information on the problems faced by people with disabilities due to the lack of limbs in their daily activities, it is considered that the discipline of Ergonomics can be essential to understand in a more systemic way, the conditions, and aspects to be improved in the environment or system in which they interact. This scientific discipline focuses on the interaction of human beings with the systems that surround them and helps them to solve problems, contributing through the improvement of products and services, taking into account human variability (Torres

& Rodríguez, 2021). In this way, it contributes to the search for better conditions of safety, satisfaction, and quality of life for people who lack a limb.

2. OBJECTIVES

2.1 Objective 1

To identify, from an ergonomic perspective, the problems, and limitations in the daily activities of people with missing limbs.

2.2 Objective 2

To recognize the experience, satisfaction, and perception of independence in carrying out daily activities.

3. METHOD

3.1 Delimitation and Participants

The project is delimited based on the following variables: Absent limb, Use of prosthesis, Independence, Performance and Satisfaction. For the identification of the level of independence and the experience in daily activities of the people, the following participation criteria were established for the questionnaire. The participants had to be Adults, from Latin American population, Spanish speakers, Gender indistinct, with absence of at least one limb, cause of absence and use of prosthesis indistinct. The fulfillment of these criteria allows us to identify a wide variety of aspects related to daily performance.

Thirty-six people from the Latin American population (mostly Mexicans) participated, of whom 14 were women and 23 were men. All participants met the above-mentioned criteria. The participants were divided into 2 groups: Prosthesis Users and Non-Users, of which 24 Users (15 men and 9 women) and 12 Non-Users (8 men and 5 women) were identified.

3.2 Questionnaire

For the elaboration of the questionnaire, two digital versions were developed in the Google Forms platform, addressed to people with absence of limb, users, and non-users of prosthesis. The questionnaire for both cases is made up of the following categories: demographic data, general information about the case and activities of daily living.

Prior to the application with the public, a pilot test was conducted with 3 participants who met the aforementioned criteria, in this test inconsistencies and redundancies were recognized, as well as demographic aspects and activities that had not been originally considered. The findings of this pilot test allowed fine-tuning details of the final questionnaire for its dissemination and correct collection of information.

3.3 Participant Recruitment

For the recruitment of participants and the application of the questionnaires, the questionnaires were disseminated with an informative banner through social media, groups or associations of amputees and prosthesis users, as well as verbal dissemination of the information through direct contacts of the researcher. The publications in social media groups were previously approved by the moderators.

The information provided to potential participants indicated the origin of the project, the institution, and departments of origin (University of Guadalajara and the Master’s degree in Ergonomics), as well as contact information of the researcher. The invitation was voluntary and once they contacted the researcher they were informed of the objectives of the project, the importance of their participation, as well as the inclusion criteria and informed consent.

In this consent form, the participants were informed about the use of the information collected, as well as the confidential handling of their personal and identification data.

Doubts about the consent form, the questionnaire, and technical aspects of its remote application at the convenience of the participants' time and the approximate response time of the questionnaire were clarified. For its application, there was no control of technical aspects (device on which they responded) or logistics (place). The Google Forms system adapts to mobile devices (cell phones and tablets) and computers.

3.4 Questionnaire application

Interested participants were provided with the link to access the User/Non-User questionnaire, according to the use of prostheses as the primary assistive device. In the questionnaire they initially read and accepted the consent to participate.

In some cases, the participants indicated their interest in the questionnaire, but did not have the equipment or skills to answer the questionnaire online by themselves (mainly by older adults), so a telephone appointment was arranged to answer as a guided interview, where the participants confirmed that they had the time to answer. The consent form was read to them, and doubts were clarified before accepting and continuing with the interview.

The conditions of the scenario that were detected were not very variable, most of the participants mentioned being at home and one participant at his workspace. In terms of devices, all participants answered the interview via telephone call on their personal telephone.

4. RESULTS

4.1 Ethical Corroboration of Results

At the beginning of the results analysis, inconsistencies were detected in 3 tests, in which the participants did not correctly complete the requested information, or the information and answers were provided by a third party. The usefulness or veracity of the authenticity of these 3 tests could not be verified, therefore they were discarded from this study. The results shown below are from the 36 participants who met the criteria and objectives previously stated.

4.2 Socio-demographic profile

Thirty-six people participated in the questionnaire, of which 24 were regular prosthesis users, 15 men (62.5%) and 9 women (37.5%) and in the case of non-users 12 participants, 8 men (61.5%) and 4 women (38.5).

The ages of the participants ranged from 25 to 64 years old, M=43.95. On the part of Prosthesis Users M=43.17, SD=9.84, while Non-Prosthesis Users M=45.38 and SD=12.25, where 13 of the participants are under 40 years old, 20 participants were between 40 and 59 years old and finally 3 participants belong to the age group over 60. In terms of citizenship, 32 participants were from Mexico with a participation rate of 88.9%, while the remaining participants were from Latin American countries such as Colombia, Uruguay, and Ecuador.

Table 1. Additional Demographic Characteristics of Participants.

Category	Distribution	Users		Non-Users	
		N	%	N	%
Level of education	Basic Education	6	25	5	41.7
	High School	6	25	4	33.3
	Specialist Technician	1	4.2	1	8.3
	College (Superior Education)	11	45.8	2	16.7
Employment situation	Employee	20	83.3	9	75
	Not Employed	4	16.7	3	25
Cause of Absence (optional)	Health condition	10	41.7	6	50
	Accident	14	58.3	4	33.3
	Unknown Cause	0	0	2	16.7

In terms of the cause of absence, a higher incidence of accidents was detected in prosthesis Users, and a higher incidence of health conditions in non-Users (mainly diabetes). Out of respect for the privacy of the participants, the collection of information on the cause of absence was optional, in which 2 non-user participants preferred to abstain from answering.

Table 2. Reported Absence of Limbs

	Users		**Non-Users**	
	N	**%**	**N**	**%**
Hand	0	0	1	8.3
Hip Disarticulation	2	8.3	0	0
Transfemoral	12	50	11	91.7
Knee Disarticulation	1	4.2	0	0
Transtibial	7	29.2	0	0
Bilateral Different Levels (Transfemoral / Transtibial)	2	8.3	0	0
Total	24	100%	12	100%

In the case of time since the absence of their limb, prosthesis Users report that it ranges from one year to 44 years (M = 11.42, SD = 11.98), while Non-Users report that it ranges from less than one year to 10 years (M = 3, SD = 3.07).

Table 3. Years since Limb Absence

	User		**Non-User**	
	N	**%**	**N**	**%**
Less than 1 year	0	0	3	25
1 - 3 years	8	33.3	6	50
4 - 6 years	6	25	1	8.3
7 - 10 years	2	8.3	2	16.7
More than 10 years	8	33.3	0	0
Total	24	100	12	100

Among the data of particular interest is that 20 participants who were prosthesis Users were integrated into work activities after the use of prostheses. In the case of non-prosthesis users, 3 did not work, representing a higher percentage compared to users. Non-prosthesis users reported a greater dependence on other members of their family, while prosthesis users reported being mostly responsible for other members of their family. Only 3 of the prosthesis users acknowledged greater dependence.

Table 4. Percentage of Responsibility of Participants in their Families

	Responsability	% Responsible for Someone else	% Someone responsible for the participant
Users	Yes	87.5	12.5
	No	12.5	87.5
Non Users	Yes	75	75
	No	25	25

Table 5. Percentage of Evaluation of Daily Activities
by Prosthesis Users and Non-Prosthesis Users.

No.	Activity	Users			Non Users		
		Easy	Neutral	Complicated	Easy	Neutral	Complicated
1	Upper Personal Hygiene	79.2	8.3	12.5	75	16.7	8.3
2	Lower Personal Hygiene	79.2	4.2	16.7	58.3	33.3	8.3
3	Lower Personal Attire	83.3	0	16.7	83.3	8.3	8.3
4	Upper Personal Clothing	83.3	8.3	8.3	75	25	0
5	Footwear	54.2	16.7	29.2	58.3	25	16.7
6	Room Cleaning	66.7	8.3	25	25	33.3	**41.7***
7	Wash Dishes	75	8.3	16.7	25	16.7	**58.3***
8	Food Preparation	66.7	20.8	12.5	25	25	**50***
9	Wash Clothes	58.3	20.8	20.8	25	25	**50***
10	Walk Pet	37.5	29.2	33.3	8.3	**50***	**41.7***
11	Pet Care	50	33.3	36.7	33.3	**41.7***	25
12	Child Care	50	37.5	12.5	50	33.3	16.7
13	Going for a Walk	50	25	25	25	25	**50***
14	Go Jogging	8.3	12.5	**79.2***	8.3	33.3	**58.8***
15	Go to the Supermarket	45.8	33.3	20.8	33.3	25	**41.7***
16	Going to the Mall	58.3	20.8	20.8	41.7	16.7	**41.7***
17	Carrying Heavy Objects	33.3	16.7	**50***	0	25	**75***
18	Playing Sports	33.3	29.2	37.5	8.3	**50***	**41.7***
19	Going to Parties	54.2	20.8	25	33.3	25	**41.7***
20	Drive Automatic Car	70.8	12.5	16.7	50	33.3	16.7
21	Driving a Standard Car	20.8	20.8	**58.3***	0	**50***	**50***
22	Work Activities	54.2	37.5	8.3	8.3	41.7	**50***

Note: Values expressed as a percentage.
**Data above 40%, where a greater complexity in the activities is detected.*

The previous table reports the percentage of ease or complexity in performing daily activities. Within the results it can be observed how, on the part of the prosthesis users, a higher level of ease was detected in the daily activities, and only 3 of the 22 activities reported a percentage of complexity higher than 50%, which were Going out to run, Carrying heavy objects and Driving cars (manual transmission), while the remaining 19 activities reported a maximum level of difficulty of 37.5% being this on the part of sports activities.

On the part of the Non-Prosthesis Users, higher levels of difficulty are observed in the performance of daily activities. At least 40% of the participants reported that 14 of the 22 activities are considered with a high level of difficulty, reaching a maximum of 75%, where participants express difficulty when carrying heavy objects. Additionally, the Non-Prosthesis users were the only ones to report a percentage higher than 40% in the "neutral" rating. Four of the activities were at this level and of these, three shared a level of greater than 40% at the high complexity level as well. These were "walking a pet", "playing sports" and "driving a car (manual transmission)", therefore, these activities reported very low levels of ease.

Of the 24 prosthesis users, 11 reported that their prosthesis allows them to walk without inconvenience, 11 moderately and 2 do not. Regarding basic personal hygiene activities, all participants recognized that they were able to perform them, with greater ease on the part of prosthesis users. The activities in which medium complexity was detected for all participants were: taking care of and walking a pet, attending social events (parties), going to the supermarket and shopping malls, and exclusively for non-users, complexity was detected in driving an automatic transmission vehicle. Among the most complex activities reported by all participants were walking, using stairs, handling heavy objects, practicing a sport, and driving a standard vehicle; non-users recognized greater complexity in household activities such as house cleaning, washing clothes and food preparation. In addition, non-users of prostheses recognize having greater difficulties in their activities at work compared to those who do use them.

After observing the results in Table 5, it can be identified that 9 of the 22 activities report opposite results in both groups, the activities "cleaning room", "Washing dishes", "Preparing food", "Washing clothes", "Going for a walk", "Going to the supermarket", "Going to the mall", "Going to parties" and "Activities at work" reported a high level of complexity by non-prosthesis wearers, while prosthesis wearers placed them at the other extreme, as activities with a low or easy level of complexity.

5. DISCUSSION

The identification of the intervening factors in the daily activities of people with missing lower limbs allows us to recognize the importance they give to the activities they can perform independently. From the distribution of the responsibilities, they have over other members of their family, it can be observed with 75% how the participants Non-Users of Prostheses declare to have greater limitations and require more assistance from a family member. These data are very close to what was observed by Alejandre & Velarde, (2021), who report that 77.2% of their participants receive support from a family member in the execution of their daily activities. Therefore, it is concluded that they present a lower level of independence reflected in a wide variety of daily activities. The results are quite evident in comparison to Prosthesis Users, where 9 of the 22 activities reported opposite results in Complexity level, having greater affectation in the non-User group.

A particularly important gap that was detected in the surveys is regarding the manual handling of loads in daily activities, where the participants, both Users and Non-Users of Prostheses, indicated high levels of difficulty, particularly with heavy objects, a point of particular interest, which, according to the results presented, even with the implementation of the prostheses, Users do not report ease in the activity. However, prosthesis Users report lower levels of difficulty compared to Non-Users.

It is suggested to study the manual handling of loads in people with limb absence, especially due to its clear relationship and influence on the performance of a wide variety of activities of daily living, such as household cleaning, washing clothes, and grocery shopping for both prosthesis users and non-users. The acquisition of groceries is an activity that the group of non-Users particularly finds more complicated and coincides with other studies such as that of Ebrahimzadeh et al., (2016). Even in studies of other indoles such as that of Roehrig et al., (2007) they agree that it is one of the most complex activities for groups of people in vulnerability.

A factor to consider may be the presence of diabetes, mainly in non-Users of prostheses, since according to Kizilkurt et al., (2020) there is a negative correlation in satisfaction with the use of prostheses, which causes the abandonment of these, and it ends up reflecting in a poor level of quality of life, where the participants experience low self-esteem, depression, anxiety, limitations in activities, among other factors. In the study by Horgan & Maclachlan, (2004) they agree on the greater presence of depression, however they report that this condition begins to decrease after 2 years from the amputation.

In addition, the average time elapsed since the amputation by non-Users is considerably lower compared to Users, so the short period of time influences their adaptation to activities. This information agrees with Raya et al., (2010) who report in their study that: time since amputation, cause of amputation and level of amputation are strong predictors of the performance of prosthesis users in walking, and how time since amputation can influence reintegration of the participants to the use of prostheses.

In the case of non-Users, other limitations in their lives are detected, such as access to job opportunities, whether new or re-employment, which are clearly lower compared to those of prosthesis users. In addition to this, the conditions in the design of the workspace can represent a limitation, especially for non-prosthesis users. Studies such as the one by Theeven et al., (2010) reiterate the importance of reintegrating people with limb loss into their social roles in the daily activities they used to have, since it is more important than just slightly improving performance in an activity like walking.

6. STUDY LIMITATIONS

Among the limitations found in the project, it is acknowledged that the list of activities was pre-established for all participants, which was also edited after the pilot tests, and a space was provided for comments where additional activities could be identified in which the participants also recognized difficulties. These additional activities were not considered for this article, as they are not statistically supported.

The evaluation of the tasks has a general sense, so the analysis of the specific aspects that make these activities complex for people with missing limbs requires more depth. A detailed review of the activities where problems of performance and independence are most commonly reported is suggested. Finally, it is recognized that the scope of the project is limited to the media in which dissemination was carried out. Proposals were made for dissemination of the project to organizations where the implementation was not successful.

7. CONCLUSION

Among the most relevant findings that can be concluded is that Prosthesis Users present a higher level of perceived independence, as well as most non-users identify a higher level of perceived difficulty in most of their daily activities and require assistance from a third party to perform them.

It is also concluded that the use of prosthesis benefits considerably the satisfaction in the performance of daily activities and the users demonstrate a higher level of independence, in addition they identify it as a fundamental element in their lives which they cannot do without.

In addition to this and according to the results obtained, although the participants report higher levels of ease, there are still certain limitations that do not allow the users a complete reinsertion and with satisfactory results in all the daily activities of advanced level. However, their needs are clearly contrasted with those of the non-Users, who report higher levels of difficulty even in Instrumental Activities, which are at a lower level in the hierarchy.

These differences between the groups of prosthesis users and non-users make evident the importance of the implementation of these devices in people with absence of a limb. As well as the evaluation and intervention of the conditions in which multiple daily activities are performed (products, spaces) that allow improving the interaction of this sector of the population with the systems that surround them.

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PROPOSAL FOR REDESIGNING THE WORK AREA IN A SEAFOOD RESTAURANT TO IMPROVE CONDITIONS IN THE WORK AREA

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Resumen: En el presente trabajo se abordan temáticas relacionados al área de la ergonomía aplicada y desarrollada en el campo laboral en franquicias marisqueras que se desempeñan en la elaboración de productos en barra fría y caliente, intentando llegar a una mejora tanto en área de trabajo, implementado técnicas y herramientas que ayuden a realizar eficazmente la actividad.

Esto es una evaluación de trabajo donde el objetivo es proponer un rediseño de las estaciones de trabajo y la distribución en el área de cocina de restaurante de mariscos, para mejorar las condiciones en el área de trabajo y que permita mejorar todo lo posible el servicio y la elaboración de la comida, considerando cumplir con los principios ergonómicos, tratando de hacer la tarea más accesible para el trabajador dentro del área de trabajo que es la cocina, dando la mejor experiencia al consumidor.

El proyecto se enfoca específicamente al área física y las estaciones de trabajo de la cocina de un restaurante de mariscos. En la que primeramente se tomaron registros de todas las instalaciones del local, las operaciones que se realizan al desarrollar el proceso, la distribución del personal, así como, las condiciones y posturas en las que se trabaja.

En segunda instancia se analizó y seleccionaron las observaciones en las que el proceso se vea mermado y buscar una solución ergonómica, buscando reducir las interferencias en el flujo y los problemas respecto a la situación actual del área.

Así mismo, se desarrolló una propuesta de diseño considerando las dimensiones requeridas de acuerdo con el número de personas que comparten el espacio, el proceso que realizan, el flujo para llevar a cabo las operaciones y la necesidad de equipamiento.

Por último, se consideró las condiciones que se deben cumplir de acuerdo con las normas de la STPS que apliquen en el área y se desarrolló otra propuesta, solo faltaría que el dueño de la autorización de implementarla pues se tendría que modificar toda la estructura.

Se dejó una nueva propuesta en caso de que el dueño algún día decida aplicarla, considerando ciertos aspectos ergonómicos que harán sentir al empleado en una agradable área de trabajo.

Key words: Distribution, improvement, working environment, comfort

Relevance to ergonomics: Better distribution and improved conditions for workers in the kitchen area.

Abstrac: This paper addresses issues related to the area of ergonomics applied and developed in the labor field in seafood franchises that perform in the preparation of products in cold and hot bar, trying to reach an improvement in both work area, implementing techniques and tools that help to effectively perform the activity.

This is a work evaluation where the objective is to propose a redesign of the work stations and the distribution in the kitchen area of the seafood restaurant, to improve the conditions in the work area and to improve as much as possible the service and the elaboration of the food, considering to comply with the ergonomic principles, trying to make the task more accessible for the worker within the work area that is the kitchen, giving the best experience to the consumer.

The project focuses specifically on the physical area and workstations in the kitchen of a seafood restaurant. First of all, records were taken of all the facilities ofthe premises, the operations that are carried out when developing the process, the distribution of the personnel, as well as the conditions and postures in which they work.

Secondly, we analyzed and selected the observations in which the process is impaired and looked for an ergonomic solution, seeking to reduce the interferences in the flow and the problems with respect to the current situation of the area.

Likewise, a design proposal was developed considering the dimensions required according to the number of people sharing the space, the process they perform, the flow to carry out the operations and the need for equipment.

Finally, we considered the conditions that must be met according to the STPS standards that apply in the area and developed another proposal, only the owner would have to give the authorization to implement it because the entire structure would have to be modified.

On the other hand, comparing the representation of the original kitchen with the simulation of the new organization, it is true that the result was similar but not the same, it kept almost the same image, but that minimal difference helped to increase the circulation area inside the kitchen, reducing accidents a little. Another point to clarify and that was not mentioned before is that the working postures were not so forced because the facilities were adequate for the workers. A new proposal was left in case the owner decides to apply it someday, considering certainergonomic aspects that will make the employee feel in a pleasant work area.

Keywords: Layout, improvement, working environment, comfort.

Relevance to ergonomics: Better distribution and improved conditions for workersin the kitchen area.

1. INTRODUCTION

In any restaurant, regardless of the type of food served, the focus that determines the ability to meet the daily demands of the customers that come to the restaurant will be related to the level of efficiency that the workers in the work area are able to meet. The productivity capacity of an organization, company or business, such as a restaurant, is closely related to the design of the work area; for Niebel and Freivalds(2009) the increase in productivity of companies and businesses is linked to their growth and increased profits. The authors also argue that "productivity improvementrefers to the increase in the amount of output per labor hour invested".

In a work area where there are workers interacting with each other and with their environment (with their different workstations or workstations), a great variety of aspects must be taken into consideration. The way in which the space is distributed for functions or tasks, as well as the components that are part of the work area and are necessary to perform the work, process or activity have some influence on the behavior that workers will have, because it is known that the conditions of the environment in which they work generate different types of sensations, However, regardless of the sensations, the purpose or function of that area remains the same, so that, evidently the ability and way of attending to work activities is determined toa large extent by the quality of the work environment (Bestratén Belloví *et al.,* 2007).

This paper addresses issues related to the area of ergonomics applied and developed in the labor field in a seafood restaurant that works in the preparation ofproducts in hot and cold bar, trying to reach an improvement in the work area, implementing techniques and tools that help to effectively perform the activity.

2. OBJECTIVES.

2.1. General Objective.

Improve as much as possible the service and food processing without losing the ergonomic side, trying to find the adequate and successful organization of the distribution of the work area, reducing the time, making the task more feasible for the worker, giving the best experience to the consumer.

2.2. Specific objectives.

- To achieve a better passage between the kitchen staff that does not generate"traffic" and there is better circulation.
- Distribute and arrange the kitchen equipment in the best possible way, so thatthe product, i.e. the food, flows smoothly and leaves the kitchen in the best possible way.
- Make the changes mentioned above trying to invest as little as possible.

3. METHODOLOGY.

3.1. Registration of the facilities of the premises

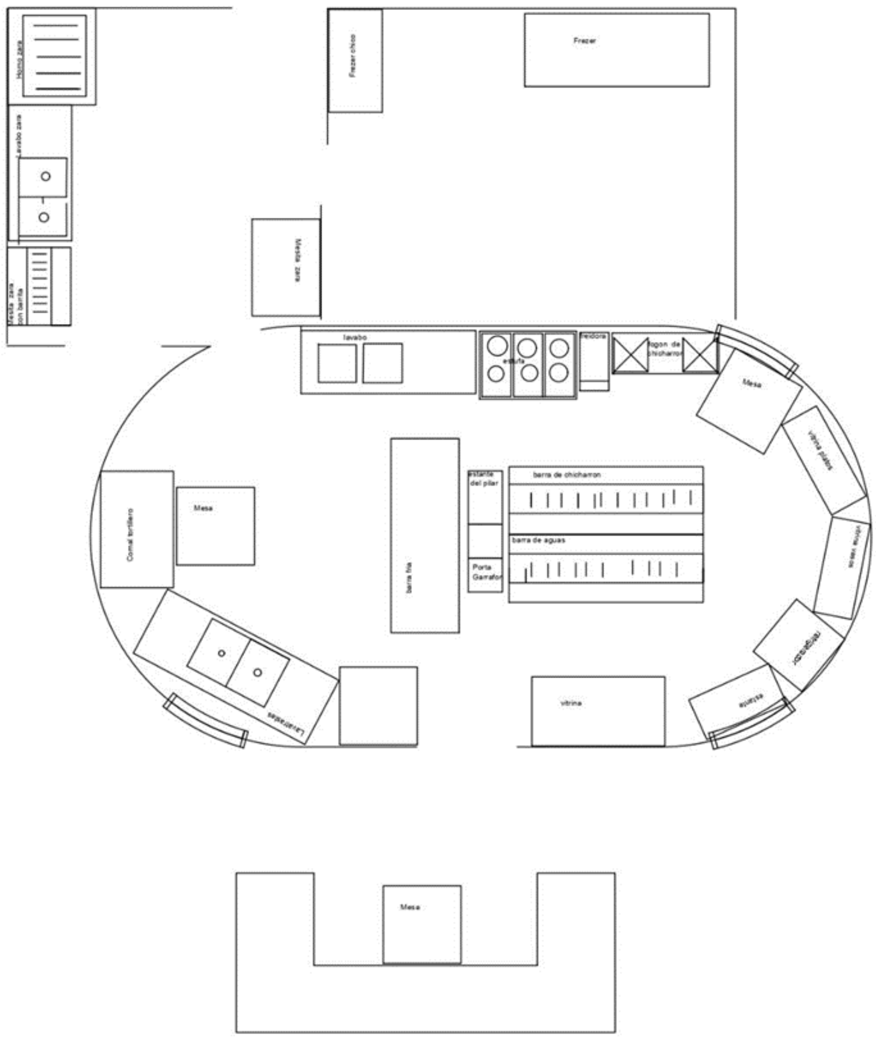

Figure 1. Original layout of the premises.

In the previous image it can be seen that the kitchen is distributed in two parts, plus the storage area, and the bar where the finished dish is prepared, the upper left region is where the fish is prepared, which has an oven, a sink, a small table and another table with a small bar, on the right side there is the storage area where there are two fryers where the fresh seafood is preserved; in the central part is the area for the preparation of the cold bar, which has a bar; the tortillas, where there is a large comal and a table where the tortillas are made; the dishwasher, plus a separate table where the accumulated slabs are placed; the fresh water area where there is a carafe holder and a bar for the preparation of lemonades, jamaicas, and micheladas; the area of the hot bar where there is a stove to prepare the machacas and dishes by style, fryer (oil distiller), stove for the chicharrones (here the fried fish is also prepared), and a table where the chicharrones are prepared, both shrimp and pot, without forgetting their respective bar where they decorate, that is to say, they finish preparing the dish, to deliver it to the client; It should not be forgotten that there are showcases where plates, glasses and other objects are stored, apart from a refrigerator where soft drinks and some vegetables that are used in the kitchen are taken; at the bottom of the image you can notice a bar with a table where the dish is delivered to the waiter, who finally gives it to the customer to enjoy it.

Figure 2 Collage of the restaurant facilies.

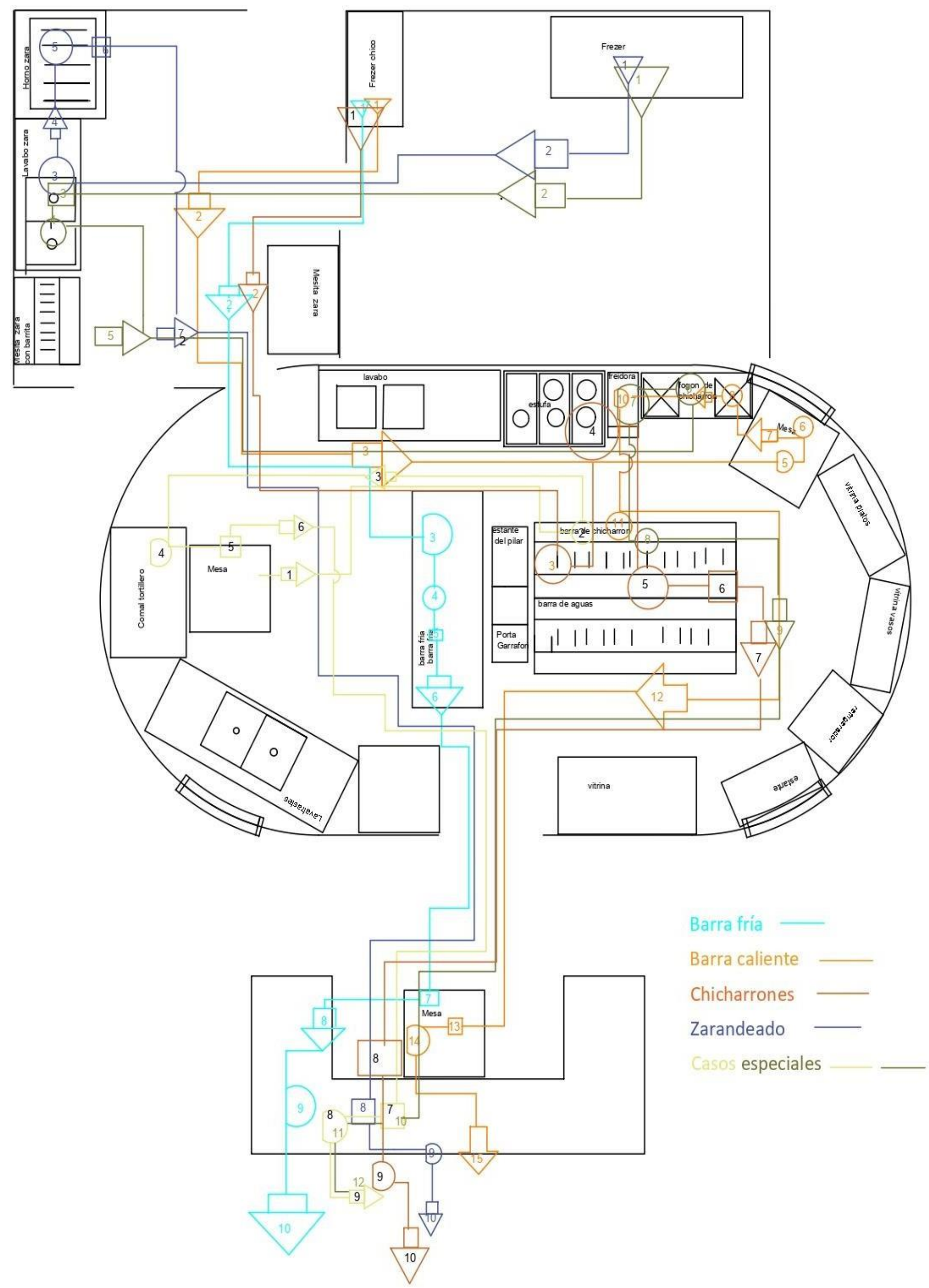

Figure 3 path diagrams of some of the foods that are prepared.

3.2. Analysis of the work area

Something that calls the attention of the work area are the shapes and proportions it has, because when moving around the area are generated collisions with some equipment, causing some inconvenience or damage within the work area reducing productivity, but, although doing the calculations with the De Guerchet Method yields a result of approximately 57 square meters (57 m2) to have a good distribution. The same amount that if we compare it with the total work area of the premises, is more than enough to be able to organize everything in a good way, because it gives a value of approximately 63 square meters.

1	equipo	largo (m)	ancho (m)	alto	no. De maqui	no. De lados	K	ss(m2)	sg(m2)	se(m2)	st(m2)	
2	horno zara	1.00	0.70		1.00	1.00	0.50	0.70	0.70	0.70	2.10	
3	lavbo zara	1.40	0.65		1.00	1.00	0.50	0.91	0.91	0.91	2.73	
4	mesita de zar	1.00	0.70		1.00	1.00	0.50	0.70	0.70	0.70	2.10	
5	mesita con ba	0.80	0.65		1.00	1.00	0.50	0.52	0.52	0.52	1.56	
6	frezer	1.90	0.75		1.00	1.00	0.50	1.43	1.43	1.43	4.28	
7	frezer pequeñ	1.07	0.56		1.00	1.00	0.50	0.60	0.60	0.60	1.79	
8	comal tortilla	1.20	0.75		1.00	2.00	0.50	0.90	1.80	1.35	4.05	
9	lavatrastes	2.00	0.90		1.00	1.00	0.50	1.80	1.80	1.80	5.40	
10	mesa	0.80	0.80		3.00	2.00	0.50	0.64	1.28	0.96	2.88	
11	porta garrafo	0.35	0.35		1.00	1.00	0.50	0.12	0.12	0.12	0.37	
12	barra de cev	2.00	0.70		1.00	1.00	0.50	1.40	1.40	1.40	4.20	
13	barra de agua	2.00	0.70		1.00	1.00	0.50	1.40	1.40	1.40	4.20	
14	porta tortiller	0.55	0.35		1.00	1.00	0.50	0.19	0.19	0.19	0.58	
15	fogon chichar	1.10	0.42		1.00	1.00	0.50	0.46	0.46	0.46	1.39	
16	freidora	0.30	0.60		1.00	1.00	0.50	0.18	0.18	0.18	0.54	
17	estufa	1.00	0.70		1.00	1.00	0.50	0.70	0.70	0.70	2.10	
18	barra chicharr	2.00	0.70		1.00	1.00	0.50	1.40	1.40	1.40	4.20	
19	vitrina platos	1.07	0.40		1.00	1.00	0.50	0.43	0.43	0.43	1.28	
20	vitrina vasos	1.00	0.90		1.00	1.00	0.50	0.90	0.90	0.90	2.70	
21	vitrina	1.37	0.71		1.00	1.00	0.50	0.98	0.98	0.98	2.93	
22	refri	0.70	0.65		1.00	1.00	0.50	0.46	0.46	0.46	1.37	
23	lavabo	1.80	0.55		1.00	1.00	0.50	0.99	0.99	0.99	2.97	
24	estante	0.90	0.45		1.00	1.00	0.50	0.41	0.41	0.41	1.22	
25	estante del pi	0.35	0.55		1.00	1.00	0.50	0.19	0.19	0.19	0.58	
26										total	57.49	mts2

Table 1 Application of the Guerchet Method in the work area.

When considering points such as plumbing, drainage and gas installations, some installations cannot be moved, such as the sinks, dishwashers, stoves, burners and the tortilla griddle, as well as the oven. When observing the sketch of the premises, he realized that the curved shape would not help at all in the homogeneous and efficient distribution of the work, as well as for economic reasons and for the time and disposition of the restaurant manager, the changes that can be made will be limited, but not impossible.

When considering points such as plumbing, drainage and gas installations, some installations cannot be moved, such as the sinks, dishwashers, stoves,burners and the tortilla griddle, as well as the oven. When observing the sketch of the premises, he realized that the curved shape would not help at all in thehomogeneous and efficient distribution of the work, as well as for economic reasonsand for the time and disposition of the restaurant manager, the changes that can bemade will be limited, but not impossible.

3.3. Simulation.

To avoid conflicts between the restaurant and its workday, the changes were first made in a design program, so as not to interrupt the restaurant's production. To make the changes once they were made in the design program, we waited until the restaurant's working day off to work for a week and verify the results.

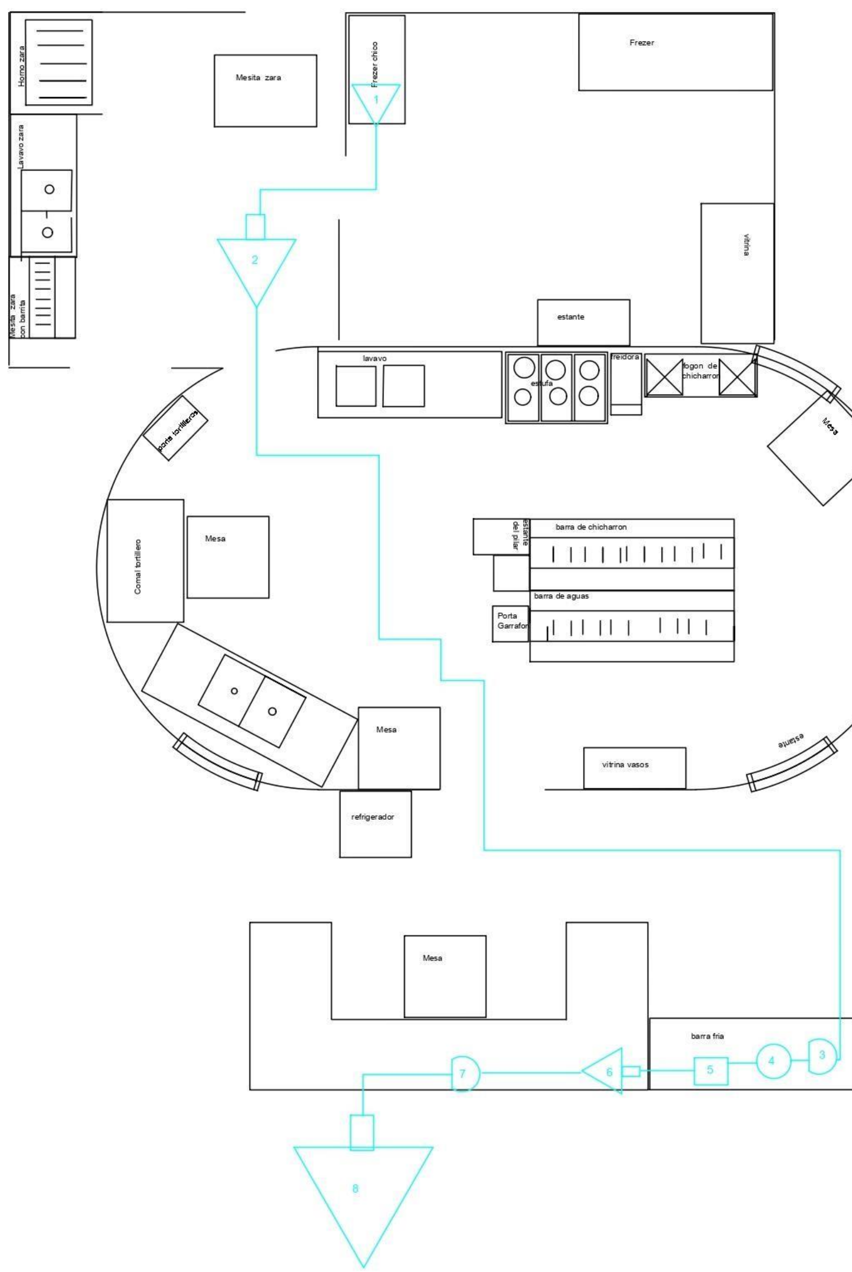

Figure 4 Representation of the new cold bar flow in the new distribution.

As can be seen in the simulation, the changes made are few and most of the path diagrams are similar except for the cold bar, which is the one that can be differentiated from the rest.

Although the limitations of the piping installations, already mentioned before, such as the drainage, gas installation, as well as the doors, made some equipmentto be organized in the same way, such is the case of the shaking area, it was takeninto consideration the arc that reaches the door because no matter how we accommodate the tables the problem would be greater, because instead of decreasing the nonconformity in the work area is increased, and that is what is sought to reduce; the only feasible solution is to consider work tables that measurefrom 70m to 75m long, which is the average reach that people have.70 m to .75 m long, which is the average reach that people have, as well as the area of the chicharrones and hot bar, the changes made are not many, because the gas pipe installations do not allow any movement, but something positive is that we managedto increase by 10% more the area of displacement of the same so the risk of a disaster due to reduced space has decreased a little more. The sinks were left in thesame place.

While it is true that the shape and distribution of the work area analyzed above,not much can be done, unless they remodel the structure of the restaurant or redesign the kitchen equipment according to the structure of the restaurant, our team launched a new proposal for design and organization, which will help employees tofind more comfortable and pleasant stay in the work area. A new form in which instead of curves, corners with 90-degree angles are contemplated, with these specifications the work area could be better utilized. New exhaust fans. As well as a ventilation system that regulates the temperature inside the establishment, so that the thermal sensation would not be as devastating as in some cases it was noticed that it reached over 40 degrees Celsius, causing dehydration and dizziness in someworkers in the kitchen area, also a new lighting system would be proposed to improve visibility within the work area. All this in order to comply with certain NOM standards of the STPS in order to provide workers with a better environment and work area.

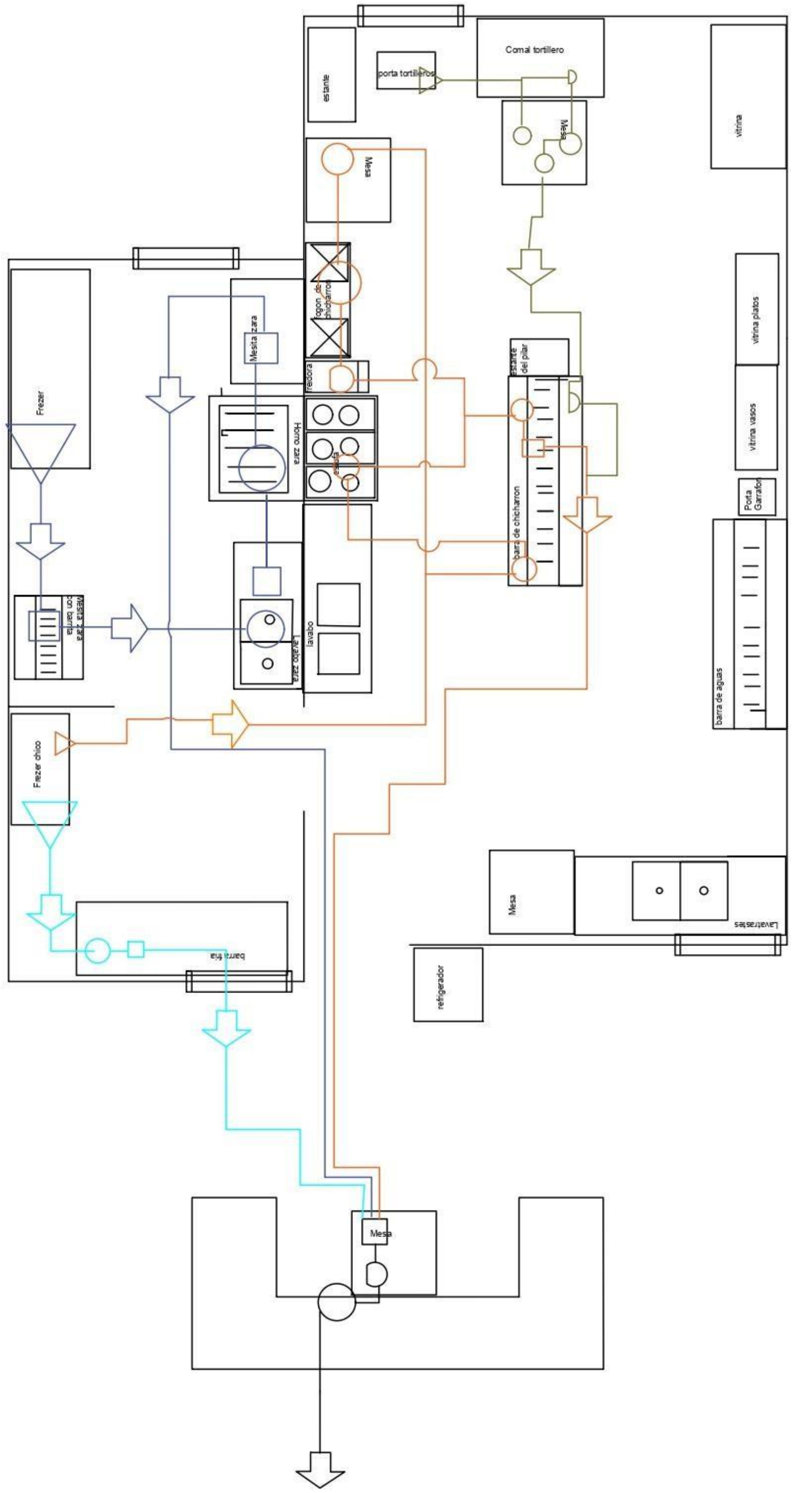

Figure 5. Path diagram in new structuring and organization proposal.

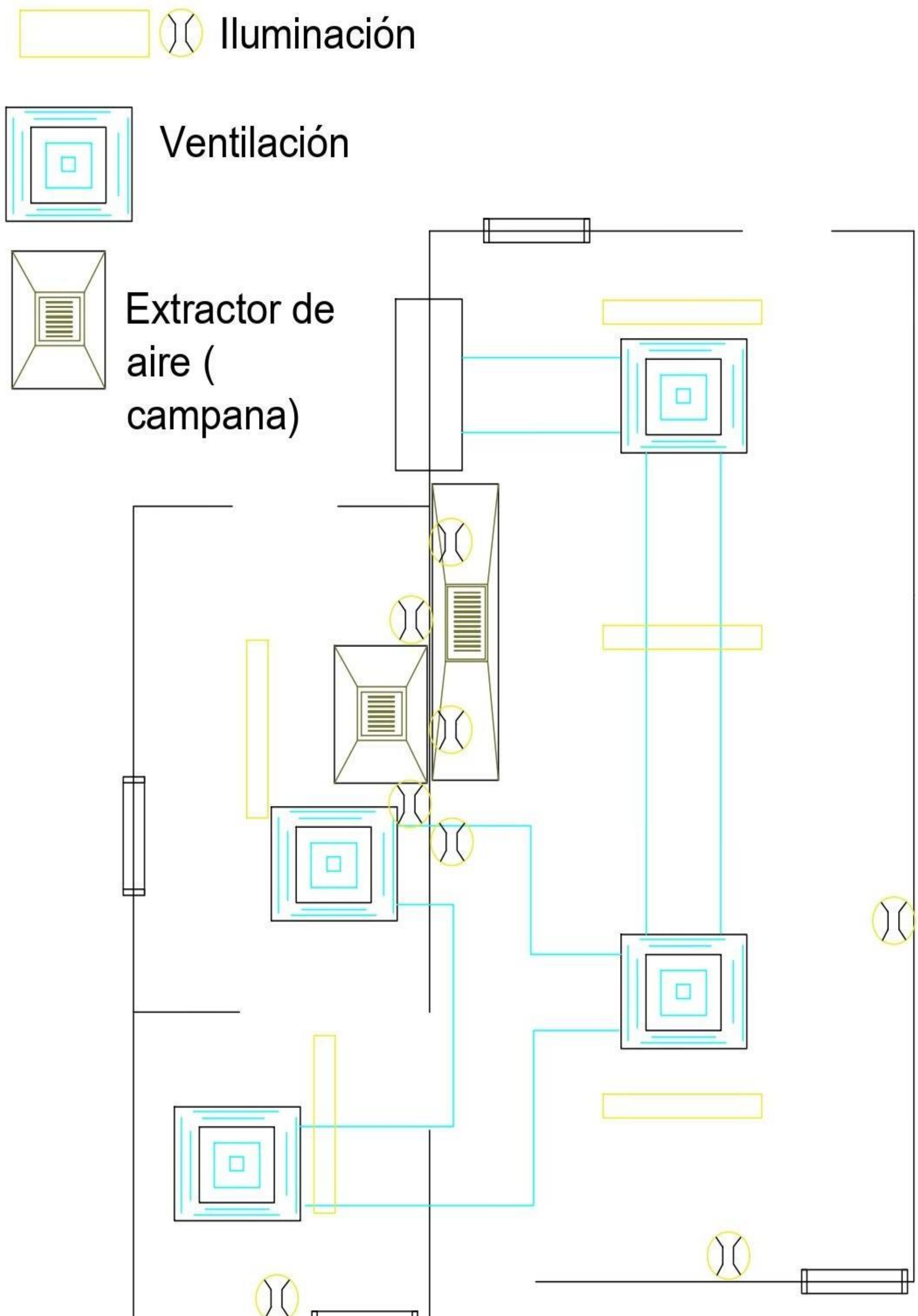

Figure 6. Ventilation system, lighting and exhaust fans.

4. RESULTS

When comparing the representation of the original kitchen with the simulation of thenew layout, it is true that the result was similar but not the same, it kept almost the same image, but that minimal difference helped to increase the circulation area inside the kitchen. Another point to clarify and that was not mentioned before is thatthe working postures were not so forced because the facilities were adequate for theworkers.

On the other hand, there is the new proposal for structuring and distribution in the premises. This will be described below:

Figure 7. Representation of dimensions and area of the proposed new model Area=59.50m2

When considering the main structure that measured approximately 63 m^2 , in thesimulation only what was inside it was rearranged, however, the new proposal of structuring and organization uses less work area, which yields a value of 60 m^2 , thus preserving enough space to move easily within the facilities without causing crashes or stagnation of personnel, It is also proposed to install air extractors to remove all the co2 produced in the kitchen, especially in the hot bar and in the zarandeadero, as well as other asphyxiating gases that are produced at the time ofmaking this type of food, as well as a ventilation system by ducts that will be regulated to have a more pleasant thermal sensation at the time of work. Sufficient windows that allow the passage of natural light plus led panel lamps to have a greatergeneral light, plus a spotlight near the area of the cold bar and hot bar as it is also inthe zarandedero, in order to avoid future injuries or accidents due to insufficient lighting.

5. DISCUSSION/CONCLUSIONS

Upon seeing the sketch of the premises, it was realized that the curved shape would not help the homogeneous and efficient distribution of work, that, due to economic issues and the restaurant owner's disposition, the changes that can be made are limited, but not unfeasible; a new proposal was left in case the owner decides to apply it one day, considering certain ergonomic aspects that will make the employee feel in a pleasant work area.

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MOMAS CAFÉ ERGONOMIC ANALYSIS

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Resumen: Actualmente podemos ver el crecimiento de empresas de cadena o independientes (MyPIMES) que se dedican a la venta de café, esto en base a una llamada "Cultura del café" que implica que ya no solamente bebemos café por su contenido de cafeína y para empezar la mañana sino que lo hacemos como una experiencia que buscamos fuera de nuestra casa, sin embargo con el crecimiento de este tipos de establecimiento también se ha generado un crecimiento en las molestias musculoesqueléticas de los empleados de este tipo de organizaciones.

Moma Café-Barra de expreso es una empresa fundada en año 2020, su producto principal es el café contando con un barista principal, además de tener otras bebidas sin café, postres y snacks; ofrece un lugar cómodo ya sea dentro del local o en la terraza para pasar un tiempo agradable además de ser pet-friendly. Esta empresa se divide en 4 secciones (cocina, área del barista, comedor y terraza). El lugar en el que se realizó principalmente este estudio para realizar la evaluación ergonómica fue el área del barista ya que es donde se pueden presentar más equipos, ambiente y sonidos más molestos. Con el fin de realizar las recomendaciones pertinentes para hacer cambios en la estación de trabajo, en caso de ser necesario.

Palabras clave: OWAS, BRIEF, REBA, LEST, Evaluación ergonómica de puesto de trabajo

Relevancia para la ergonomía: La adopción continua o repetida de posturas dolorosas durante el trabajo genera fatiga y a la larga, puede provocar trastornos en el sistema musculoesquelético. Esta carga estática o postural es uno de los factores

para tener en cuenta en la evaluación de las condiciones de trabajo, y su reducción es una de las medidas fundamentales a adoptar en la mejora de las posiciones. Es por eso por lo que la aplicación de los métodos de evaluación postura cobra relevancia como herramientas de mejora que nos permite estar monitoreando la salud del operador y saber cuándo es arriesgado tenerlos en una posición durante un período prolongado de tiempo.

Abstract: Currently, we can see the growth of chains or independent companies (MyPIMES) dedicated to coffee sales; this is based on a so-called "Coffee Culture" that implies that we no longer only drink coffee for its caffeine content and to start our days with energy. Still, we do it as an experience that we look for outside our home; however, with the growth of this type of establishment, there has also been a growth in the musculoskeletal discomfort of employees of this type of organization.

Moma Café-Barra de express is a company founded in 2020; its main product is coffee with the main barista, in addition to having other types of drinks, desserts, and snacks; it offers a comfortable place either inside the premises or on the terrace to spend a pleasant time in addition to being pet-friendly. This company is divided into four sections (kitchen, barista area, dining room, and patio). The place where this study was mainly carried out to perform the ergonomic evaluation was the barista's area since it is where more equipment, atmosphere, and more annoying sounds can be presented in seeking to make the relevant recommendations for workstation changes following ergonomic guidelines.

Keywords. Ergonomic evaluation, OWAS, BRIEF, REBA, LEST.

Relevance to Ergonomics: The continuous or repeated adoption of painful postures during work generates fatigue and, in the long run, can cause disorders in the musculoskeletal system. This static or postural load is one of the factors to be considered in the evaluation of working conditions. Its reduction is one of the fundamental measures to improve positions. That is why research on posture assessment methods is so important; it is essential to see the operator’s health and know when it is risky to have them in a position for a prolonged period.

1. INTRODUCTION

According to information provided by the U.S Secretary of Agriculture and Rural Development, coffee is the second most consumed beverage in the world. It is estimated that 2.25 billion cups of coffee are consumed daily worldwide. Our country produces coffee in fourteen states, but 90% of its production is concentrated in four states (Chiapas, Veracruz, Puebla, and Oaxaca). On the other hand, the Center for Studies for Sustainable Rural Development and Food Sovereignty (CEDRSSA), in a study requested by the Mexican House of Representatives and reported in 2019, mentions that according to information from the United States Department of Agriculture (USDA), coffee consumption in Mexico grew at an average annual rate of 1.8% between the 2006/2007 and 2017/2018 yearly cycles. We are in this last cycle in 2.4 million bags of 60 kilograms. 60.6% of consumption corresponded to soluble coffee, and 39.4% to roasted and ground coffee (CEDRSSA, 2019).

While Euromonitor (2017), in its report called "Analysis of the Coffee Consumption Market in Mexico 2016," mentioned that there is a final product consumption of 87,300 tons of coffee, of which 40.5% corresponds to ground coffee and 5.3% to coffee beans which corresponds to 45.8% of the total. The above is concerning the fact that it is considered that Mexicans have developed a "coffee culture" in which many consumers drink coffee as a pleasant experience and make it outside their homes.

All the above is important to mention because it leads us to understand the growth of coffee shops, both chain (2.8% growth from 2016 to 2021) and independent (MyPYMES); however, what has not developed at the same speed is the design with the ergonomic approach of the human-machine systems that we find in these businesses, and therefore we begin to have baristas with musculoskeletal discomfort that in the future may become work-type injuries (Albarracin et al., 2018).

This ergonomic evaluation aims to detect the presence, in the positions evaluated, of risk factors for the appearance of the workers who occupy them with disergonomic health problems. Several studies relate these occupational health problems with these risk factors at a certain level (Ruiz et al., 2022). It is, therefore, necessary to carry out ergonomic evaluations of the posts to detect the level of such risk factors (Escalante & Guaita, 2022; Adaramola & Ugbebor, 2014; Anusha Chintada & Umasankar, 2022). Although the legislations of each country vary in terms of their normative demands, companies must identify the dangers derived from the presence of high ergonomic risks in their jobs.

Moma Café is a company that cares both about the well-being of its consumers and that of its workers, so they allowed this ergonomic study to detect possible risks in work done in the barista area and are entirely open to feedback to improve the workplace.

Next, a brief description of the evaluated work area (in this case, the barista's site) will be given. The barista's workspace has 1.5m wide x 4m long dimensions. The workstation is small, but for the tasks that are carried out, it is of appropriate size since there is only one person at a time. No objects, equipment, or furniture can interfere with the movements or activities.

2. OBJECTIVE

Perform an analysis of the working conditions in which Moma coffee is found through methods such as the Checklist for initial ergonomics risk evaluation (LCE), the Ovako Working Analysis System (OWAS), the Baseline Risk Identification of Ergonomic Factors (BRIEF), the Rapid Entire Body Assessment (REBA), and the Economics Laboratory and Labor Sociology (LEST), and offer recommendations to improve the workplace and physical conditions

3. DELIMITATION

The evaluation intends to create proposals for improvement, focusing on ergonomics to eliminate or reduce the risks of injuries and accidents among workers and improve the productivity and quality offered in Moma Café.

4. METHODOLOGY

To carry out this ergonomic improvement study, we first went to the Moma Espresso Bar site, requesting the owners' permission to collect the necessary information.

Once the authorization was obtained, the area that the study would encompass had to be chosen; in this case, the barista's room, where most of the orders for this establishment were carried out (Figure 1).

Figure 1. Barista´s area

Subsequently, all the necessary observations of the tasks carried out by the operator, in this case, the barista, were made. The primary concern was observing their position and scope; their work could be facilitated or hindered depending on their positions. Once the observations were recorded, the data was analyzed in detail to apply the appropriate analysis methods to determine the fairest way to form conclusions and final recommendations that would be useful for their further development. Based on Ly (2011) recommendations, environmental measures were taken, and improvement suggestions were made.

5. RESULTS

Some postures that were considered critical are shown next:

Figure 2. Barista´s postures

The LCE arrogates forty-six proposed actions (128 items evaluated) related mainly to the narrow dimensions of the workplace, environmental conditions, and some safety features concerning the equipment. Six of the actions are considered urgent, but none are very urgent.

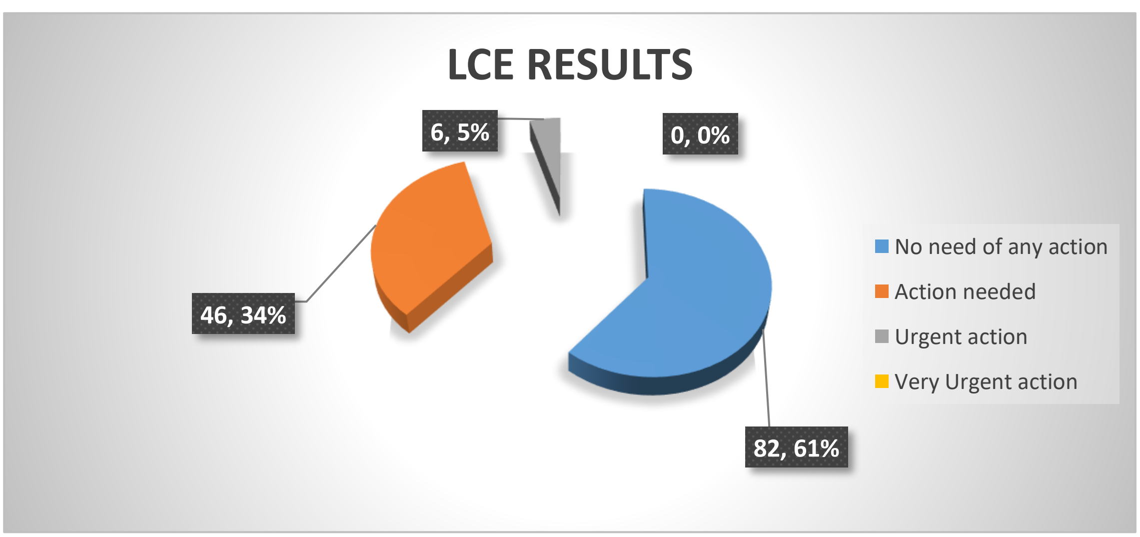
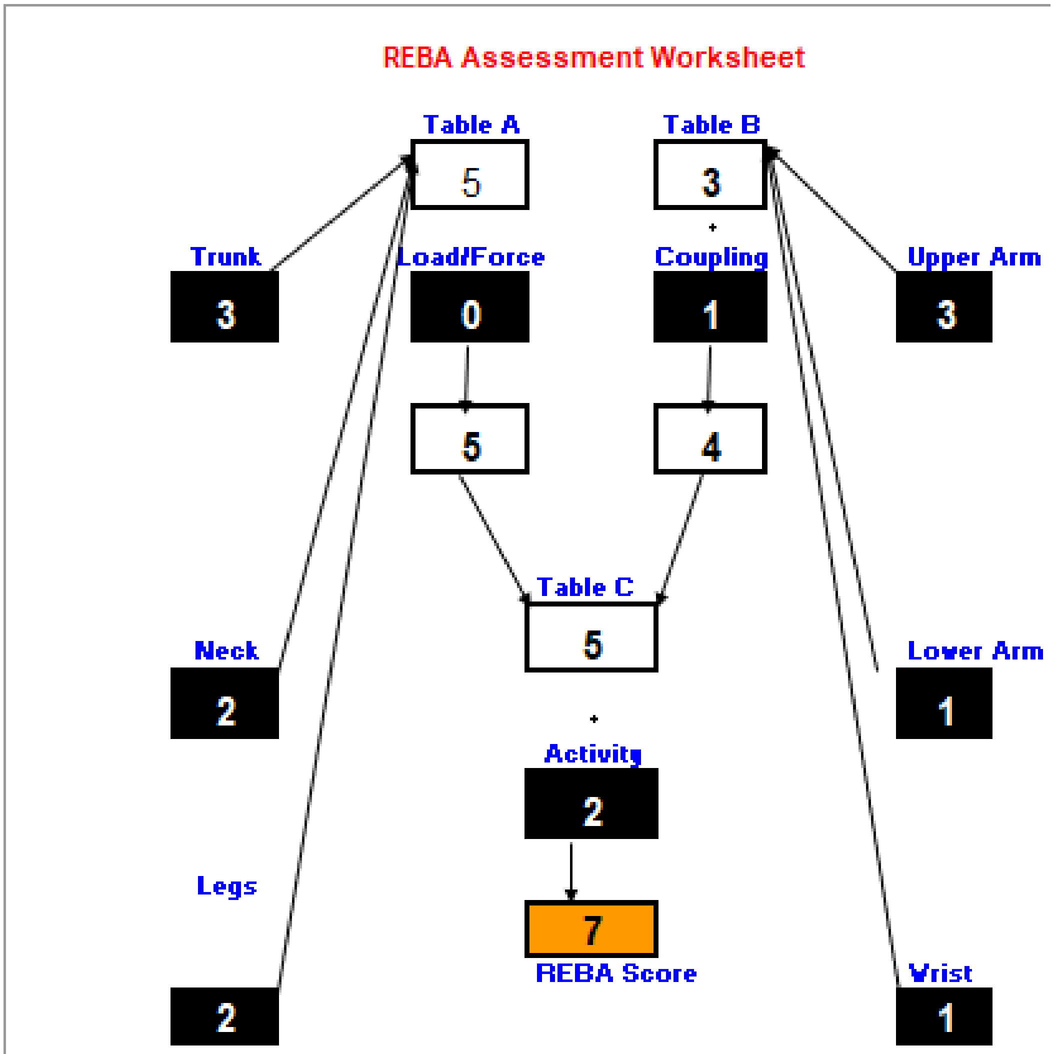


Figure 3. LCE Results

The risk factor obtained with the BRIEF method was 28, which means a medium priority to change some tasks and avoid injuries. The OWAS results (Risk Factor 2) complement the BRIEF outcomes, which show that the postures related to the job can cause injuries to the worker's musculoskeletal system.

The REBA method yields a score of 5 (Figure 4), which implies a medium risk level, so a necessary action is needed, but it does not have an urgency factor.



REBA Score	Risk Level	Action
1	Negligable	None necessary
2-3	Low	May be necessary
4-7	Medium	Necessary
8-10	High	Necessary soon
11-15	Very High	Necessary now

Figure 4. REBA results

The LEST methodology yields result in its five dimensions, as shown in figure 5. It can be seen that the physical environment is the most critical one.

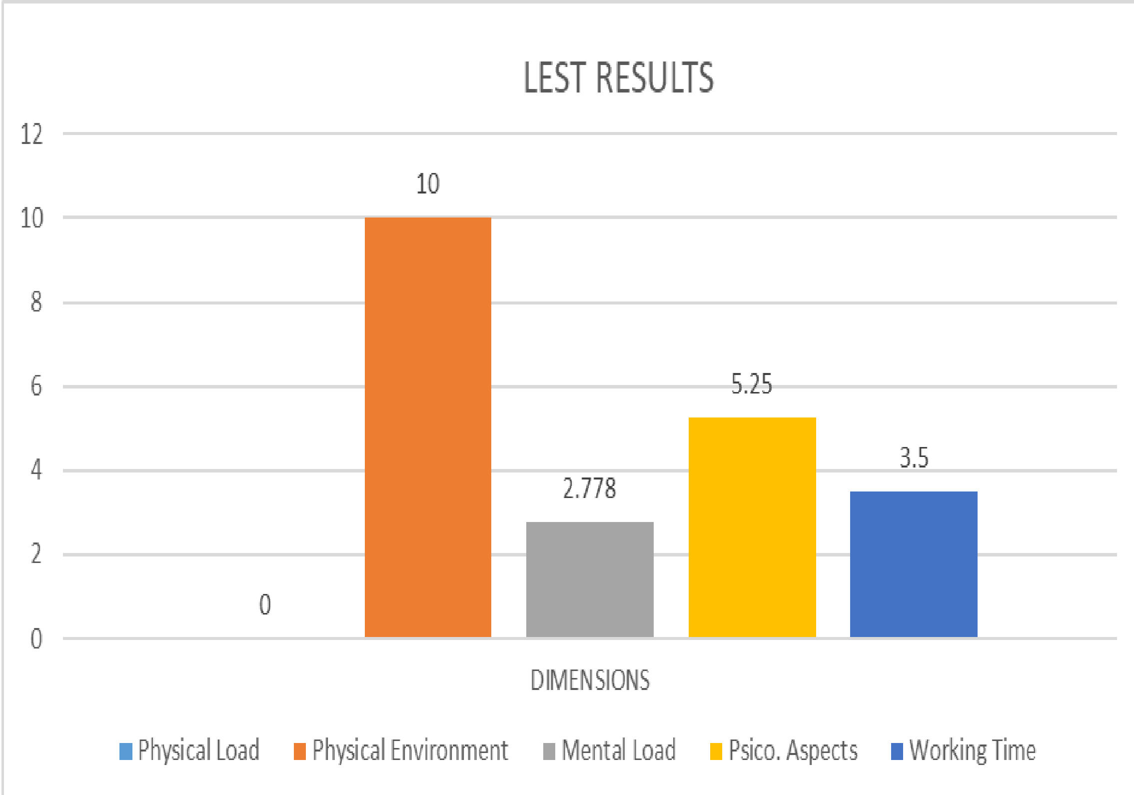


Figure 5. LEST results

6. DISCUSSION/CONCLUSIONS

The postures held by the barista represent a risk of medium priority, with the parts of the body most affected being the neck, legs, and back. For many people, the barista line of work can be a straightforward and risk-free job since it does not require moving to many places and repeating the same operation several times. However, in the long run, being in the same position during the workday and performing the same task several times can be very tiring and wear down the worker little by little. It is important to place more lighting in the work area; 200 luxes are necessary to carry out the activities safely and without compromising the worker's eyesight, according to NOM 025-STPS-2008. The shelves at the top should be placed at a more accessible height so that the bar is at an appropriate size, and the worker would not have to tilt their head.

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POSTURE EVALUATION WITH RULA AND OWAS IN A FRUIT STAND

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Resumen: El método Owas es un método observacional, es decir, parte de la observación de las diferentes posturas adoptadas por el trabajador durante el desarrollo de la tarea a intervalos regulares. Las posturas observadas son clasificadas en posibles combinaciones según la posición de la espalda, los brazos, y las piernas del trabajador, además de la magnitud de la carga que manipula mientras adopta la postura.

Cada postura observada es clasificada asignándole un código de postura. A partir del código de cada postura se obtiene una valoración del riesgo o incomodidad que supone su adopción asignándole una Categoría de riego (Owas distingue cuatro Niveles o Categorías de riesgo para cada postura).

Así pues, realizada la codificación de las posturas, el método determina la Categoría de riesgo de cada una de ellas individualmente. Posteriormente se evalúa el riesgo o incomodidad para cada parte del cuerpo (espalda, brazos y piernas) de forma global, es decir, considerando todas las posturas adoptadas. Para ello se asigna una Categoría de riesgo a cada parte del cuerpo en función de la frecuencia relativa de las diversas posiciones que adoptan en las diferentes posturas observadas.

El análisis de las Categorías de riesgo calculadas para cada postura observada, así como para las distintas partes del cuerpo de forma global, permitirá identificar las posturas y posiciones más críticas, así como las acciones correctivas necesarias para mejorar el puesto.

El método de Rula divide el cuerpo en dos grupos, el Grupo A que incluye los miembros superiores (brazos, antebrazos y muñecas) y el Grupo B, que comprende las piernas, el tronco y el cuello. Mediante las tablas asociadas al método, se asigna una puntuación a cada zona corporal (piernas, muñecas, brazos, tronco...) para, en función de dichas puntuaciones, asignar valores globales a cada uno de los grupos A y B.

La clave para la asignación de puntuaciones a los miembros es la medición de los ángulos que forman las diferentes partes del cuerpo del operario. El método determina para cada miembro la forma de medición del ángulo. Posteriormente, las puntuaciones globales de los grupos A y B son modificadas en función del tipo de actividad muscular desarrollada, así como de la fuerza aplicada durante la realización de la tarea. Por último, se obtiene la puntuación final a partir de dichos valores globales modificados.

Con la evaluación del diseño del área de trabajo con los métodos OWAS y rula, se observo que no es un área de trabajo crítica, las posturas que adopta el trabajador no son críticas, se ve que hay una distribución más o menos razonable y que las molestias que sufre pueden ser por el trabajo constante, ya que tiene que estar de pie en gran parte del trabajo y le ocasiona dolor de espalda, aunque también como observaciones se comprobó que el área de trabajo cuenta con tapete antifatiga, como recomendaciones, se propuso que se realicen paisas activas, es decir estiramientos, contar con un lugar para descansar sentado cuando no haya clientes, también al momento de preparar el vaso de fruta/cacahuates/papas preparadas, se puede adecuar un soporte para el vaso, para así no estar tomando el vaso con la mano y tener que doblar la muñeca, pero todas estas recomendaciones o soluciones propuestas no necesitan ser inmediatas, se puede ampliar el estudio, pero las mejoras se pueden realizar en un futuro, sin urgencia porque las posturas, y en sí, el área de trabajo no son críticas.

Palabras claves: Salud, ergonomía, postura.

Relevancia para la ergonomía: Se busca que se tomen en cuenta todos los tipos de trabajos, no solo a nivel industria, sino también a un nivel macro como lo puede ser un negocio informal, y que se logre comunicar la importancia de aplicar la ergonomía en el trabajo.

Abstract: The Owas method is an observational method, that is, it starts from the observation of the different postures adopted by the worker during the development of the task at regular intervals. The postures observed are classified into possible combinations according to the position of the worker's back, arms, and legs, in addition to the magnitude of the load handled while adopting the posture.

Each posture observed is classified by assigning a posture code. From the code of each posture, an assessment of the risk or discomfort that its adoption entails is obtained, assigning it a Risk Category (Owas distinguishes four Risk Levels or Categories for each posture).

Thus, once the postures have been encoded, the method determines the Risk Category of each of them individually. Subsequently, the risk or discomfort for each part of the body (back, arms and legs) is evaluated globally, that is, considering all the postures adopted. To do this, a Risk Category is assigned to each part of the body based on the relative frequency of the various positions they adopt in the different postures observed.

The analysis of the Risk Categories calculated for each posture observed, as well as for the different parts of the body globally, will allow the most critical postures and positions to be identified, as well as the corrective actions necessary to improve the position.

Rula's method divides the body into two groups, Group A which includes the upper limbs (arms, forearms and wrists) and Group B which comprises the legs, trunk and neck. Using the tables associated with the method, a score is assigned to

each body area (legs, wrists, arms, trunk...) in order to assign global values to each of the groups A and B based on these scores.

The key to assigning scores to members is the measurement of the angles formed by the different parts of the operator's body. The method determines for each member the way of measuring the angle. Subsequently, the global scores of groups A and B are modified depending on the type of muscle activity developed, as well as the force applied during the performance of the task. Finally, the final score is obtained from these modified global values.

With the evaluation of the design of the work area with the OWAS and rula methods, it was observed that it is not a critical work area, the postures adopted by the worker are not critical, it is seen that there is a more or less reasonable distribution and that the The inconvenience he suffers may be due to constant work, since he has to stand up for a large part of the work and causes back pain, although as observations it was also found that the work area has an anti-fatigue mat, as recommendations, it was proposed that active paisas be carried out, that is, stretching, have a place to rest sitting when there are no clients, also when preparing the glass of prepared fruit/peanuts/patatoes, a support for the glass can be adapted, so as not to be taking the glass with the hand and having to bend the wrist, but all these recommendations or proposed solutions do not need to be immediate, the study can be extended, but the improvements can be made in u n future, without urgency because the postures, and in itself, the work area are not critical.

Key words: Health, ergonomics, postures, rula, owas.

Relevance for ergonomics: The aim is to take into account all types of work, not only at the industry level, but also at a macro level, such as an informal business, and to communicate the importance of applying ergonomics at work.

1. INTRODUCTION

In the informal sector there is not much development of information on how to work, since everyone acts and develops independently, but it is also important, even in a small sector of the working population, the development of information and application of posture evaluation to inform or correct erroneous postures at the time of work.

As reported by (INEGI, 2021) The informal employed population, which includes those employed who are laborly vulnerable due to the nature of the economic unit for which they work, such as those whose labor link or dependence is not recognized by their work source, in the first quarter of 2021 was 29.2 million, 1.6 million less than in the same quarter of 2020.

The safety of the worker is important no matter the area in which it is located or the type of work sector in which it is located, that is why it is proposed to conduct an investigation in an informal workplace, in a fruit stand, and so that the worker can develop their work in a correct way and without possible damage in the future.

2. OBJECTIVES

General Objective:
Evaluate the working conditions of a fruit station and inform the worker so that he/she knows exactly what his/her needs are, what his/her operations and movements are during the working day, in order to offer optimal conditions that enhance his/her productivity and efficiency.

Specific objectives:
- Analyze and assess worker's movements with the rula and owas method.
- Analyze and evaluate the principles of occupational ergonomics.

3. METHODOLOGY

3.1. Activity Observation

We visited a snack stand and observed how it operates and the repetitive movements performed by the worker.

3.2. Evaluation with the rula method.

The postures applied at work were evaluated using the rula method.

Figure 1. Position 1

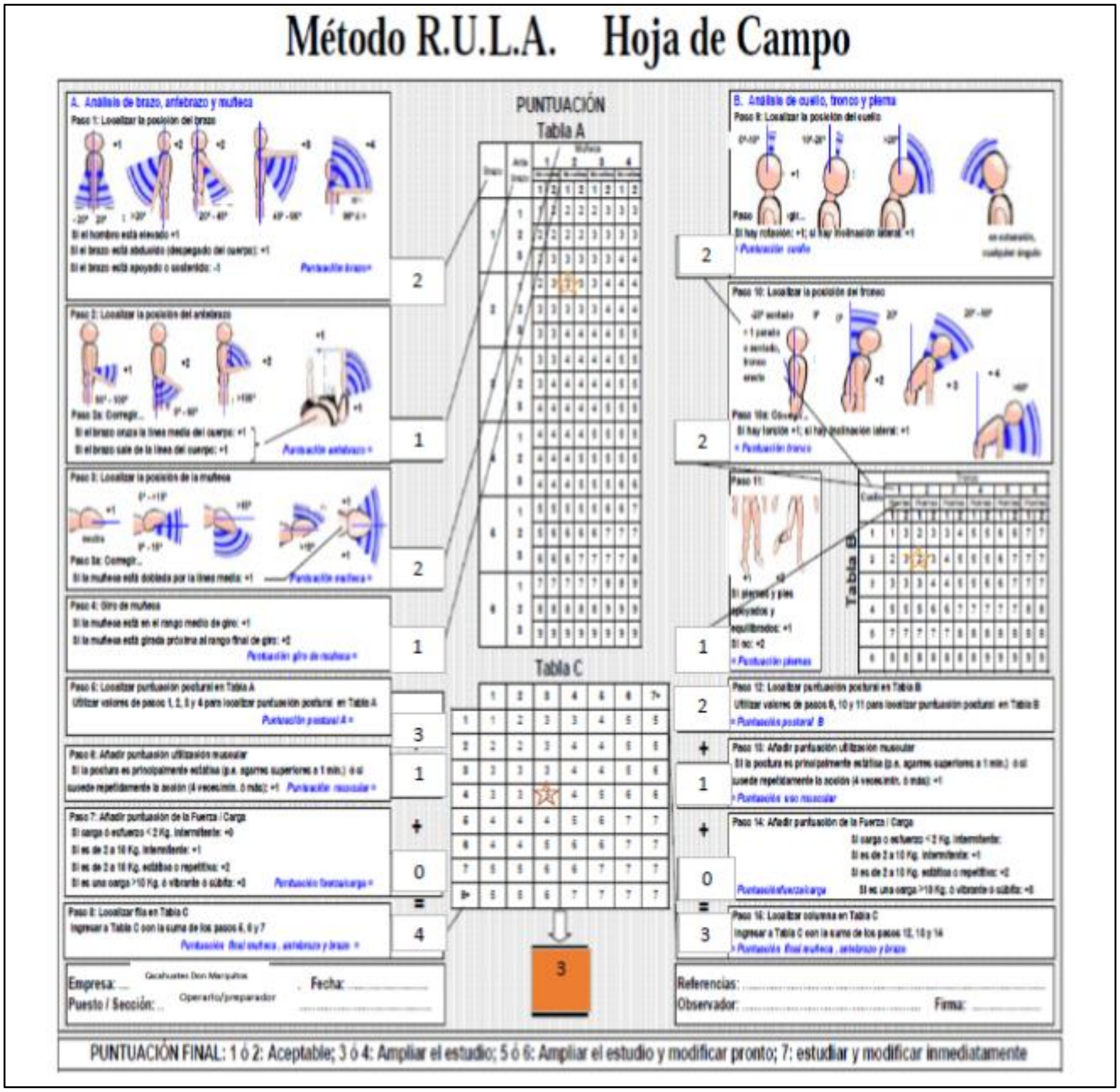

Figure 2. Rula worksheet for position 1

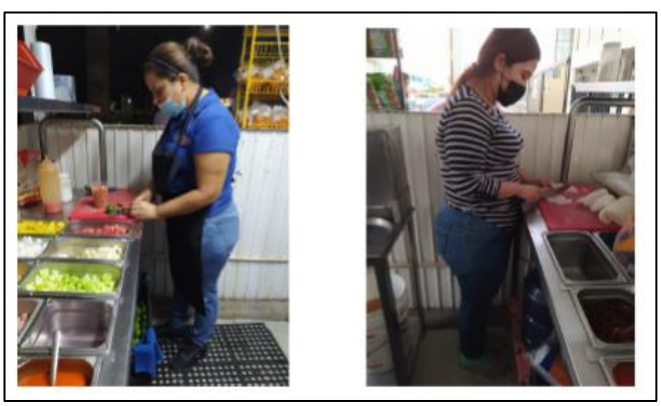

Figure 3. Position 2

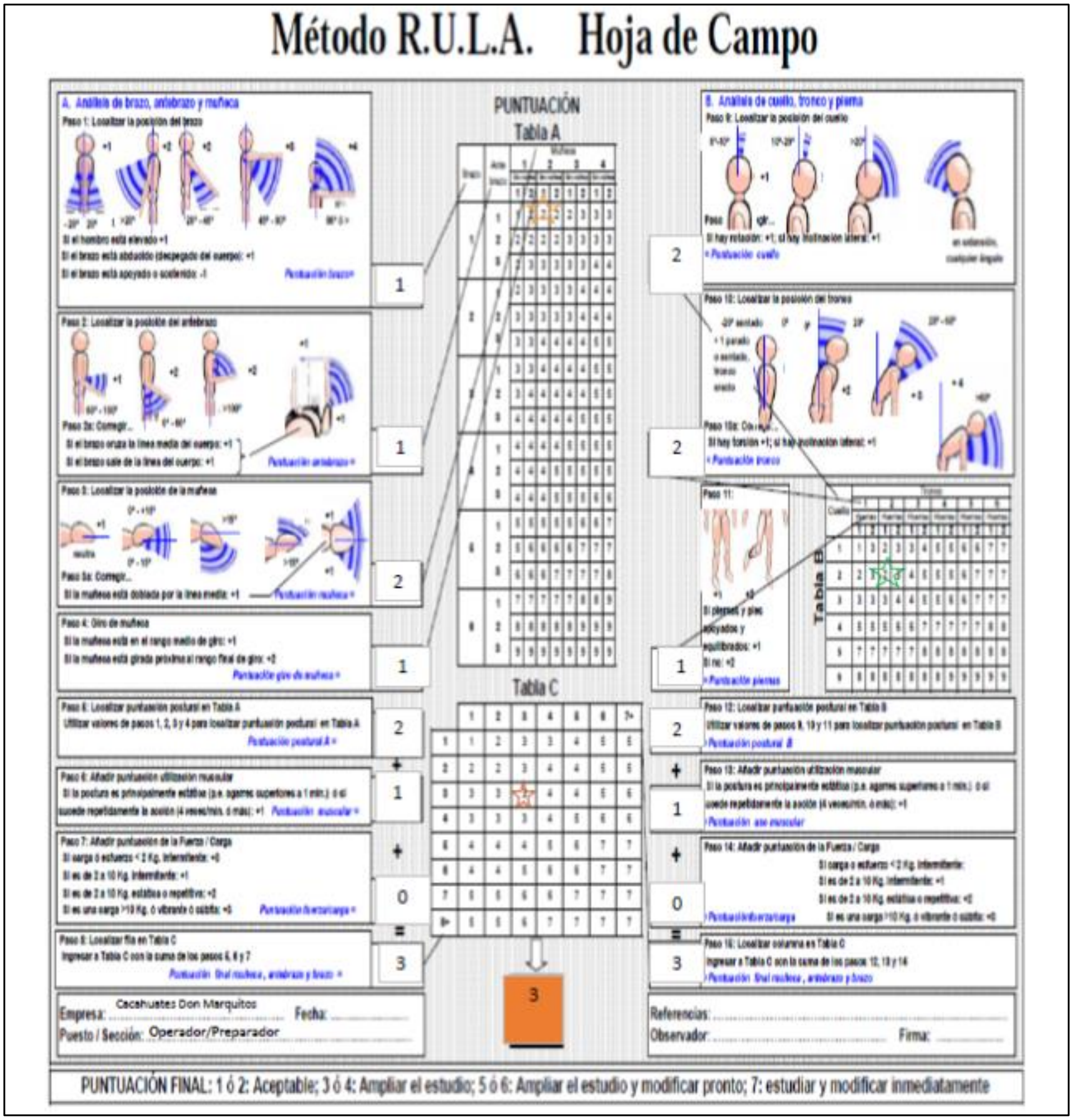

Figure 4. Rula worksheet for position 2

Figure 5. Position 3

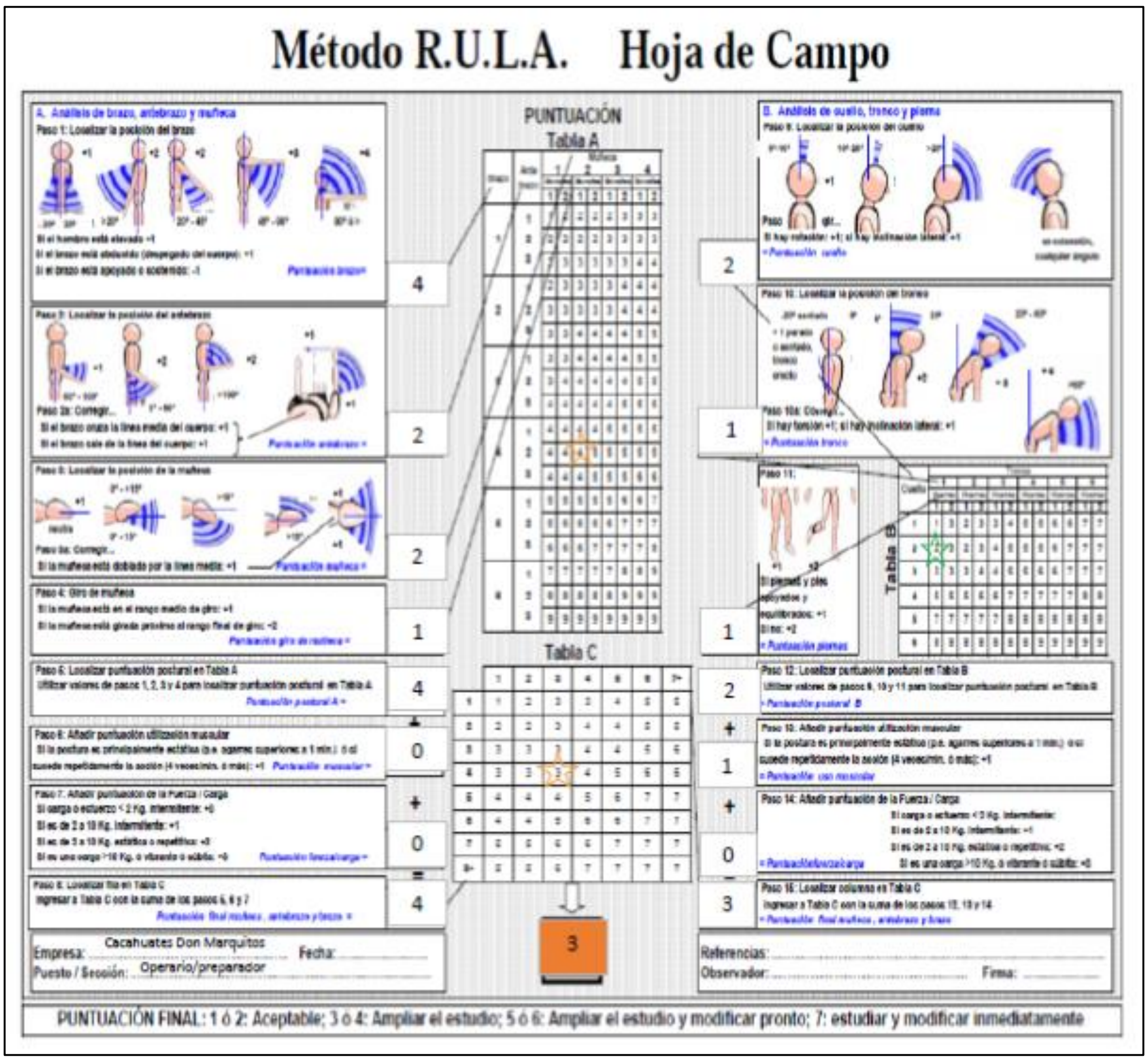

Figure 6. Rula worksheet for position 3

3.3. Evaluation with the owas method.

The postures applied in the work were evaluated through the owas method.

Posición 1

Método OWAS

PIERNAS		1			2			3			4			5			6			7		
CARGA/FUERZA		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
ESPALDA	BRAZOS																					
	1				1																	
	2																					
1	3																					
	1																					
	2																					
2	3																					
	1																					
	2																					
3	3																					
	1																					
	2																					
4	3																					

Figure 7. OWAS evaluation for position 1

Posición 2

Metodo OWAS

PIERNAS		1			2			3			4			5			6			7		
CARGA/FUERZA		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
ESPALDA	BRAZOS																					
	1				1																	
	2																					
1	3																					
	1																					
	2																					
2	3																					
	1																					
	2																					
3	3																					
	1																					
	2																					
4	3																					

Figure 8. OWAS evaluation for position 2

Posición 3

Metodo OWAS

PIERNAS		1			2			3			4			5			6			7		
CARGA/FUERZA		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
ESPALDA	BRAZOS																					
	1				1																	
	2																					
1	3																					
	1																					
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2	3																					
	1																					
	2																					
3	3																					
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4	3																					

Figure 9. OWAS evaluation for position 3

Categorías de Riesgo de las posiciones del cuerpo según su frecuencia relativa.

	Frecuencia Relativa	≤10%	≤20%	≤30%	≤40%	≤50%	≤60%	≤70%	≤80%	≤90%	≤100%
ESPALDA	Espalda derecha	1	1	1	1	1	1	1	1	1	1
	Espalda doblada	1	1	1	2	2	2	2	2	3	3
	Espalda con giro	1	1	2	2	2	3	3	3	3	3
	Espalda doblada con giro	1	2	2	3	3	3	3	4	4	4
BRAZOS	Dos brazos bajos	1	1	1	1	1	1	1	1	1	1
	Un brazo bajo y el otro elevado	1	1	1	2	2	2	2	2	3	3
	Dos brazos elevados	1	1	2	2	2	2	2	3	3	3
PIERNAS	Sentado	1	1	1	1	1	1	1	1	1	2
	De pie	1	1	1	1	1	1	1	1	2	2
	Sobre una pierna recta	1	1	1	2	2	2	2	2	3	3
	Sobre rodillas flexionadas	1	2	2	3	3	3	3	4	4	4
	Sobre una rodilla flexionada	1	2	2	3	3	3	3	4	4	4
	Arrodillado	1	1	2	2	2	3	3	3	3	3
	Andando	1	1	1	1	1	1	1	1	2	2

3.4. Explanation of results.

The information obtained was provided to the worker and the possible improvements that should be applied in their movements to have a correct performance in their work were explained.

4. RESULTS

Postures evaluated with the rula method and their respective scores and recommendations for the correct development of the work.

Respect to the rula method, a level of 3 was obtained in each posture, which indicates that changes in the task may be required; and it is convenient to deepen the study.

In the owas method, with respect to the risk categories by posture codes, a level 1 was obtained in the back, arms and legs, which indicates that it is a normal and natural posture with no harmful effects on the musculoskeletal system; and that it does not require corrective action.

Respect to the risk categories of the body positions in their relative frequency, a level 1 was obtained for back and arms, indicating that it does not require corrective actions, but a level 2 was obtained for legs, indicating that it is a posture with the possibility of causing damage to the musculoskeletal system; and that corrective actions are required in the near future.

5. CONCLUSIONS

Performing this work helps to provide the relevant information to know if the work being performed is at the correct levels or corrections are needed, so that if it is at level 1 the risk that the worker is running is acceptable, but if it is at level 4 urgent changes are required in the tasks performed, this information provided helps the worker to realize how to perform their work in a correct and safe manner.

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ERGONOMICS DESIGN FOR PEOPLE WITH MOTOR DISABILITIES. CONSTRUCTION OF A DEVICE FOR WORK POSTURAL CONTROL.

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Resumen El presente documento tiene como objetivo describir el proceso de diseño que se llevó a cabo para la construcción un producto de control y gestión postural dirigido a personas con discapacidad motriz (PCDM) que trabajan durante una jornada de 8 horas en una institución inclusiva del estado de Aguascalientes. Se lleva a cabo un estudio mixto descriptivo y analítico en donde se destacan algunos aspectos a tener en cuenta en la práctica del diseño inclusivo, a través de métodos de desarrollo de servicios centrados en las personas y la incidencia de normativas destinadas al control de riesgos ergonómicos, espacios de trabajo y permanencia de posturas en el marco laboral nacional actual con una profunda revisión literaria. Como resultado se obtiene un manual técnico y el diseño y creación de un dispositivo funcional ergonómica y antropométricamente adecuado a un espacio de trabajo que estudia la relación que existe entre la fatiga laboral relacionada a la postura sedente en una PCDM y la satisfacción en el desarrollo de sus actividades para la generación de nuevo conocimiento que sirva de sustento para la apropiación de una cultura de reeducación postural mediante la práctica contínua de activación física como medio de descanso laboral. Se concluye que para lograr un diseño de producto óptimo dirigido a la salud laboral es necesario contemplar no solo aspectos médicos y sociales, sino principios de diseño e ingeniería para lograr soluciones holistas generadoras de conocimiento técnico sobre el factor humano en su particular interacción con el entorno.

Palabras clave: Diseño inclusivo, discapacidad, antropometría, ergonomía, normativa.

Relevancia para la ergonomía: Para las PCDM, incurrir en el proceso de diseño de un producto dirigido a su salud laboral a través de una perspectiva ergonómica sugiere un proceso exitoso en todos los sentidos, ya que con técnicas y normas para productos y servicios que regulan y siempre están pendientes de la persona se garantiza una mejora significativa en la vida del trabajador.

Abstract The objective of this document is to describe the design process that was carried out for the construction of a postural control and management product aimed at people with motor disabilities (PWMD) who work during an 8-hour shift in an inclusive institution in the state of Aguascalientes. A mixed descriptive and analytical study is carried out, highlighting some aspects to be taken into account in the practice of inclusive design, through methods of developing services centered on people and the incidence of regulations aimed at controlling of ergonomic risks, workspaces and permanence of postures in the current national labor framework with a deep literary review. As a result, a technical manual and the design and creation of an ergonomically and anthropometrically appropriate functional device for a work space that studies the relationship between work fatigue related to the seated posture in a PWMD and satisfaction in the development of its activities for the generation of new knowledge that serves as support for the appropriation of a culture of postural reeducation through the continuous practice of physical activation as a means of rest from work. It is concluded that to achieve an optimal product design aimed at occupational health, it is necessary to consider not only medical and social aspects, but also design and engineering principles to achieve holistic solutions that generate technical knowledge about the human factor in its particular interaction with the environment.

Keywords: Inclusive design, disability, anthropometrics, ergonomics, regulations.

Relevance to Ergonomics: For PWMD, incurring in the process of designing a product aimed at their occupational health through an ergonomic perspective suggests a successful process in all senses, since with techniques and standards for products and services that regulate and are always pending the person is guaranteed a significant improvement in the worker´s life.

1. INTRODUCTION

Postural education and ergonomics of the work environment applied to people with disabilities (PWD) do not refer to a special or different approach to people who do not have any disability, but it is about promoting an adjustment on the characteristics that these people demand (Ministerio de Trabajo y Economía Social, 2015).

In recent years, inclusive labor policies have fostered integration into the productive sphere, areas designated to the range of skills that a person with a disability (PWD) can execute, promoting the participation of a team that not only includes medical and social work aspects, but also that includes disciplines such as design and engineering, in a multidisciplinary system capable of managing technical knowledge about the human factor in its interaction with the work environment (Romero, 2006).

In that sense, having an holistic vision applied to the design and development of solutions focused on users with specific characteristics is synonymous with being aware of diversity, a concept that has received more and more attention with the general movement towards user-centered design. comment Brinkley et al. (2021), placing greater emphasis on inclusive design that proposes techniques for an optimal experience for people with disabilities or specific characteristics, since it lies in the accompaniment and monitoring of these throughout the research and design process, recognizing, the design team, from a phenomenological perspective, that these people experience the world through their bodies (Sarmiento 2020).

With the objective of developing products that are suitable for the user, for such a design process, some authors add the ergonomic factor that studies the abilities and skills of the workers, taking into account their performance and functionality characteristics to determine the design requirements with the participation of these and not in their understanding; allowing to adapt the different design judgments between disability and the workplace and transforming the accessibility of spaces into tools that facilitate their innovative capacity (Islas, 2010; Ministerio de Trabajo y Asuntos Sociales, 2004; Pérez, 2013; Puyuelo & Merino, 2017).

2. OBJECTIVE

Design a postural recognition and management device based on anthropometric and ergonomic principles for workers with motor disabilities; for which it is necessary to: (1) determine the labor reality of PWMD, (2) examine literature and products related to the topic of occupational health for PWMD, (3) define system requirements, (4) build anti-fatigue prototype and (5) validate operation and operation strategy with variable measurement instrument.

3. DELIMITATION

This study is carried out in the city of Aguascalientes, Ags., where 3.83% of people have a disability (more than 30 thousand people) (H. Ayuntamiento de Aguascalientes, 2017) and 21% participate in an economic activity (INEGI, 2004). Combined in a period of 4 semesters delimited from January 2021 to December 2022, the SNDIF State of Aguascalientes is chosen, and with the necessary consent permits, the research is carried out with a group of workers with motor disabilities who work 8 hours in a row in a wheelchair in front of a desk doing office activities; studying postural, ergonomic and perceptual values regarding fatigue and the incidence of these factors in their job satisfaction.

3. METHODOLOGY

A mixed approach is shown that observes the phenomena of postural load, fatigue and satisfaction as they occur in the work context of a PWMD, cross-sectionally, since in a period of time it identifies said reality and when investigating and documenting it without altering the variables, it is given a descriptive character.

3.1 Human Centered Design

In an inclusive framework, the Human-Centered Design (HCD) method is selected, as shown in figure 1, which is a guide to techniques that the design team uses to understand, based on the approach and empathy with the participating people with disabilities, the problems they face, delving deeply into their own and characteristic environment (Archuby, 2016), transforming the information into feasible ideas as design requirements and integrating the possibilities of technology to propose solutions innovative and that respond to real needs; being focused on users helps identify new opportunities and increase the speed and effectiveness of product creation (CIAJ A.C., 2020).

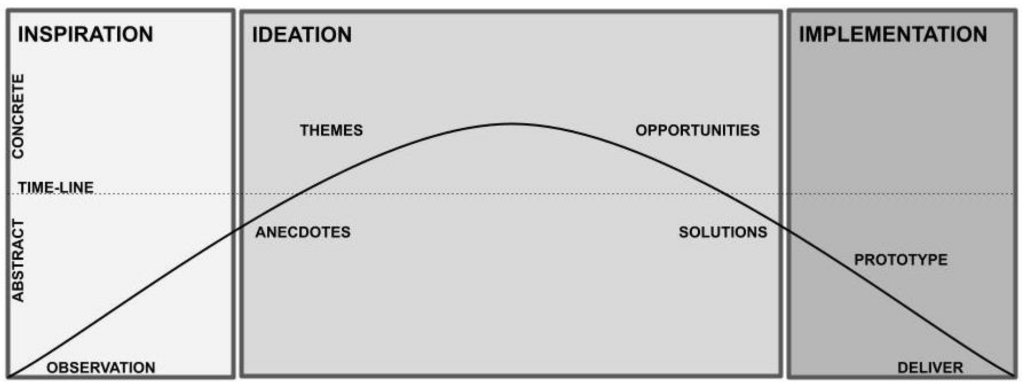

Figure 1. Human Centered Design. Elaboration with information from Design Council (2021).

3.2 Official Mexican Regulations (NOM)

In the inclusion exercise that accompanies the design process, to achieve an effective product, conceptualized from the labor reality of the participating people with disabilities, the Official Mexican Standards are used: **NOM-036-1-STPS-2018**, whose The objective is to establish the elements to identify, analyze, prevent and control ergonomic risk factors in the workplace, to prevent alterations to the health of workers (DOF, 2018).

The **NOM-034-STPS-2016**, called "Security conditions for the access and development of activities of workers with disabilities in the work centers", to understand that the necessary modifications or adaptations to the work centers facilitate the worker with disabilities participate in activities or receive services in safe conditions according to disability, that is, create products, services and systems with qualities or characteristics that facilitate accessibility for people with disabilities (DOF, 2016).

Together, the **ISO 11226:2000/Cor 1:2006** standard "Evaluation of work postures" allows evaluating static work postures, specifying the recommended limits for static postures that do not require the application of external forces, or that this is minimal, taking into account body angles and maintenance time (IEN, 2014;

INSST, n.d.), in order for the device to recognize and approximate an ideal posture for the worker.

3.3 Information gathering tools

Some tools are used that use by default the method that will accommodate the design and construction of the device, executed successively according to the phases of the process; within which an instrument of 20 reagents ordered in two dimensions is applied; ergonomics with three indicators: work space, working conditions and general satisfaction perceived by these factors; and fatigue with an indicator: physical conditions, this one, made up of two variables: postural control and work fatigue whose objective is to measure the degree of satisfaction of a worker in a permanent seated posture with respect to the ergonomic composition of the job as well as the postural state that is maintained in the development of work activities.

We worked with 20 subjects, of which 7 are women and 13 are men between 25 and 45 years of age who share similar characteristics to the selected workers with motor disabilities. Subjects perform repetitive activities in a permanent sitting position and are in front of a computer during an 8-hour day shift with two 30-minute rest periods, in a work space consisting of a desk or work table, an adjustable chair and without any active rest interaction.

Once the people were selected, the inspiration stage began, where an instrument was applied to the collaborators of this work in the form of an interview focused on the quality of work and the environment of the user and the supervisory and management personnel of the same. Subsequently, in the ideation stage, a summative instrument is administered regarding the user's working and postural conditions and based on this, a brainstorming of improvement ideas is generated. Finally, in the implementation stage, the design team made up of a designer and a programmer generates a list of requirements taking into account ergonomic and anthropometric principles and a series of current regulations regarding the issue of products that affect the occupational health of people with disabilities. disability and prototypes an experience for its evaluation with collaborators, as shown in table 1.

Table 1. Information gathering tools.

Inspiration	Design brief. Person-centered interview. User map.
Ideation	Variable measurement instrument. Brainstorm.
Implementation	Normative. Function matrix.
	Experience prototyping. FMEA analysis. Usability questionnaire.

Note: Own elaboration.

A design summary was obtained that revealed the reality that evidences the problem, while generating a specific profile of the user necessary for the formulation of the product requirements; where the scope, scale, basic details of the design project were identified; understood in depth the work, the elements and characteristics that make up the study through the information obtained by the interaction of the design team, which managed the information collected about the needs of the worker with disabilities, the socio-economic-technological network involved , the functions of the product, the resources, times and desired results, as shown in table 2.

Table 2. Design brief.

Project name	ANTI-FATIGUE POSTURAL CONTROL DEVICE FOR WORKERS WITH MOTOR DISABILITIES
Overview/scope	Work space with standard ergonomic conditions, adapting the necessary comforts for the collaborators in a particular way and according to their limitations.
Objectives	To design a postural recognition and management device based on anthropometric and ergonomic principles for workers with motor disabilities.
User profile	People with motor disabilities between 35 and 55 years old who work using a wheelchair doing office activities in an 8-hour day shift, worrying about their institutional occupational health conditions.
Message	A work tool to significantly improve the quality of work of PWMD where cutting-edge technology can minimize the adverse effects of disabilities, transcending the limits of their condition and expanding their capabilities.
Visuals	Communication interface with the user. Seated postural rehabilitation strategies poster.
Details	Job satisfaction study in PWMD. Study of the inclusive design process. Posture control device. Product user manual.
Schedule	January 2021-December 2022. $2500 MXN c/u.

Note: Own elaboration.

Given the state of the Covid-19 pandemic, the instrument was designed and administered in a virtual mode for the convenience of the participants, shared with each of them through the Google Forms web tool, an online survey filling platform. Next, to propose the technological, structural, ergonomic and strategic solutions to the problem addressed, the 8 ideas that display the characteristics and functions that are projected for the optimal design of the product were generated, selected and documented, projected in table 3 and figure 2 respectively.

Table 3. Selection of the 8 ideas that constitute the prototype.

Idea 1	Lateral measurement system with ultrasonic sensors.
Idea 2	Component protection case with fixing to the work table.
Idea 3	Rotation and tilt of the case by means of a ball joint for consistency.
Idea 4	2 side screens for sensors, a front screen for a camera.
Idea 5	Case inserted in partition element.
Idea 6	Communication: intuitive graphic interface with the user.
Idea 7	Video camera to validate the data thrown by the sensors.
Idea 8	Network of pressure sensors to validate the data thrown by the camera.

Note: Own elaboration.

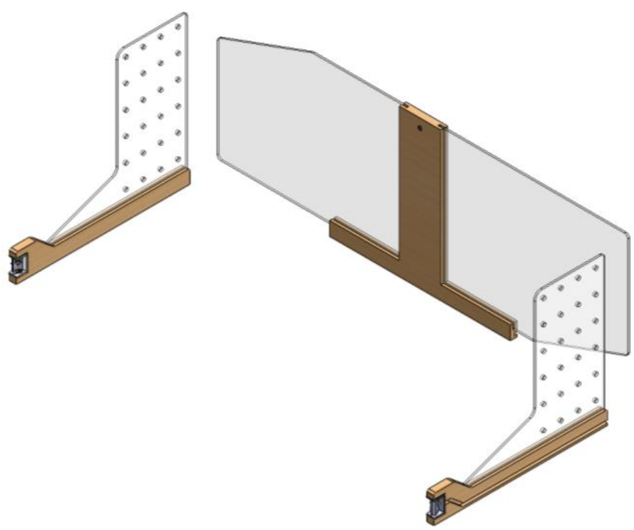

Figure 2. Isometric view for the system. Own elaboration.

Finally, the definition of the product was obtained through the knowledge and confirmation of the customer's expectations in terms of functions and product requirements. The sequence of operation expected by the client was declared in a functional matrix, as can be seen in tables 4, 5 and 6, identifying the result of the product based on the needs of the user with motor disabilities to establish the necessary operations of the plane of work, always keeping in force the selected normative principles projected in a functional prototype in the assembly stage whose validation has not yet been applied.

Table 4. Function matrix fase 1: Communication.

FUNCTIONAL MATRIX		
REQUEREMIENTS		WISHES
1	Left sensor operability.	Object recognition and measurement of its distance from the sensor.
2	Right sensor operability.	Object recognition and measurement of its distance from the sensor.
3	Front sensor operability.	Object recognition and measurement of its distance from the sensor.
4	Recognition and printing of information from sensors.	Interpretation of information from sensors (CMS).

Note: Own elaboration.

Table 5. Function matrix fase 2: Interface.

FUNCTIONAL MATRIX		
REQUEREMIENTS		WISHES
1	Graphic interface.	Box size approx. 10cmx6cm. Minimalist design (simple design).
2	Semiotics.	Box with FIUAQ colors (do not lose UAQ identity). Warning symbols and colors in accordance with signaling regulations.
3	Language.	Spanish language, with short messages.
4	Alert messages.	Left loading or poor left posture. Right charge or poor right posture. Front loading, poor front posture. Good posture.

Note: Own elaboration.

Table 6. Function matrix fase 3: Validation.

FUNCTIONAL MATRIX		
REQUEREMIENTS		WISHES
1	Camera connection.	Connect the camera to the sensor system using the Arduino programming language.
2	Camera shot.	Schedule a shot every time there is a "sedentary lifestyle" (that is, when the body detected by the sensors indicates that there is a pause or extra temporary incidence in poor posture.
3	Image vs metric comparison.	In the graphical interface, a visual comparison will be made between the photograph taken in postural migration and the postural migration detected by the sensor, so that the user can corroborate the loss of hygiene.
4	Posture summary.	In the graphical interface, a summary of the postural migrations adopted by the user in the scheduled day (8 hours) will be made.

Note: Own elaboration.

4. CONCLUSIONS

The culmination of the development of this procedure is projected in a prototyping of experience that allows the manufacture and assembly of a device capable of measuring the symmetry and frontal deviation of the torso of a user and, through a communication interface, alerts him of incorrect posture on a timeline by capturing an image once that symmetry is corrupted. In turn, the system suggests to the user an optimal accommodation or a rest strategy depending on the case that is warranted during the course of the day.

The idea of intrusive elements in the postural support system is ruled out, since due to the motor disability of the users, the success of the product will depend on the degree of comfort that it grants and the sensation of complexity to the user in terms of operability of its displacement and work tools.

5. CONTRIBUTION TO ERGONOMICS

For ergonomics, the contribution that is made is that through the results of this design process, a work tool can be accommodated whose task is to reduce the exposure of PWMD who work in front of a desk on a screen, to threats work or a physical factor within your work environment that may harm your body; which affects the rehabilitation of uncomfortable work postures.

This system allows studying the symmetry of the individual's sitting posture, deconstructing the anthropometric aspects that intervene in the relationship between it and the ergonomics of the work team that is used, to understand the different physical and perceptual behaviors in the exercise of their activities, encouraging the user to generate a habit of validated postural education that incorporates postural-work rest protocols.

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TASKS ANALYSIS IN SPECIALIZED CONSTRUCTION WORK IN THE ALTOS NORTE REGION OF JALISCO

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Resumen: Los trabajadores de la construcción en México están expuesto a riesgos ergonómicos que, en mediano o largo plazo, se asocian con trastornos musculoesqueléticos tanto en miembros superiores como inferiores. El realizar actividades manuales por encima del nivel del hombro representa un factor más que se puede asociar a la fatiga muscular de los miembros superiores, lo cual lleva a una reducción del rendimiento físico de los trabajadores. En la región Altos Norte de Jalisco, la construcción tradicional del techo consiste en la colocación manual de "cuñas" para formar una bóveda que posteriormente se limpia para eliminar el exceso de mezcla y dejar una vista aparente. En dicha actividad interviene un operador especializado cuyas principales actividades las realiza de pie y con los brazos por encima del nivel del hombro para eliminar el exceso de mezcla, utilizando una pequeña herramienta manual. Al realizar el análisis de tareas se clasifican y priorizan las posturas que adopta el trabajador para determinar cuáles son las posturas que requieren un mayor análisis, después de la clasificación realizada de acuerdo a la metodología utilizada se detectaron 3 actividades como relevantes, que en su conjunto acumulan el 90% de las imágenes analizadas, además, al utilizar el software Humantech® Industrial Ergonomics, se valoran los miembros involucrados en la operación y determina mediante una escala de riesgo el nivel al cual están expuestos, con esta herramienta se identificaron ambos miembros superiores con un nivel de riesgo elevado acumulando una calificación global de 33 puntos, en una escala de 30 a 49 para el nivel alto.

Palabras clave: Postura forzada, movimientos repetitivos, nivel del hombro, construcción

Aportaciones a la ergonomía: Los trabajadores de la construcción están expuestos a diversos riesgos ergonómicos, el llevar a cabo un análisis de tareas detallado para identificar cuantitativamente el nivel de riesgo al que están expuestos ayudará a identificar áreas de oportunidad y para la generación de propuestas para intervenir en la tarea para tratar de generar mejoras en sus condiciones de trabajo y tratar de disminuir la exposición a los factores de riesgo. Con un adecuado análisis de tareas se puede identificar puntualmente las posturas y los miembros del cuerpo que presentan un mayor riesgo para los trabajadores.

Abstract: Construction workers in Mexico are exposed to ergonomic risks that, in the medium or long term, are associated with musculoskeletal disorders in both upper and lower limbs. Performing manual activities above shoulder level represents one more factor that can be associated with muscle fatigue of the upper limbs, which leads to a reduction in the physical performance of workers. In the Altos Norte region of Jalisco, traditional roof construction consists of the manual placement of "wedges" to form a vault that is later cleaned to eliminate excess mixture and leave an apparent view. This activity involves a specialized operator whose main activities are performed standing up and with his arms above shoulder level to remove the excess mixture, using a small hand tool. When performing the task analysis, the postures adopted by the worker are classified and prioritized to determine which postures require further analysis, after the classification performed according to the methodology used, 3 activities were detected as relevant, which together accumulate 90% of the images analyzed, in addition, by using the Humantech® Industrial Ergonomics software, the members involved in the operation are evaluated and the level to which they are exposed is determined by means of a risk scale. With this tool, both upper members were identified as having a high risk level, accumulating an overall rating of 33 points, on a scale of 30 to 49 for the high level.

Keywords: Forced posture, repetitive motions, shoulder level, construction.

Relevance to Ergonomics: Construction workers are exposed to various ergonomic risks, carrying out a detailed task analysis to quantitatively identify the level of risk to which they are exposed will help to identify areas of opportunity and for the generation of proposals to intervene in the task to try to generate improvements in their working conditions and try to reduce exposure to risk factors. With an adequate task analysis, it is possible to identify the postures and body members that present a greater risk to workers.

1.INTRODUCTION

Construction work presents several ergonomic risks relevant to the workers who perform it (Zepeda Quintana et al., 2016). According to León Cruz (2011), more than 75% of construction workers in Mexico are exposed to multiple risks that were associated with musculoskeletal disorders of upper and lower limbs. One of the main risk factors is to develop repetitive manual activities above shoulder level (Grzywiński et al., 2014), which can directly impact negatively on the worker's fatigue level; since, as the fatigue level increases the worker's performance decreases (Hernandez Arellano et al., 2015). Fatigue is an indicator that work conditions need to be addressed.

According to information from the National Institute of Statistics, Geography and Informatics (INEGI, 2019), in Mexico there were 19,501 companies dedicated to construction, in which around 676,301 people work in this sector; in the state of

Jalisco 62,797 were dedicated to this activity, that is, almost 10% of the total number of workers in the country work in this state.

According to Ramírez Ponce, (2002), the technique of vault construction in Mexico dates back to the second part of the 19th century, and even mentions the municipality of Lagos de Moreno, Jalisco, as one of the possible sites where the technique originated. In the Altos Norte region of Jalisco, the traditional system of construction of the roofs of houses is developed in two phases: the gluing of the wedges and the cleaning of the vaults when they are finished. The first phase consists of placing small bricks called "wedges", which are glued one by one by hand to form a vault, while the second phase consists of removing the excess cement mixture to give the vault a more aesthetic appearance. These activities are carried out by specialized construction workers known as "maestros bovederos".

According to the literature review, it was found that there are no studies, at least documented, that characterize and analyze the tasks of specialized construction workers.

1.1. Objectives

- Classify the manual activities performed by a specialized construction worker.
- Identify the postures that represent the greatest risk to the worker.
- Carry out a biomechanical analysis of the most affected limbs when performing the activities.

1.2. Delimitation

The observation and analysis work will focus on the postures of the upper limbs, although there are several risk factors in other parts of the worker's body.

2. METODOLOGY

The methodology of the study consists of 4 sections:

2.1 Study design

a. Delimitation of activity of interest; it will focus on activities that present forced postures preferably with the upper limbs above shoulder level.

2.2 Participants

a. Search and invitation of subjects to participate. The profile sought is that of specialized construction workers who perform manual activities and are dedicated to the artisan elaboration of vault ceilings, with at least 5 years of experience in construction in the Altos Norte region of Jalisco.

2.3 Materials

a. Analysis of global activities; conduct field visits and visualize at the work site the activities they normally perform during the workday.

b. Videotaping of the activities to conduct a task analysis. Once the activity of interest has been identified, a video recording of the activity in question is made using the camera of the personal cell phone. The video is then analyzed using the GOM Player® media player.

c. Task analysis in specialized software Humantech® Industrial Ergonomics. To identify the members of the body and the level of risk they present when performing the analyzed activity.

2.4 Methods

a. Classification and characterization of activities. To follow the task analysis methodology of Gómez-Bull (2015) to identify the highest risk postures in the analyzed activity.

3. RESULTS

The study focused on the standing manual activities performed by construction specialists, where forced postures with repetitive movements and with the upper limbs above shoulder level were present. There is an interest in the gluing of "cuñas" for the construction of vault (see Figure 1).

Figure 1. Vault ceiling construction

3.1 Contact and search for participants

Visits were made to several places where construction work was being carried out and the person in charge of each site was contacted to invite them to participate in the study. In the municipality of Lagos de Moreno, Jalisco, 12 visits were made and only one site manager agreed to participate in the study, however, the activities

they were carrying out at that time did not correspond to the activities of interest of this study, so 2 more sites were visited in the municipality of Union de San Antonio, Jalisco, where a positive response was obtained from the site manager.
Once the participation of the group of construction workers was confirmed, a subsequent visit was made to observe at a glance the activities they commonly carry out during their workday. Only two workers were working at the site; the person in charge of the work and an assistant, where basic information was collected as shown in Table 1.

Table 1. Basic information on workers

Position	**Age range**	**Experience (in years)**
Person in charge	50 – 60	45
Assistant	30 – 40	8

3.2 Filming of activities

The activities performed by the construction workers during their workday of approximately 10 hours a day were observed and it was detected that the helper is in charge of eliminating the excess mixture from the vault ceiling, an activity he performs for at least 4 hours a day, standing on a support, for which he usually keeps both arms above shoulder level (see Figure 2). This activity adds value to the construction by leaving an apparent finish, which is why its execution is essential.

Figure 2. Vault ceiling cleaning

3.3 Task analysis

Once the activity of interest for the project was identified, a task analysis was developed; in this activity, the person in charge of performing it does it standing up, keeping his arms above his head, making movements and exerting a little pressure on the grooves of the mixture to eliminate the excess. According to the methodology of Gómez-Bull et al (2015), a separation of the activity into subtasks was performed with the images captured frame by frame, resulting in Table 2.

Table 2. Separation into subtasks

1. Surface cleaning with right arm
2. Removing excess mixture with tool
3. Surface cleaning with right arm
4. Rotate body and move to new position
5. Surface cleaning with left arm
6. Change tool control
7. Surface cleaning with right arm
8. Removing excess mixture from tool
9. Surface cleaning with right arm
10. Removing excess mixture on tool
11. Surface cleaning with right arm
12. Lift both arms (one cleans and the other holds)

After the separation into subtasks, a classification of the captured images was made to identify those postures that are adopted most of the time, according to the methodology being followed, 3 activities were identified that accumulate more than 10% of the photographs (see Table 3); these activities should be analyzed with greater detail.

Table 3. Classification of photographs

Subtask	**Number of pictures**	**%**
1. Surface cleaning with right arm	17	34%
2. Removing excess mixture with tool	2	4%
3. Rotate body and move to new position	2	4%
4. Cleaning surface with left arm	9	18%
5. Lift both arms (one cleans and one holds)	19	38%
6. Change tool control	1	2%

3.4 Biomechanical analysis

To identify the exposed limbs and the associated risk level, the Humantech® Industrial Ergonomics software (n. d.) was used, which considers the variables of strength, posture, duration and frequency of the activity to assign an individual rating to the limbs involved in the activity according to the scale shown in Figure 3, then accumulates the individual points to assign an overall weighting and assign a priority level, according to Figure 4.

Figure 3. Individual scale

Figure 4. Overall scale

Using the software to analyze the video of the vault cleaning activity yielded the results shown in Figure 5.

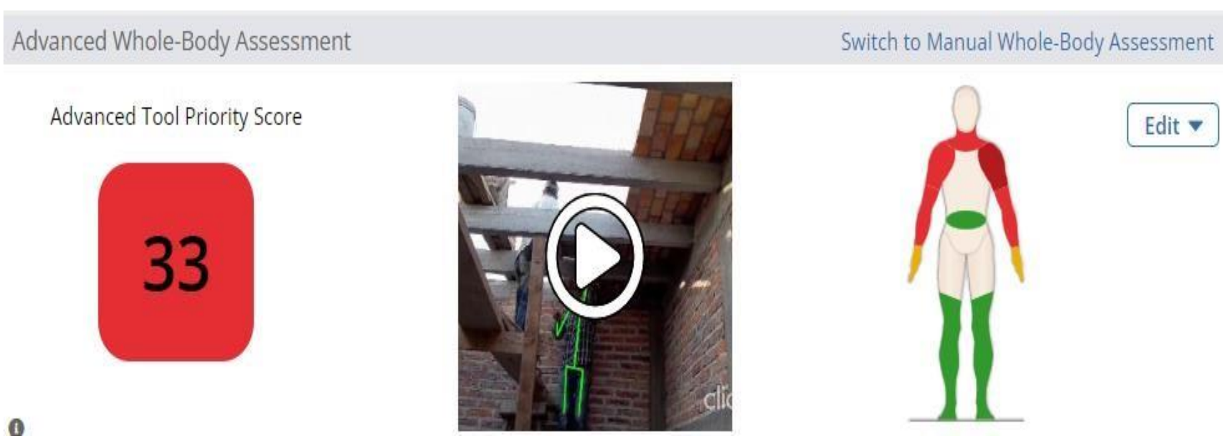

Figure 5. Software analysis

According to the result obtained, it is verified that both arms are in a high priority scale, which indicates that urgent modifications in the activity are necessary, in addition, the left shoulder is the member with the highest risk level, while the hands and wrists present a moderate risk. The lower limbs were not considered for the analysis of this project. Figure 6 shows the rating scale assigned by the software to the individual limbs.

Advanced Tool Assessment

	Hands/Wrists		Elbows		Shoulders		Neck	Back	Legs
	Left	Right	Left	Right	Left	Right			
Score ▲	3	3	6	4	7	4	4	1	1
Force	0	0	0	0	0	0	0	0	0
Posture	1	1	3	3	3	3	3	1	1
Duration	1	1	2	0	3	0	0	0	0
Frequency	1	1	1	1	1	1	1	0	0
Risk Rating	Mod	Mod	High	High	Higher	High	High	Lower	Lower

Figure 6. Individual rating scale

4. CONCLUSIONS

The tasks that were identified with the highest risk according to the classification of photographs were "Lifting both arms; one cleans and is supported by the other" with 38% and "Cleaning surface with the right arm" with 34%, which indicates that the right arm is kept above shoulder level during a little more than 70% of the execution of the activity. However, according to the biomechanical analysis performed in the software, the moment of greatest risk occurs in the left shoulder, when the worker raises and maintains his arm above shoulder level.

Ergonomic risks can always exist in manual activities, however, with proper and early detection, controls can be created to reduce them. Task analysis accurately identifies the activities that cause the greatest risk in an activity, and Humantech® Industrial Ergonomics software performs an analysis and assessment of the members involved, assigning a risk level according to its scale for their attention. By using these two tools, it is certain that the activities and members most exposed to ergonomic risk have been fully identified, so that research can continue to develop solutions focused on reducing the level of risk**.**

ACKNOWLEDGEMENT

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ERGONOMIC ANALYSIS OF THE WORK STATIONS IN THE COMPANY COMERCIALIZADORA SUPER FLOR S.A. DE C.V.

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Resumen Dentro de la región norte del estado de Sinaloa ubicamos una empresa comercializadora de productos básicos con nombre "Súper Flor, SA. DE CV.", en ella se comercializa diversidad de artículos y accesibilidad para los consumidores locales, esta empresa con 4 área de trabajo y un equipo de trabajo dinámico. Sin embargo, se han presentado dificultades para realizar las diferentes tareas, debido a los problemas de una mala distribución de espacios, asignación de tareas, tiempos muertos en diferentes procesos, molestias y dolores en diferentes partes del cuerpo de los trabajadores cuando realizan sus tareas y así como espacios inadecuados para realizar el manejo manual de cargas que se realiza en bodega. Con esta investigación se tiene como objetivo diseñar las condiciones ergonómicas de los puestos de trabajo. Se realizada el análisis durante dos semanas para identificar las condiciones inadecuadas, DTA y visualizar si existen problemas de lesiones musculoesqueléticas cuando realizan las actividades.

Palabras clave: Lesiones musculoesqueléticas, Comercializadora de productos, Manejo Manual de Cargas, DTA.

Relevancia para la ergonomía: La ergonomía es la interacción entre los seres humanos y otros elementos de un sistema. Este estudio aporta información que contribuye a la mejora de las condiciones laborales de la empresa.

ABSTRACT: Within the northern region of the state of Sinaloa we located a commodity trading company named "Súper Flor, SA. DE CV.", which sells a variety of items and accessibility for local consumers, this company has 4 work areas and a dynamic work team. However, there have been difficulties to perform the different tasks, due to the problems of poor distribution of spaces, allocation of tasks, downtime in different processes, discomfort and pain in different parts of the body of workers when performing their tasks and as well as inadequate spaces for manual handling of loads that is performed in the warehouse. The objective of this research is to design the ergonomic conditions of the workstations. The analysis was carried out for two weeks to identify inadequate conditions, cumulative trauma disorder and

to visualize if there are problems of musculoskeletal injuries when performing the activities.

Keywords: Musculoskeletal injuries, Product marketer, Manual Handling of Loads, DTA.

Relevance to Ergonomics: Ergonomics is the interaction between human beings and other elements of a system. This study provides information that contributes to the improvement of the working conditions of the company.

1. INTRODUCTION

Ergonomics is the process of adapting the work to the worker, taking charge of designing the machines, the tools and the way in which the tasks are carried out, to maintain the pressure of work on the body at a minimum level according to the definition provided by the Society of Ergonomics. Ergonomists of Mexico (SEMAC). According to the Statistical Report of the Mexican Institute of Social Security of 2016, the number of work-related illnesses in 2016 reached 12,622 cases, of which 4,607 registered cases of DTA, representing the first type of work-related illness (STPS, 2018).

In supermarkets, mass consumption products are marketed in different areas, for which the workers are in charge of moving the products from the warehouse to the display points and placing them properly on shelves for marketing; These activities are carried out in limited spaces and during customer service hours, so they must work with special care considering that the public often interferes, decentralizes or prevents better development. In addition to this, workers carry out their activities in places without lighting, without appropriate equipment, with monotonous and/or repetitive activities, which undoubtedly leads to psychological and physical problems, resulting in absenteeism and low productivity (Luzuriaga Zárate, 2020).

In the present study, an analysis of the general ergonomic conditions in which the trading company Super Flor S.A de C.V. is located was carried out, which has a total of 10 workers in the floor area (Warehouse, creamery and stationery) and 2 workers in management and administration. It was found that two work stations in the warehouse area are causing inappropriate positions for the operator. This research seeks to analyze and identify the musculoskeletal injuries of workers, this through the application of two of the different tools that Ergonomics offers us, the RULA method (Rapid Upper Limb Assessment) and Corlett & Bishop.

The evaluation of exposure to risk factors in the workplace related to DTAs is an essential aspect in their management and prevention (Rodríguez & Guevara, 2011).

2. OBJECTIVE

Analyze the ergonomic risks that can be found in the workstations of the warehouse area of the trading company "Super Flor S.A de C.V." to determine musculoskeletal injuries and company conditions

3. DELIMITATION

The analysis refers to the ergonomic conditions in which the operators of the company Super Flor S.A. find themselves. de C.V., located in the community of Palos Blancos in the municipality of Guasave, belonging to the state of Sinaloa. Evaluating the workers and activities that are carried out in the jobs of the warehouse area, such as, stirrups of warehouse products with the RULA and Corlett and Bishop method in a workday of 7 hours a day from Monday to Friday, and a 14 hour daily schedule on Saturdays and Sundays.

4. METHODOLOGY

The study was carried out in various stages:

1. A diagnosis of the company was carried out through tours, identifying the characteristics of the workers, as well as the work stations and the situation in which the company finds itself.
2. The work stations were analyzed for a certain time, and the activities that present risk factors for the operator were identified, in this case the warehouse product stevedores (floor workers), showing musculoskeletal injuries in the employees.
3. The applicable evaluation methods were RULA (work fatigue test), Corlett and Bishop (bodily discomfort) with which the risk that the worker runs in his work area was evaluated, as well as the application of Official Mexican Standards (NOM).

5. **RESULTS**

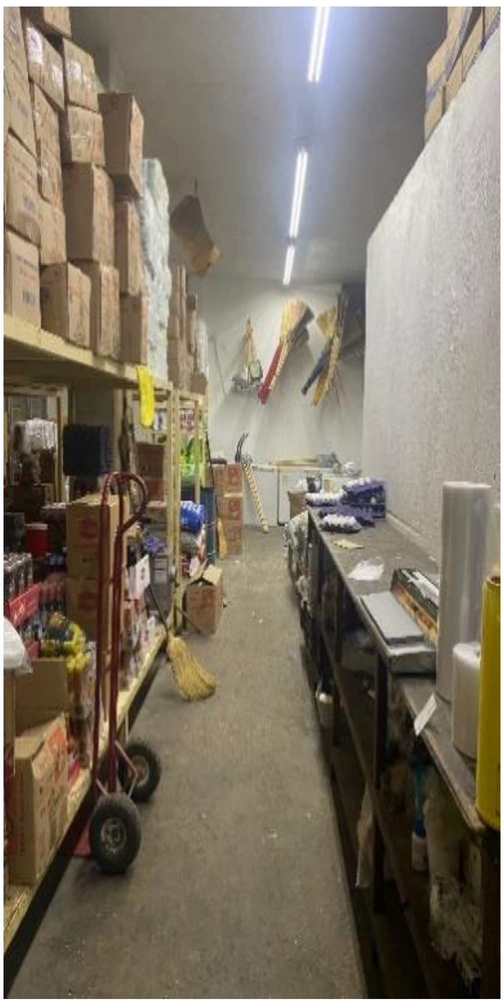
Through the application of Ergonomic Evaluation Methods, it is possible to identify and assess the ergonomic risk factors present in the jobs where agents of negative impact on the worker were found, including incorrect postures in repetitive lifting and excess levels. of load in the activities carried out.

6 people work in the company, of which 3 are men between the ages of 20 and 35 and 3 women between the ages of 20 and 41 with a 7-hour workday for 5 days and 2 full-time days. 14 hours with a 15-minute break every 2 hours and the rest day is during the week. The loading activities that are carried out in the

warehouse are activities in charge of men and the administrative and counter service activities are activities of women.

Station 1 has 7 operations with an estimated time of 31 minutes. In this season there are greater risks in Bodega. the activity is to stir 40 to 60 sacks of flour, each sack has a weight of 50 to 60 kg.

Station 2 has 7 operations with an estimated time of 40 minutes. At this station, 50 to 80 boxes of beverage products are loaded. In a kneeling position. This activity is carried out in a reduced area between the roof of the cold room and the roof of the establishment.



Workstations 1

Workstations 2

Figure 1 Workstations with the highest risk for workers.

Workstations evaluation 1

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Figure 2 Cargo movements in the Warehouse with sacks of 50 to 60 kg.

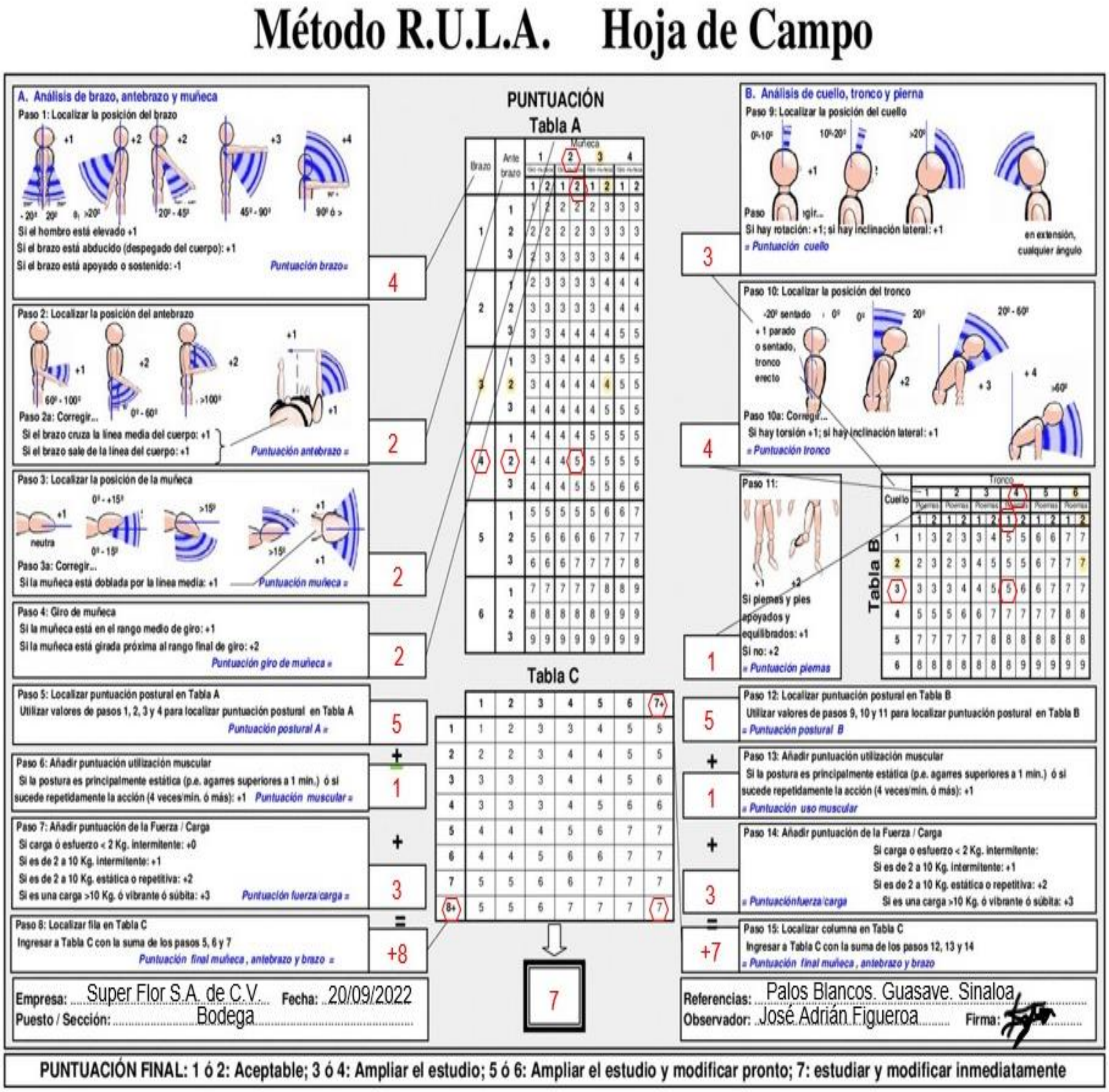
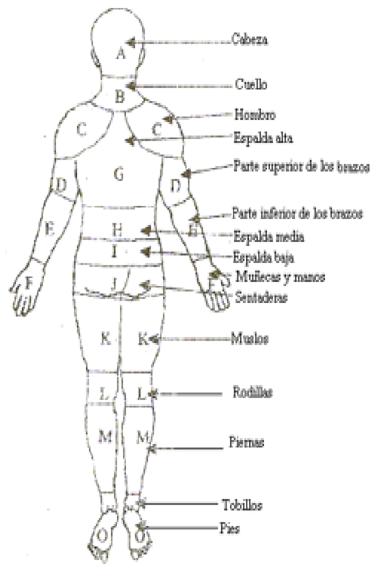


Figure 3. Application of the Rula Method at station 1

Result: A score of 7 was obtained, indicating that the workstation should be studied and modified immediately.

Aplicación de Corlett and Bishop



M=Molestia

D=Dolor

(Corlett & Bishop, 1976)

Observaciones: ____

____

	L	M	M	J	V	S	D	L	M	M	J	V	S	D
A														
B		M		M		D				M			M	
C		M	D		M	M		M		D			D	
D	M		M						M		M			
E														
F														
G														
H	D		D	M		D			M		D		D	
I	D	D				M			D		M		M	
J														
K														
L			M		M			M			M			
M														
N														
O						M					M			

Figure 4 Application of the Corlett and Bishop Method Station 1.

Workstations evaluation 2

Figure 5 Load movements at station 2

The application of the Rula Method in station 2 of the Warehouse, the employee is in charge of stacking 50 to 80 boxes of drinkable products. In a kneeling position. This activity is carried out in a reduced area between the roof of the cold room and the roof of the establishment.

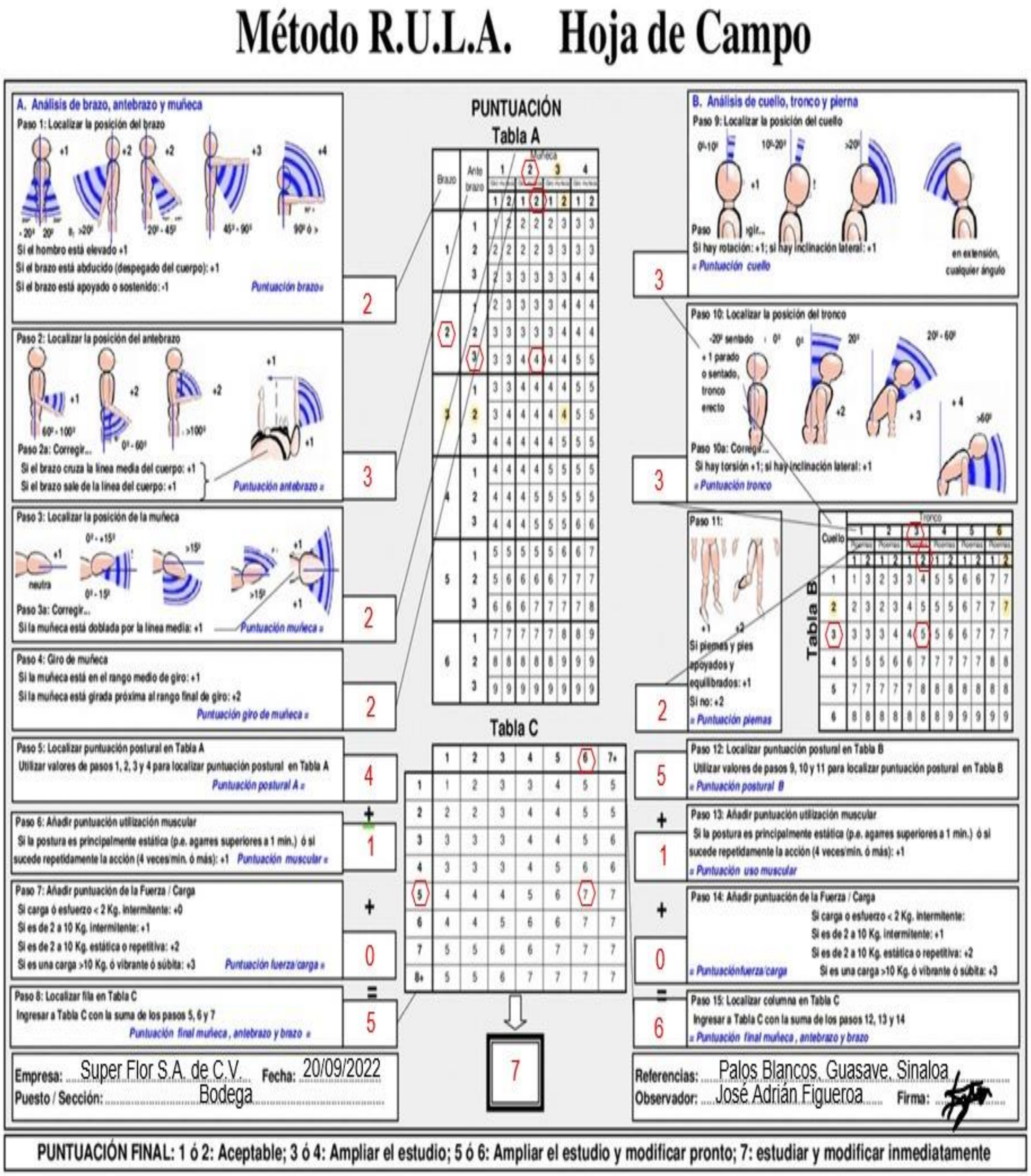
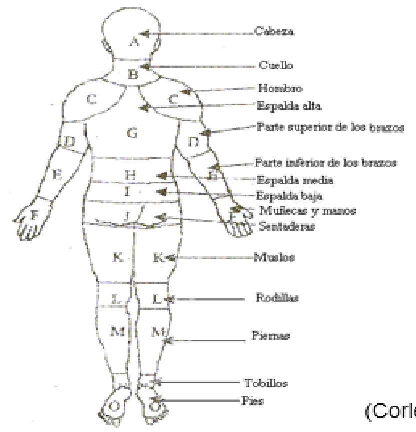


Figure 6 Application of the Rula Station 2 Method

Result: A score of 7 was obtained, indicating that the workstation should be studied and modified immediately.

Aplicación de Corlett and Bishop

Marque con una cruz las partes del cuerpo donde sienta alguna molestia o dolor y numérelas en orden ascendente según su grado de molestia o dolor.



M=Molestia

D=Dolor

(Corlett & Bishop, 1976)

Observaciones: ____

____

	L	M	M	J	V	S	D	L	M	M	J	V	S	D
A														
B		M			M	M				M			M	
C		M		M		M			M		M		M	
D	M	D		D				M		D			D	
E														
F														
G														
H	M	D		D		D			M	D			D	
I		M	M	D		D		M		M			D	
J														
K														
L			M			D		D			M		D	
M														
N														
O														

Figure 7 Application of the Corlett and Bishop Method

6. DISCUSSIÓN AND CONCLUSIONES

The ergonomic analysis allows detecting the risk factors to which the workers are exposed when they carry out operations in station 1 and 2. The environmental conditions, such as temperature and humidity to which the workers are exposed, develop poor performance, presenting exhaustion physical, lack of concentration, fatigue from the 3rd day of work, both for station 1 and station 2, which is in a cold room. The inadequate postures that the worker presents when performing the task, both in station 1 and station 2, Cumulative trauma disorders are developed in the following areas: Neck, shoulders, upper arms, knees, as well as lower back, middle and tall. With the application of the RULA Method in these 2 inadequate postures, level 7 is detected for each analysis posture.

A proposal to reduce the effect of environmental conditions in stations 1 and 2 is to alternate the activities inside and outside the same, as well as the exposure time of the worker inside the cold room as indicated by NOM-015-STPS- 2001. It consists of doing a rotation of activities, first inside the cold room and the next activity outside it, with work periods of two hours and rest of 10 min, in order for the worker to take recovery time, likewise change the position on their knees and integrate personal protective equipment for manual handling of loads and exposure to thermal conditions due to working in a cold room. Likewise, take care that the Official Mexican standards are complied with because NOM-002-STPS-2010, NOM-006-STPS-2014, NOM-017-STPS-2008 and NOM-036-1-STPS-2018 are not present, since that the prevention of accidents, the allocation of personal protective equipment is not present, as well as identifying ergonomic risks at work.

In station 1, a warehouse order assignment is needed since it is outside the scope of the employee and the product is not handled. There is NO training for the operator on how to carry out load handling

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EVALUATION OF ERGONOMIC RISK FACTORS IN THE WORKSTATION OF HANDLOOM WEAVERS CONSIDERING THE CHARACTERISTICS OF THE SOCIOCULTURAL CONTEXT

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Resumen: Dentro del sector artesanal, el trabajo que realizan los artesanos textiles deriva en la exposición a diversos factores de riesgo ocupacional que pueden llegar a afectar su desempeño laboral. Diversos estudios que han abordado los peligros y riesgos percibidos para la salud de los artesanos asociados con la actividad de tejido, se han enfocado en medidas objetivas que suelen subestimar aspectos del contexto sociocultural, los cuales pueden dar respuesta a características específicas de la estación de trabajo. El objetivo de este estudio es evaluar los factores de riesgo ergonómico presentes en la estación de trabajo de tejedores de telares manuales, así como la identificación de aspectos socioculturales relevantes para el diseño de una intervención ergonómica a futuro. Para esta identificación se llevaron a cabo entrevistas semiestructuradas, así como sesiones de observación que permitieron, a través de la prueba estandarizada Quick Exposure Checklist (QEC), identificar los factores de riesgo ergonómico. En este estudio participaron dos grupos de artesanos textiles; tejedores de telar de pedal y tejedores de telar de pedal con *chicote* del estado de Oaxaca. Los resultados obtenidos mostraron que el grupo de tejedores de telar de pedal con *chicote* presentaron un nivel de riesgo muy alto en la zona del cuello, por su parte, los tejedores de telar de pedal presentaron un nivel de riesgo alto en la misma zona seguida de la espalda, algunos de los resultados de la prueba QEC podrían tener una posible explicación según lo percibido en las sesiones de observación de los participantes.

Palabras clave: Ergonomía, Factores de riesgo, tejedores, telares manuales

Relevancia para la ergonomía: Este estudio aborda un tema poco explorado en México desde una perspectiva ergonómica, además, se enfoca en una población del sector informal que no suele ser considerada en el desarrollo de investigaciones relacionadas a la salud. En este sentido, y a través de los principios de la ergonomía ocupacional, se busca dejar un registro que contribuya a la mejora de la salud y productividad de artesanos textiles, trazando una estrategia diseñada de acuerdo a las características y necesidades de este sector de la población.

Abstract: Within the handicraft sector, the work performed by handloom weavers results in exposure to various occupational risk factors that can affect their work performance. Several studies that have addressed the perceived hazards and risks to the health of handloom weavers associated with the weaving activity have focused on objective measures that tend to underestimate aspects of the sociocultural context, which may respond to specific characteristics of the workstation. The objective of this study is to evaluate the ergonomic risk factors present in the workstation of handloom weavers, as well as the identification of relevant sociocultural aspects for the design of the future ergonomic intervention. For this identification, semi-structured interviews were carried out, as well as observation sessions that allowed, through the standardized Quick Exposure Checklist (QEC) test, the identification of ergonomic risk factors. Two groups of handloom weavers participated in this study; pedal loom weavers and pedal loom weavers with *chicote* from the state of Oaxaca. The results obtained showed that the group of pedal loom weavers with *chicote* presented a very high level of risk in the neck area, while the pedal loom weavers presented a high level of risk in the same area followed by the back, some of the results of the QEC test could have a possible explanation according to what was perceived in the observation sessions of the participants.

Keywords. Ergonomics, Risk factors, weavers, handlooms

Relevance to Ergonomics: This study addresses a topic that has been little explored in Mexico from an ergonomic perspective; in addition, it focuses on a population of the informal sector that is not usually considered in the development of research related to health. In this sense, and through the principles of occupational ergonomics, we seek to leave a record that contributes to the improvement of the health and productivity of textile artisans, outlining a strategy designed according to the characteristics and needs of this sector of the population.

1. INTRODUCTION

Over the years, handicrafts have become an important industry in developing countries, characterized mainly by conserving traditional practices and techniques of indigenous groups. According to statistics from the National Fund for the Promotion of Handicrafts, there are more than 12 million artisans in Mexico, representing 10% of the country's economically active population. The states that concentrate the largest number of artisans are Oaxaca, the State of Mexico, Chiapas, and Yucatan (FONART, 2020).

The literature reports that, within the textile artisan sector, working on handlooms is conducive to weavers adopting postures that are harmful to their health (Naz et al., 2015); that is, from an occupational ergonomics perspective, weavers are susceptible to presenting musculoskeletal symptoms derived from adopting uncomfortable postures, long working hours, repetitive movements, among other characteristics (Das et al., 2018). In addition to the above, Devi and Rajeswar (2019) mention that few investigations propose any preventive method for health problems associated with the working conditions of weavers, even more so, when due to the traditional approach to looms, many investigations related to occupational health in this field have focused on organized sectors leaving aside informal sectors (Durlov et al., 2019).

Another difficulty is the low interest in social and cultural characteristics, and aspects related to language, values, and beliefs are little considered when proposing improvements for these groups (Smith-Jackson & Wogalter, 2000). Therefore, in addition to identifying ergonomic risk factors, it is important to obtain and analyze qualitative information that helps to understand the weaving activity performed by handloom weavers.

In Mexico, there is little published data on occupational ergonomics in the handicraft sector, which indicates the need to generate more research focused on this field. The current work was carried out in the state of Oaxaca with the participation of handloom weavers; specifically, pedal loom weavers and pedal loom weavers with *chicote*, the latter is a variant of the pedal loom whose principles of use are the same. However, the difference lies in the weaving process, where the threads are passed through a shuttle that requires a constant manual impulse to move it from one end to the other. In this study, the QEC method was applied to obtain a quick diagnosis of the ergonomic risk factors during the weaving process, a total of 17 weavers participated, also, through a semi-structured interview, relevant concepts about the workstation of handloom weavers were collected, analyzed and identified.

2. OBJECTIVE

To evaluate the ergonomic risk factors present in the workstation of textile artisans, together with the identification of relevant socio-cultural aspects for the development of a proposal for future ergonomic intervention aimed at the prevention or reduction of musculoskeletal symptoms directed to the textile artisan sector.

3. DELIMITATION

The present research project is limited to the characteristics that compose the weaving task carried out by handloom weavers; in this case, the pedal loom and the pedal loom with a *chicote* are analyzed. This study is developed with the participation of artisans from the state of Oaxaca.

4. METHODOLOGY

This is an exploratory, cross-sectional study divided into two stages. In the first stage, risk factors are evaluated, and qualitative data are analyzed to identify relevant sociocultural aspects for the design of future ergonomic intervention.

4.1 Sociodemographic Questionnaire

To collect information from the participants, a sociodemographic questionnaire was applied, consisting of 15 questions related to age, marital status, school grade, and working hours, among other aspects. A total of seventeen conveniently selected weavers with ages between 22 and 66 years participated, of which nine were pedal loom weavers and eight were pedal loom weavers with *chicote.*

4.2 Semi-structured interview

To gather information on sociocultural and work aspects relevant to the development of this study, a total of 10 semi-structured interviews were carried out, made up of 10 items, which were oriented to learn about aspects related to the experience, work, and health of the handloom weavers.

4.3 Diagnosis by Quick Exposure Checklist (QEC)

To carry out the diagnosis of the ergonomic risk factors, an observation session was carried out with 15 participants performing the fabric activity in their usual workplaces; these sessions were videotaped for 10 continuous minutes.

The standardized test used to obtain a diagnosis of ergonomic risk factors was the Quick Exposure Checklist (QEC).

The QEC method is a quick checklist (see Figure 1) that evaluates exposure to ergonomic risks at work; it consists of 15 items covering physical risk factors such as load, force, duration, posture, frequency of movement, visual demand, repetition, and vibration, as well as psychosocial risk factors such as stress and work pace, and uses a 4-level risk exposure rating scale: low, moderate, high and very high (David et al., 2008).

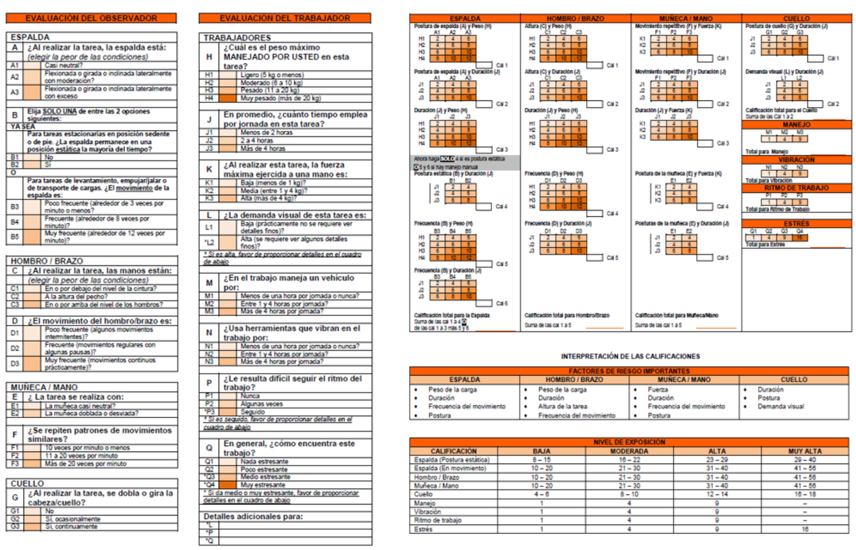


Figure 1. QEC method. Field sheet.

5. PROCEDURE

The potential participants were invited and informed about the objective of the study; they were provided with an informed consent form through which they were explained what their participation would consist of. Once their consent was obtained, the sociodemographic questionnaire was applied, which required approximately 5 minutes to be answered by the participants, followed by the semi-structured interview, which was recorded for later analysis and lasted between 15 and 20 minutes on average.

It should be noted that before starting the observation session, the participants answered the eight questions corresponding to the Worker Evaluation section of the QEC test field sheet; this activity took less than 5 minutes. On the other hand, the observation session required a previous time for the installation of the video recording equipment and the realization of a 2-minute test, after which the main activity lasted 10 continuous minutes.

6. DATA ANALYSIS

The responses to the sociodemographic questionnaire were concentrated in an Excel spreadsheet, and averages were obtained for age, working days, experience, and percentages of marital status and schooling, and a brief descriptive analysis was made for each group of weavers.

The semi-structured interviews were analyzed using NVivo version 11 software, in which the information was constituted using a hierarchical organization of three main nodes determined according to the objective of the interviews; these nodes were: experience, health, and work, which contained secondary nodes. Likewise, a word frequency calculation and a conglomerate analysis were carried out to determine the closeness between concepts.

The video recordings of the observation sessions were analyzed using the GOM Player, which made it possible to establish speed parameters and obtain representative frames used to complete the Observer Evaluation section of the QEC standardized test.

7. RESULTS

7.1 Participants

The group of pedal loom weavers was made up of a total of nine participants; six women and three men, with an average age of 49 years; the workday of this group corresponds to an average of 5.4 days of work per week and 7.7 hours of work per day. The group of pedal loom weavers with *chicote* consisted of one woman and seven men, with an average age of 28.8 years, an average of 5.4 days of work per week, and an average of 6 hours of work per day. Table 1 shows the results of the sociodemographic questionnaire.

Table 1. Characteristics of the participants

	Pedal loom weavers (f)	Pedal loom weavers with *chicote* (f)
Sex		
Female	6	1
Male	3	7
Marital Status		
Married	7	2
Single	2	6
Last grade of studies		
Elementary school	6	-
Secondary school	1	1
High school	2	2
University	-	5
	Average ($\bar{x}$)	**Average ($\bar{x}$)**
Age	48.8 years Range 31 - 66	28.8 years Range 22 - 55
Experience	28.8 years	13.25 years
Working day (days/week)	5.4 days	5.4 days
Working day (hours/day)	7.7 hours	6 hours

7.2 Semi-structured interviews

The analysis of the interviews made it possible to explore topics related to the daily work of the weavers, especially aspects related to their experience, work, and health.

7.2.1 Experience

The interviews revealed that the pedal loom weavers with *chicote* have less knowledge of the origins of the loom; however, they demonstrate that they have acquired and developed weaving skills in a shorter period.

On the other hand, most of the members of the pedal loom weavers group learned the trade at an early age, having been instructed mainly by their parents, as opposed to the pedal loom weavers, who mostly learned in less time and through training outside the home.

7.2.2 Work

Regarding work, it was found that both groups of weavers have a similar workday of 5.4 working days per week, on average. Questions were also asked about aspects related to the use of the loom, its modifications, and age; on these issues, both groups agree that the design of the looms does not generate work inconveniences for them. However, the weavers of the pedal loom with *chicote* point out that the most frequent problems occur during the manipulation of the yarns, since when weaving the weft, sometimes the yarns break; on the other hand, the weavers of the pedal loom share that they must be attentive to the pattern or design of the canvases to avoid making mistakes; these inconveniences require the weavers to maintain their attention during the manipulation of the threads, which is why they agree that their work is visually demanding.

In both groups, the hand looms have not been modified since they were acquired; in this regard, weavers comment that it has not been necessary because they have not had any problems with its use; the average age of the pedal looms is 44 years, and the average age of the pedal loom with *chicote* is ten years.

7.2.3 Health

Another area explored was the health of the weavers, derived from the weaving activity, in which it was found that both groups present a work routine that they have established according to their experience, their skills, and the workload that they usually present in both groups it was detected that they prefer to have a constant work rhythm, however, the pedal loom weavers comment that after a day of between 4 to 5 hours of continuous work is when the body begins to resent, that is, they begin to detect slight physical discomfort such as back, neck and arm pain mainly.

Both groups of weavers opt to take short breaks or rest to lessen the discomfort they may experience, but these breaks do not have a defined schedule or duration. In addition to the above, both groups indicated that in addition to physical discomfort, they sometimes experience stress due to the proximity of deadlines, which is why they modify their work rhythms to achieve their initial objectives.

Figure 2 shows the words mentioned most frequently during the semi-structured interviews, which can describe the handloom weaving activity expressed by the participants of both groups.

Figure 2. Cloud of words most frequently expressed by handloom weavers.

To determine the proximity between the most frequent concepts, a conglomerate analysis was carried out (Figure 3), in which it can be seen that the concepts of body and rhythm, as well as arm and resent, stretching and pauses, originality and tradition are the pairs of concepts that are closest to each other.

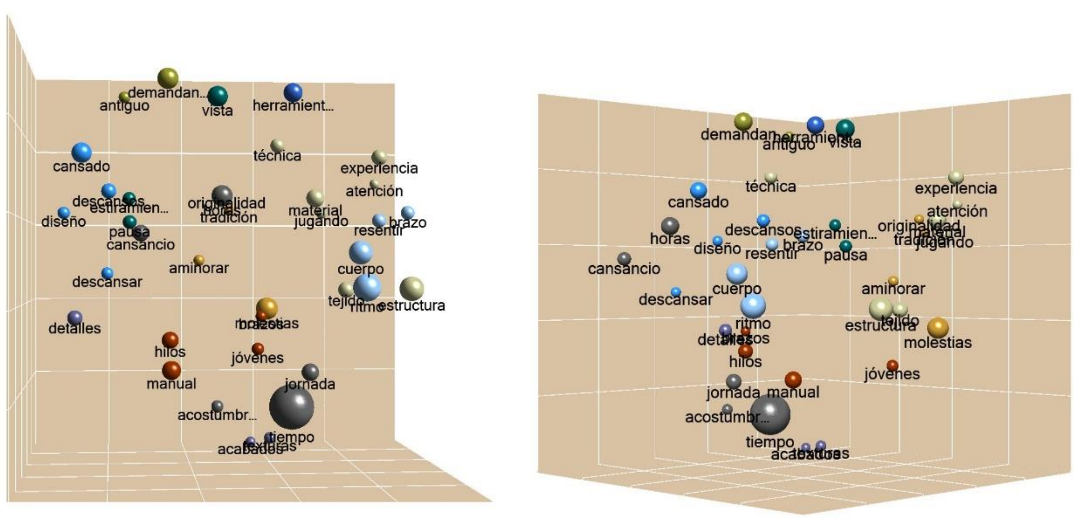


Figure 3. Proximity between the most frequent concepts obtained from the participants' discourse. Left: Frontal view, Right: Perspective view.

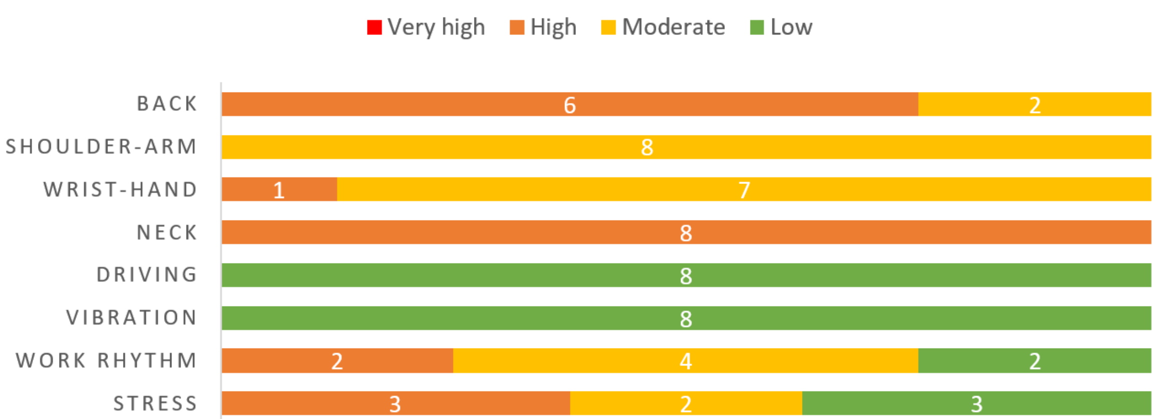
7.3 Quick Exposure Checklist (QEC)

The results of the standardized QEC test were obtained in two stages; the first corresponds to the second section of the field sheet of the QEC method (Worker Evaluation), which allows gathering information about the workday through the direct participation of the workers. This section was answered before starting the observation session with each participant; it should be noted that eight of the nine pedal loom weavers and seven of the eight pedal loom with *chicote* weavers participated in the observation sessions. Figures 4 and 5 show an example of the photograms obtained from the observation sessions in each group of weavers, which were used to answer the first section of the field sheet of the QEC method (Observer Evaluation).

Figure 4. Observation session with pedal looms weavers.

Figure 5. Observation session with weavers using a pedal loom with *chicote.*

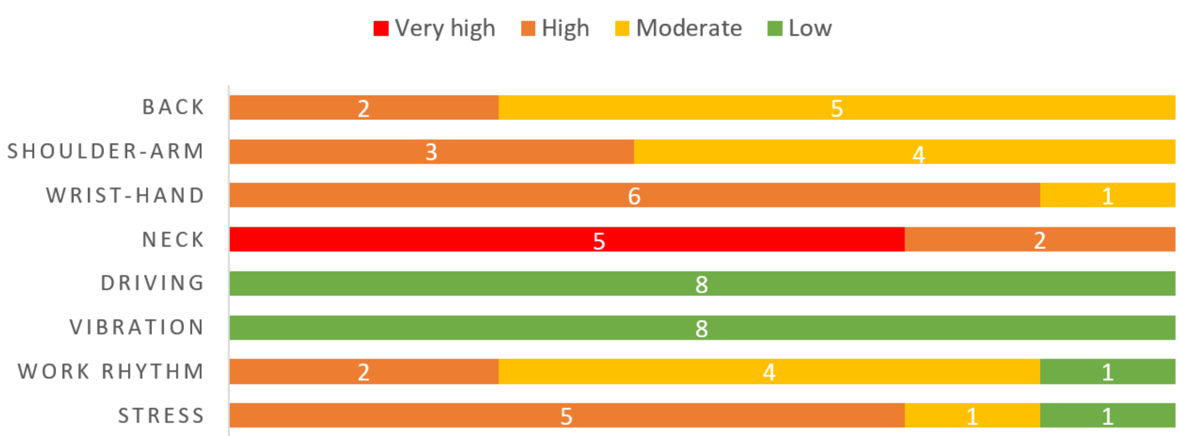
Graphs 1 and 2 show the results obtained from the standardized QEC test, it is worth noting that the majority of participants of the pedal loom reported a high level of exposure to risk in body segments such as neck and back, a moderate level in shoulders-arms, as well as in wrist-hand mainly.



Graph 1. Level of risk presented by pedal loom weavers.

On the other hand, the group of pedal loom weavers with *chicote* presented a very high level of exposure to risk in the neck, this was the highest level found among the participants of both groups. The majority presented a high level of risk in the wrist-hand area, and a moderate level of exposure to risk in the back.

Both groups presented a low level of risk exposure in aspects related to vibration from handling tools or driving vehicles. It should be noted that in the evaluation of the back, the Static back option was considered for both groups because, in both cases, the back remained in the same position (static) most of the time they performed the task.



Graph 2. Level of risk presented by the pedal loom weavers with *chicote*.

8. DISCUSSION

The initial objective of this project was to evaluate the ergonomic risk factors, which were carried out using the QEC method. It should be noted that before the analysis of the data, it was interesting to find that according to the sociodemographic data of the participants and based on the National Population Council (2000), two populations of weavers were identified; a population of young adults with an average age of 29 years (pedal loom weavers with *chicote*) and a population of mature adults (pedal loom weavers) with an average age of 49 years, in this sense, the possible inference of age in the levels of risk reported cannot be discarded, however, finding a possible relationship of these variables could be covered in another stage of this study.

The results of the QEC test allowed observing that the young population presented the highest level of risk, that is, in the group of pedal loom weavers with *chicote*, where the weaving activity has more impact on the neck area, reporting a very high level of risk. It is worth noting that during the observation sessions, it was possible to appreciate that the rhythm of work in the pedal loom with a *chicote* has a higher level of intensity than the pedal loom, a characteristic that could be due to the constant manual effort required to pull the shuttle from one end of the loom to the other, added to this, the neck movement becomes constant because as mentioned in the section on the results of the interviews, one of the biggest problems described by the weavers was the breaking of the threads during the weaving process, for this reason, the weavers constantly supervise the trajectory of the shuttle.

On the other hand, the maximum level of risk found in the group of pedal loom weavers was high, also affecting the neck, followed by the back. This result is probably because the pedal loom weavers maintain a more static position of the back during the weaving activity, together with a daily workday that is usually longer than that of the group of young adults, most of whom presented a moderate level of risk in this same part of the body (back).

Also, the QEC test allowed us to obtain results on the risk of stress and the pace of work, and it was the group of young adults who mostly presented a high mainly of stress. In the interviews, most of them commented that the problems that arise during the weaving activity, such as the breaking of threads, becomes stressful because this type of inconvenience delays them, sometimes affecting the delivery date of the work.

Another objective of the study was to gather qualitative information that could help to identify social and cultural aspects. It should be noted that the word cloud and the conglomerate analysis, resulting from the analysis of the interviews, allowed visualizing concepts such as teaching and learning the trade, as well as aspects related to the originality of the works, their design, textures, and finishes that the weavers use in their weavings, as well as aspects related to the originality of the works. However, it is known that the current market demands new products, the weavers have opted to innovate in the design of patterns and materials with diverse applications, without modifying the workstation, which is proven by the fact that the structure of their looms have not been intervened since they acquired them; they only replace the wooden pieces that deteriorate over time.

This last finding allows us to propose a strategy that focuses on ergonomic exercises and stretching centered on the areas of the body with the highest level of ergonomic risk since, as was found in the interviews, both groups of weavers choose to take regular breaks and rests during their workday, but without a defined schedule or duration.

9. CONCLUSIONS

Through the QEC test, a diagnosis of the levels of exposure to risk in both groups of textile artisans was obtained; the results confirm the need to address aspects related to the weaving activity since, according to several authors, it is recommended to identify and apply measures when the exposure levels found are moderate, high or very high (Castelló et al., 2010).

The results described above will contribute to the development of the second stage of the study, in which the aim is to design and implement an ergonomic strategy aimed at preventing or reducing the levels of exposure to ergonomic risks in the textile handicraft sector.

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TELEWORK AND ERGONOMICS DURING THE PANDEMIC AND ITS EFFECT ON HEALTH

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Resumen El presente artículo tiene como propósito el determinar si el tiempo de Dedicación de los maestros (Teletrabajo) y la ergonomía se asocia a la Salud de los académicos de enseñanza superior e investigadores de una institución de Educación superior en la ciudad de Hermosillo, durante el periodo de confinamiento debido al COVID-19. Se utiliza para evaluar la dimensión de Salud el Cuestionario de Salud General de 12 ítems (GHQ12) para evaluar el bienestar psicológico y detectar problemas psiquiátricos no psicóticos y para la variable Ergonomía usando los Doce consejos de Ergonomía / Factores Humanos (E/FH) para realizar actividades remotas (teletrabajo). Es una estudio transversal y descriptivo de las posibles relaciones de las variables citadas. En el resultado se reporta que no hay efecto significativo en entre el tiempo de Dedicación y la Salud, pero se encuentra una débil relación entre la variable Ergonomía y salud a un nivel de significancia del 1%.

Palabras clave: Teletrabajo, Salud Psicológica, Ergonomía

Relevancia para la ergonomía: Tratar de establecer la relación del teletrabajo y la ergonomía en la salud percibida de los docentes de una escuela de educación superior.

Abstract The purpose of this article is to determine whether the time of dedication of teachers (Telework) and ergonomics is associated with the health of higher education academics and researchers of a higher education institution in the city of Hermosillo, during the period of confinement due to COVID-19. The 12-item General Health Questionnaire (GHQ12) is used to assess psychological well-being and detect non-psychotic psychiatric problems and for the variable Ergonomics using the Twelve Ergonomics / Human Factors (E/FH) tips to perform remote activities (teleworking). It is a cross-sectional and descriptive study of the possible relationships of the variables cited. In the result it is reported that there is no significant effect between the time of Dedication and Health, but there is a weak relationship between the variable Ergonomics and health at a level of significance of 1%.

Keywords: Teleworking, Psychological Health, Ergonomics

Relevance for ergonomics: Try to establish the relationship between teleworking and ergonomics in the perceived health of teachers in a higher education school.

1. INTRODUCTION

As a result of the COVID-19 pandemic in Mexico, 232 thousand teachers at the bachelor's, master's and doctorate levels (INEGI, 2020) find it necessary to leave the classrooms of a school and move to an office, stay, room or bedroom from home to teach his classes virtually, this due to the closure of public and private schools which was ordered by the federal government.

According to the UNESCO IESALC report (2020), the most evident impact on teachers is the continuity of teaching activity under the virtual modality. Although higher education institutions have learning platforms, this was used more as a complement to classroom education. Higher education teachers suffered an abrupt change in the way they taught their classes, as they were forced to use different online technological means and the use of educational digital platforms to continue their classes, many of them without being properly prepared or trained to do so. use them (Torreros, 2021). A large number of them did not have their material adapted to the use of these platforms, so they had to make an additional effort to first learn how to use them and then prepare their material.

2. OBJECTIVES

To determine if the Dedication time of teachers (Teleworking) and ergonomics is associated with the Health of higher education academics and researchers of a Higher Education institution in the city of Hermosillo, during the period of confinement due to COVID-19 .

3. METHODOLOGY

The present study is cross-sectional and descriptive and seeks to analyze the perception of the respondents about the effect of Teleworking and the ergonomic conditions during confinement due to COVID-19 in the dimensions of Psychological Health.

The Ergonomics Research Network of Northwest Mexico (RIENO) conducted a survey in several higher education institutions in the states of Sonora, Sinaloa, Baja California and Baja California Sur, in order to study the effects of teleworking on education teachers. higher. The data of this study are based on those obtained in the survey that was applied in a single institution during the months of November 2021 to January 2022.

3.1. Study design

Of the dimensions analyzed by this survey, Psychological Health was selected, which uses the 12-item General Health Questionnaire (GHQ12) as an instrument to assess psychological well-being and detect non-psychotic psychiatric problems (Hardy et al. 1999) and Ergonomics which was elaborated using the Twelve Ergonomics / Human Factors (E/FH) tips to carry out remote activities (telework) or learning tasks at home using tablets and smartphones, (Ebara and Yoshitake, 2020).

3.2. Participants

The survey was addressed to the teaching staff of higher level educational institutions in the Northwest of Mexico. In our case, the information was taken from a single institution, located in the city of Hermosillo, Sonora in Mexico. At the time of the survey, this had 296 undergraduate and postgraduate professors. The institution began to carry out teleworking activities (online or virtual classes) from March 2020 to March 2022.

Of the 296 teachers, 157 responded to the survey with appointment types of 1= Base, 2= Fees, 3= Fees/eventual and 4= Mixed, as well as Type of dedication to the program of 1= Teaching and 2= Teaching + Research .

3.3. Data collection

The survey was prepared in Google Form and shared via institutional email to all teachers, explaining in it the importance of participation. Department heads were asked to report on the survey at their academic meetings. A total of 296 invitations were sent out of which 157 responses were received.

3.4. Telecommuting

To measure the teleworking dimension, we will be considering it in the variables Dedication Time and Dedication. With dedication time we refer to the number of hours assigned, which can be Full Time when they are assigned 40 hours per week to academic and administrative work, part time when they have 20 hours. weekly and Subject with loose hours. The full-time teachers of the surveyed institution develop teaching work in front of the group with 20 +- 2 hours maximum per week. The rest of your time is considered support or administrative hours. Support hours include consultancies, research work, tutorials. In dedication there are two types of response which are Teaching and Teaching + research. Teachers with Teaching + Research dedication have fewer hours assigned to the group, but hours assigned to their research project that are handled as Administrative. For the purposes of this analysis, we will be measuring the effects of Full Dedication Time and Teaching and Teaching+Research Dedication.

3.5. Health

For the evaluation of the Health dimension, the version of 12 questions or items of the General Health Questionnaire (Hardy et al. 1999) was used, the answers were structured on a 4-point scale (0 to 3) where 0 is considered Greater than than usual and 3 as Much less than usual. The answers to six of the questions are answered positively and another six negatively, making the adjustment so that the evaluations of the variables in the dimension are consistent. Some of the questions are; [I've been able to concentrate on what I'm doing] and [I've lost a lot of sleep from worrying]. The Likert method (Hardy et al. 1999) is used to calculate the total score, which fluctuates between 0 and 3, with lower values indicating a perception of better health. The internal consistency of the instrument is 0.84 using Cronbach's Alpha for the sample. A variable Ergo_prom is created that contains the average of the answers to the 12 questions. This will be used to make comparisons.

3.6. Ergonomics

The Ergonomics dimension was evaluated with twelve questions based on the Twelve Ergonomics/Human Factors (E/FH) advice manual for remote activities (telework) published by ULAERGO (2020). This manual is in turn an extended revision of the manual of the Japanese Society of Human Factors and Ergonomics (JES) where 7 recommendations or advice are presented for people who work remotely.

The evaluation considers two subdimensions; Health, evaluated by a single question; [During or after a day at work, are you free from pain or discomfort in your feet, legs, back, shoulders and neck?] and the Work Environment sub-dimension for eleven questions, some of which are; [Can you sit comfortably in your chair for the entire working day?] or [During your working day, do you have a footrest?]. The response scale goes from 0 to 4 where 0 is Always and 4 Never. The questions have a negative meaning. The Likert method is used, as is the Health method, to calculate the total score, which fluctuates between 0 and 4, with lower values indicating a better perception of ergonomic practices. The internal consistency of the instrument is 0.877 in Cronbach's Alpha for the 12 elements, noting that in the analysis of suppressed elements, when removing the question the health dimension, a Cronbach's Alpha of 0.877 is obtained for the sample, showing good consistency. The Ergo_prom variable is created, which considers the average of the responses.

4. RESULTS

4.1. Descriptive Analysis

A total of 157 surveys were received considering a response rate of 53% of the teachers. Table 1 shows the main characteristics of the teachers surveyed. It is observed that the proportion of the sample of teachers surveyed by gender is 60.5 men and 39.5 women. An important consideration is the Age of the respondents, the highest proportion is in the segment of 50 to 59 years with 35%, with the segments over 40 years having 75.2%. The mean for pooled data is 48.38 years with a standard deviation of 11.15. The proportion of the sample of teachers with a basic position is 57.3%, Fees 35% and 7.7% Mixed (base hours and fees). It is noteworthy that 77.7% of the teachers have postgraduate studies, which indicates the quality of the institution's education.

Table 1. Characteristics of the teachers who participated in the survey

Variable		Frec	%	% acum
Género	Hombre	95	60.5	60.5
	Mujer	62	39.5	100.0
Edad	20 a 29	7	4.5	4.5
	30 a 39	32	20.4	24.8
	40 a 49	37	23.6	48.4
	50 a 59	55	35.0	83.4
	60 o más	26	16.6	100.0
Estado Civil	Soltero	43	27.4	27.4
	Casado	86	54.8	82.2
	Unión Libre	8	5.1	87.3
	Divorciado	13	8.3	95.5
	Viudo	7	4.5	100.0
Dependientes Económicos	0 dependientes	35	22.3	22.3
	1 dependiente	31	19.7	42.0
	2 dependientes	47	29.9	72.0
	3 o mas dependientes	44	28.0	100.0
Tipo de Nombramiento	Base	90	57.3	57.3
	Honorarios	55	35.0	92.4
	Mixto	12	7.7	100.0
Dedicación	Docencia	123	78.3	78.3
	Docencia + investigación	34	21.7	100.0
Horas dedicación	Tiempo completo	73	46.5	46.5
	Medio tiempo	20	12.7	59.2
	Asignatura	64	40.8	100.0
Depto. Adscripción	Ciencias Básicas	32	20.4	20.4
	Ciencias Económico-Administrativas	15	9.6	29.9
	Ingeniería Eléctrica y Electrónica	8	5.1	35.0
	Ingeniería Industrial	55	35.0	70.1
	Ingeniería Metal Mecánica	25	15.9	86.0
	Posgrado	8	5.1	91.1
	Sistemas Computacionales e Informática	14	8.9	100.0
Escolaridad	Licenciatura	35	22.3	22.3
	Maestría	105	66.9	89.2

	Doctorado	17	10.8	100.0
Antigüedad institución	6 a 12 meses	1	0.6	0.6
	1 a 2 años	11	7.0	7.6
	2 a 5 años	19	12.1	19.7
	5 a 10 años	31	19.7	39.5
	10 a 15 años	33	21.0	60.5
	15 a 20 años	11	7.0	67.5
	20 a 25 años	11	7.0	74.5
	25 a 30 años	21	13.4	87.9
	30 + años	19	12.1	100.0

4.2 Health

Regarding the perception of the psychological health of teachers, it was previously mentioned that the General Health Questionnaire questionnaire was used. The scale for measuring the health of teachers is negative, that is, the lower the rating, the better the health, so levels of 0 are perfect health and 3 is poor health. Considering the total of the surveys received, the participating teachers rated their perceived health with a mean value of 1.25, which is in the Regular health segment. Basic descriptive statistics appear in Table 2

Table 2. Basic Health Statistics

Variable	N	Media	E.Emedia	Desv.Est.	Mediana
Salud_prom	157	1.2505	0.0424	0.5313	1.3333

Groupings were also established in three levels where the averages of appreciation from 0 to 1 indicate Good health perception, Regular Health from 1.01 to 2 and Poor Health from 2.01 to 3. Table 3 shows the perception by the percentage of Teachers of according to the groupings mentioned

Table 3. Perceived Health

Salud	Porcentaje	PrcAcum
Buena	30.57	30.57
Regular	64.33	94.90
Mala	5.10	100.00

When analyzing the gender variable, the mean for men is 1.33 and women 1.13, remaining in the Regular segment. Table 4 summarizes the information:

Table 4 Health by Gender

Genero	Buena	Regular	Mala	Total
Hombre	14.01	42.68	3.82	60.51
Mujer	16.56	21.66	1.27	39.49
Total	30.57	64.33	5.10	100.00

Cell content % of total

In the Age variable, the highest was that of the group 30 to 39 years old with 1.30 as an average. Table 5 shows the perception by age group. 30.5% of those surveyed reveal a perception of Good Health and only 5% as Bad.

Table 5 Age and Health

Edad	Buena	Regular	Mala	Total
20 a 29	1.274	3.185	0.000	4.459
30 a 39	7.643	10.828	1.911	20.382
40 a 49	8.280	13.376	1.911	23.567
50 a 59	8.280	26.115	0.637	35.032
60 o más	5.096	10.828	0.637	16.561
Total	30.573	64.331	5.096	100.000

Cell content % of total

4.3. Ergonomics

For the perception of Ergonomics, the evaluation considers that 0 is Optimal compliance with Ergonomic standards and 4 is Poor compliance. The mean of the Ergo_prom variable of the respondents is 1.78, which indicates good compliance with ergonomic standards for teleworking.

Table 6 Basic Statistics Ergonomics

Variable	Medi	E.Emedi	Desv.Es	Median
Ergo_pror	1.782	0.0645	0.8083	1.7500

By gender, women observe a higher average of 1.88 than men, Table 7.

Table 7 Average ergonomics vs. Gender

Genero	Ergo_prom
Hombres	1.71
Mujeres	1.87
Prom.	1.7824

4.4. Health / Telecommuting

An ANOVA analysis was carried out to verify if there are differences in the means of the values obtained in the Health dimension by the time of Occupation. The p-value is 0.044 in the analysis, so there is not enough evidence to conclude that there are differences in the mean at a significance level of 1% in the effect of Hours dedicated to Health. Table 7

Table 7. ANOVA for Health / Hours Dedication
Method

Hipótesis nula	Todas las medias son iguales
Hipótesis alterna	No todas las medias son iguales
Nivel de significancia	$\alpha = 0.01$

Equality of variances was assumed for the analysis

Factor Information

Factor	Niveles	Valores
Factor	3	Tiempo Completo, Medio Tiempo, Asignatura

ANOVA

Fuente	GL	SC Ajust.	MC Ajust.	Valor F	Valor p
Factor	2	1.750	0.8751	3.19	0.044
Error	154	42.284	0.2746		
Total	156	44.035			

Model Summary

S	R-cuad.	R-cuad. (ajustado)	R-cuad. (pred)
0.523998	3.97%	2.73%	0.09%

Factor	N	Mean Media	Desv.Est.	IC de 99%
Tiempo Completo	73	1.3390	0.5123	(1.1791, 1.4990)
Medio Tiempo	20	1.013	0.548	(0.707, 1.318)
Asignatura	64	1.2240	0.5297	(1.0531, 1.3948)

St. Dev. pooled = 0.523998

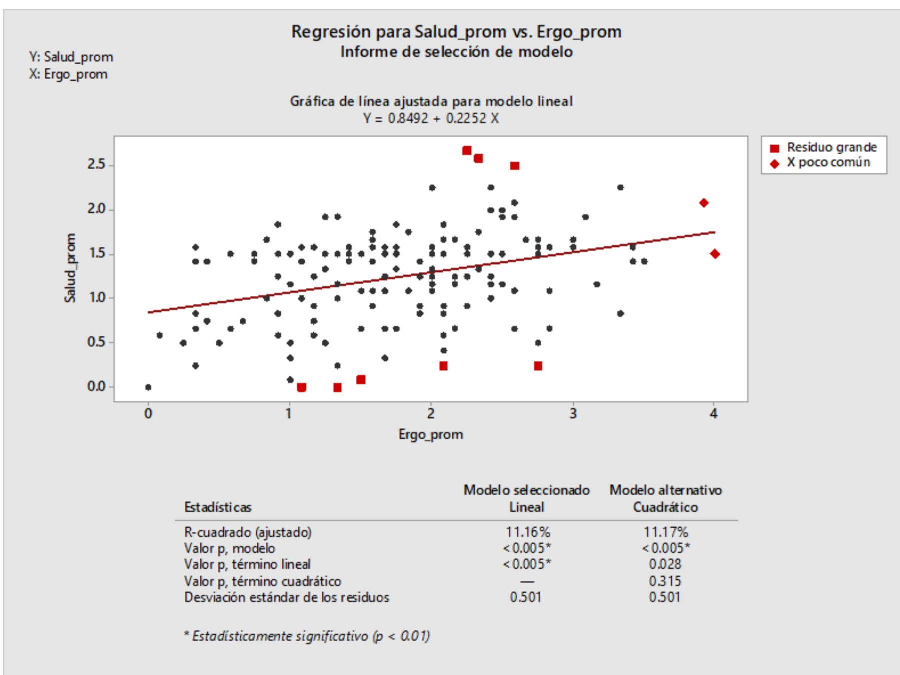
4.5. Health / Ergonomics

ANOVA is performed to contrast the Salud_avg variable with Ergo_avg, finding that there is no difference in the means. The p-value is 0.071. Table 8.

Table 8 ANOVA Health_avg / Ergo_avg

Fuente	GL	SC Ajust.	MS Ajust.	F	Valor p
Ergo_prom	41	14.88	0.3629	1.43	0.071
Error	115	29.15	0.2535		
Total	156	44.03			

According to the regression analysis, it was found that the relationship between the two variables is statistically significant at 1% ($p<0.001$) and that the model is explained by 11.73% of the variation of Salud_avg and that there is a



positive relationship between both. variables of r=0.34. The fitted equation for the linear model that describes the relationship between Y and X is: Y = 0.8492 + 0.2252

X . If the model fits the data well, this equation can be used to predict Avg_Health for a Avg_Ergo value, or find the Avg_Ergo setting that corresponds to a desired Avg_Health value or range of values. The statistically significant relationship does not imply that X is the cause of Y.

5. DISCUSSION AND CONCLUSIONS

In this study, we compare perceived health with respect to time spent and ergonomics in teachers' work. We found in our analysis that there is not, at least with the data collected, a significant difference between the Dedication Time (Full, Half and Subject) and the perception of Health among teachers. In the bibliography consulted for this work, differences are indicated in this aspect, since some report an increase in stress and another decrease (Widar, 2020) citing (Tustin, 2014). According to these researchers, the differences may be due to the different cultural and social backgrounds of the teachers surveyed. An element that may also have an influence is the academic preparation of the teachers, which, although it could not be verified in the study, it is suggested that it be reviewed later.

Another factor is that the survey did not discriminate the time used by the teacher for classes (full time) with administrative and support loads, and situations may arise where teachers have very little academic workload compared to the group.

Regarding the comparison of Ergonomics and Health in the regression analysis, a weak relationship between the two is shown. This may be because the survey model needs to be adjusted. It is considered to start an inferential study of the correlation of an exploratory nature of the Ergonomics and Health variable using the PLSPM methodology of the R software dedicated to the analysis of partial path modeling of least squares (PLS-PM) for metric and non-metric data. Using this software it is possible to adjust the model to the variables that provide the most significance.

We conclude that in the analysis carried out, no significant relationship was found between Health and the hours of dedication, which may be due to the size of the sample and the lack of precision of the hours compared to the group. Regarding ergonomics, there is enough evidence for a significant relationship, but very weak, since it only explains 11.7% of the effect of Health_avg.

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EVALUACIÓN DE TRABAJO UTILIZANDO LA HERRAMIENTA QEC EN LA INDUSTRIA DE ENSAMBLE DE PARTES.

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Resumen Resulta de especial interés evaluar las condiciones laborales de los puestos de trabajo de la industria de ensamble de partes, como las posturas, la frecuencia de ejecución, las cargas a levantar y la duración del trabajo, y a partir de ahí, determinar la prevalencia del desarrollo de Trastornos Musculoesqueléticos (TME), para posteriormente diseñar puestos de trabajo para prevenir un TME. La presente investigación surgió de la necesidad de prevenir el desarrollo de TME, ya que estos trastornos representan uno de los padecimientos laborales más frecuentes. El estudio fue un diseño experimental del tipo preexperimental. Se procedió a realizar una investigación transeccional correlacional-causal para conocer a detalle la forma en como las diferentes variables a estudiar afectan y pueden causar la presencia de Trastornos Musculoesqueléticos (TME). La recolecta de información se realizó mediante la herramienta de evaluación ergonómica Quick Exposure Check (QEC). Mediante esta herramienta 12 diferentes actividades fueron evaluadas mediante la participación de 39 personas. Se determinó la prevalencia de un TME para cada región del cuerpo (cuello, hombros, espalda, muñeca y cuello). La asociación de las variables independientes categóricas con respecto a la variable principal de la presencia de un TME se analizó mediante la prueba $\chi 2$ de Pearson, que se calculó mediante una tabla de contingencia o tabulación cruzada. Además, se obtuvo el p-valor para la significación, con un intervalo de confianza del 95%. Las actividades que representaron un nivel de riesgo alto fueron las actividades de empaque y de movimiento de material que representaron el 42.86% del total de nivel de riesgo alto. Los TME más prevalentes de los trabajadores se hallaron principalmente en la muñeca con un 64.10%, un 35.90% en espalda, seguido de hombros y cuellos con un 30.77%. Se sugiere la implementación y el desarrollo de programas de prevención como las pausas activas, estas deben de ser calculadas y programadas. No es recomendable turnos de 12 horas de trabajo físico por parte de las personas, esto puede dividirse en turnos haciendo la misma actividad no más de 4 horas.

Palabras clave: Trastornos Musculoesqueléticos, Quick Exposure Check, prevalencia.

Relevancia para la ergonomía: El trabajo de investigación aporta la utilización de la herramienta ergonómica en la ejecución de tareas, así como la aplicación de principios de diseño ergonómicos que no solo aplican a este tipo de industria sino a todas aquellas que realicen actividades repetidas o en posición de pie.

Abstract: Evaluate the working conditions as postures, execution frequency, lifted loads and the work duration, in order to determinate the prevalence of Musculoskeletal Disorders (MSD) developments, is the especial interest in the parts assembly industry whit the purpose to redesign the jobs. This research arose from the need to prevent the MSDs development, because these disorders represent one of the most frequent occupational sufferings. This research was an experimental design of the pre-experimental type. Cross-sectional correlational-causal research was carried out to learn how the different variables can cause Musculoskeletal Disorders (MSD) during work activities. Data collection was performed using ergonomic assessment Quick Exposure Check (QEC). Using this tool, 12 different activities were evaluated through 39 people. The MSD prevalence was determined for each body part (neck, shoulders, back, wrist and neck). The association of the variables was analyzed using Pearson's X^2 test, which was calculated using a contingency table or cross tabulation. The p-value for significance was obtained, with a 95% confidence interval. The activities that represented a high-risk level were the packaging and material movement that represented 42.86% of the total high-risk level. The MSDs prevalent were found on the wrist with 64.10%, 35.90% on the back, followed by shoulders and necks with 30.77%. The implementation and development of prevention programs such as active breaks are suggested. It is not recommended 12 hours shifts physical work and the shifts can be divided in no more than 4 hours.

Keywords. Musculoskeletal disorders, Quick Exposure Check, prevalence.

Relevance to Ergonomics: The research provides the use of QEC ergonomic assessment in order to evaluate task execution, as well as ergonomics principals that can not only be applied in this industry but also those that carry out repeated activities or in a standing position.

1. INTRODUCCIÓN

En la industria la actividad física es constante y repetitiva lo cual provoca en muchas ocasiones lesiones musculoesqueléticas. Estas enfermedades musculo-esqueléticas tiene un gran impacto a nivel mundial desde el punto de vista de productividad y debido a su alta prevalencia, son la razón primaria de dolor muscular en las personas y por consecuencia la ausencia en el trabajo.

De acuerdo con la OMS los Trastornos Musculoesqueléticos (TME) son todas aquellas enfermedades del aparato locomotor ocasionados por el trabajo y abarca todo tipo de dolencias desde molestias leves hasta lesiones incapacitantes (Luttmann, Jager y Griefahn, 2004). El Instituto Nacional de Seguridad y Salud

Ocupacional (NIOSH) ha clasificado a los TME como la segunda enfermedad más común resultante del trabajo (Benítez, 2021).

López, González, Colunga y Oliva (2014) mencionan que cerca del 58% de la población mundial mayor a los 10 años, un tercio de su tiempo en el trabajo y que del 30 al 50% de los trabajadores está expuesto a riesgos ocupacionales que pueden generar lesiones de trauma acumulativo.

Por otro lado, Rodríguez, García y Ortiz (2020) comentan que es común que los desórdenes musculoesqueléticos formen enfermedades relacionadas con el trabajo. Mencionan que en la Unión Europea estas lesiones representan el 53% de dichas enfermedades y que en Colombia con la principal razón de enfermedad profesional con un 82%.

Perruccio, Yip, Power, Canizares y Badley (2019) explican que los TME son afecciones que pueden afectar los músculos, los huesos y las articulaciones y estos normalmente afectan nuestro sistema musculoesquelético como cuello, hombros, muñecas, espalda, caderas, piernas, rodillas y pies.

En México de acuerdo con las estadísticas del Instituto Mexicano del Seguro Social (IMSS) del año 2011 se reportaron 536,322 casos lo pues representó la principal causa de morbilidad musculoesquelética (López et al., 2014).

De acuerdo con Baek, Kim y Yi (2015) mencionan que los principales factores que determinan un TME son la carga física en exceso, las posturas incómodas y las tareas altamente repetitivas. Por otro lado, Sánchez, Rosero, Galleguillos y Portero (2017) comentan que el origen de los TME es multifactorial como posturas forzadas, incómodas, inclusive factores psicosociales y organizativos. Semper (2016) menciona que el 40% de los TME son la zona lumbar, el 27% en el cuello, el 26.60% en la zona dorsal el 11.80% en brazos y antebrazos y el 7% en manos muñecas y dedos. Jurado (2020) además aclara que el dolor del cuello es frecuente como patología al realizar actividades operativas y que existe una alta prevalencia de casos de dolor lumbar, así como también una serie de molestias en manos y muñecas. A demás Alaníz, Quinteros y Robiana (2020) dicen que los TME son acumulativos y se presentan debido al resultado de una exposición repetida durante un tiempo prolongado.

La herramienta ergonómica Chick Exposure Check (QEC) es un método de observación de posturas y movimientos de partes del cuerpo como la espalda, hombro, muñecas y cuello. Además, mediante esta herramienta se puede obtener información sobre las condiciones de trabajo como la duración del trabajo, peso máximo manejado e intensidad del esfuerzo (Nadri H. Fasih, Nadri F., y Nadri A. 2013).

De acuerdo con Woods (2005) QEC ha sido diseñado por profesionales para evaluar la exposición a factores de riesgo relacionados con el trabajo y así proporcionar una base para intervención ergonómica en el puesto de trabajo.

Por otro lado, David (2005) menciona que el método QEC es muy recomendable para la evaluación de la postura del trabajador en lugar por ejemplo del método RULA. Además, menciona que el método no solo es una herramienta apropiada para la evaluación de riesgos, sino que además el método es una mejora completa para la evaluación total de los riesgos que ocurren en las empresas.

La puntuación final de QEC se basa en una puntuación de cada parte del cuerpo evaluadas por el observador y el trabajador. El nivel de riesgo de las tareas de acuerdo con la puntuación final se clasifica en 4 categorías. En donde el riesgo bajo va desde un valor de 8 a 14 puntos en la espalda, 10 a 20 puntos en hombro y brazo y en el cuello de 4 a 6 puntos. Un nivel de riesgo moderado va de 16 a 22 puntos en espalda en posición estática y de 22 a 30 puntos en cuello y muñeca y de 8 a 10 puntos en cuello. El nivel de riesgo alto va de 24 a 28 puntos en espalda estática, de 32 a 40 puntos en hombro/brazo y en cuello el puntaje es de 12 a 14 puntos. Por último, un nivel de riesgo muy alto va de 30 puntos hasta 42 puntos y en cuello 16 puntos (David, Woods, Li, y Buckle (2005). Como lo pueden ver en la Table 1.

Tabla 1. Nivel del Riesgo

Puntuación	Bajo	Moderado	Alto	Muy alto
Espalda (B1-B2)	8-14	16-22	24-28	≥30
Espalda (B3-B5)	10-20	22-30	32-40	≥42
Hombro/brazo	10-20	22-30	32-40	≥42
Mano/muñeca	10-20	22-30	32-40	≥42
Cuello	4-6	8-10	12-14	≥16

2. OBJETIVOS

- Aplicar y analizar la herramienta ergonómica Quick Exposure Check (QEC) en las actividades de los procesos de la industria de ensamble de partes en una empresa de la localidad.

- Proponer mejoras en los procesos que permitan la disminución o eliminación de Trastornos Musculoesqueléticos (TME)

3. METODOLOGÍA

El estudio fue un diseño experimental del tipo preexperimental. Se procedió a realizar una investigación transeccional correlacional-causal para conocer a detalle la forma en como las diferentes variables a estudiar afectan y pueden causar la presencia de Trastornos Musculoesqueléticos (TME).

En el estudio se observó la manera en cómo la gente realizaba sus actividades al momento de realizar sus actividades laborales. La investigación fue diseñada bajo el planteamiento metodológico del enfoque mixto, ya que el estudio fue observable y medible.

La recolecta de información se realizó mediante la herramienta de evaluación ergonómica Quick Exposure Check (QEC). Mediante esta herramienta 12 diferentes actividades fueron evaluadas mediante la participación de 39 personas. El resultado del análisis de cada una de las posturas fue llevado a una calificación cuantitativa, y posteriormente se generó un análisis de los datos obtenidos. La información obtenida fue posible conocer el grado de exposición de los trabajadores al riesgo de un TME.

La evaluación ergonómica QEC comprende de 2 bloques en donde el primer bloque se forma de cada una de las partes corporales del cuerpo que pudieron ser factores de riesgo. Y el segundo bloque consta de los factores de riesgos relacionados con el trabajo como la fuerza, duración, postura y repetición.

En relación con las diferentes posturas el instrumento considera 3 diferentes posiciones que son: posición neutra, posición con flexión moderada y postura con flexión excesiva. La manera en como en la empresa se midió esta variable fue mediante los grados de inclinación de las personas al ejecutar la tarea.

Otro aspecto evaluado con el instrumento QEC fue la frecuencia o repetición en donde 3 aspectos fueron considerados; si la operación es muy repetitiva de alrededor de 3 veces por minuto o menos se le dio la categoría de infrecuente, si la operación se realiza de 8 veces por minuto se le dio la categoría de frecuente, y si la actividad se realiza más de 12 veces por minuto o más se le designo como muy frecuente.

Con respecto a la fuerza la herramienta QEC considera una escala de Likert con categorías de respuesta:1=ligero, 2=moderado (entre 5 kg y 10 kg), 3=pesado (entre 10 y 20 kg) y 4=muy pesado (más de 20 kg).

Y por último el aspecto de la duración en el trabajo, QEC aplica la pregunta ¿Cuánto tiempo pasas al día en esta tarea? Las posibles respuestas a esta pregunta fueron puestas bajo el siguiente criterio: 1=1 hora menos de 2 horas, 2=de 2 horas a 4 horas y 3=más de 4 horas.

La recolección se llevó durante un periodo de 1 mes en donde se observó el proceso en la empresa y se analizaron las actividades en sus ciclos completos de trabajo. Un total de 39 personas fueron observadas y evaluadas. Los horarios de recolección de datos fueron de las 6:00 am a 12:00 pm de lunes a viernes. La herramienta QEC se aplicó dos veces al mismo grupo de personas.

La captura de la información se llevó mediante el programa de Excel 2010 en el que se ingresaron los datos tomas de la evaluación QEC. Posteriormente los análisis de datos fueron analizados estadísticamente mediante el programa SPSS Statistics 22.00.

Se determinó la prevalencia de un TME para cada región del cuerpo (cuello, hombros, espalda, muñeca y cuello). La asociación de las variables independientes categóricas con respecto a la variable principal de la presencia de un TME se analizó mediante la prueba $\chi 2$ de Pearson, que se calculó mediante una tabla de contingencia o tabulación cruzada. Además, se obtuvo el p-valor para la significación, con un intervalo de confianza del 95%.

4. RESULTADOS

La muestra en el presente trabajo estuvo constituida por 39 trabajadores pertenecientes a 12 diferentes actividades como se puede ver en la Tabla 2. Las actividades que representaron un nivel de riesgo alto fueron las actividades de empaque y de movimiento de material que representaron el 42.86% del total de nivel de riesgo alto. El 14.29% corresponde al corte de material. En relación con el nivel de riesgo moderado la actividad que representa un 28.00 % corresponde a empaque. El 16.00 % corresponde a la actividad de inspección de empaque en el nivel de riesgo moderado. Y por último un 12 % en el nivel de riesgo moderado corresponde a las actividades de jiggeo, limpieza de material y movimiento de material.

Tabla 2. Nivel de Riesgo de las Actividades Evaluadas

	Nivel de Riesgo		
Actividades Evaluadas	**Alto**	**Moderado**	**Total**
Almacén	1	1	2
Corte Material	2	0	2
Empaque	3	7	10
Inspección empaque	1	4	5
Jiggeo	1	3	4
Limpieza de Material	0	3	3
Marcar Piezas	1	1	2
Moldeo de Pieza	1	0	1
Movimiento Material	3	3	6
Pistolear	0	2	2
Pulir Pieza	1	0	1
Sopleteo	0	1	1
Total	**14**	**25**	**39**

Los TME más prevalentes de los trabajadores se hallaron principalmente en la muñeca con un 64.10%, un 35.90% en espalda, seguido de hombros y cuellos con un 30.77%, tal como se muestra en la Tabla 3.

Tabla 3. Prevalencia de TME en las diferentes partes del cuerpo.

Parte de Cuerpo	**No.**	**%**
Espalda	14	35.90%
Hombro	12	30.77%

Muñeca	25	64.10%
Cuello	12	30.77%

De 27 personas que tuvieron una posición neutra de la espalda al estar trabajando 24 registraron un nivel de riesgo moderado que corresponde al 88.9 %. Por otro lado, 11 personas realizaron actividades en donde la flexión de la espalda fue moderada dando como resultado que 10 personas tuvieran un nivel de riesgo alto lo cual presenta un 90.9 %. Por último, la persona que mantuvo una flexión de la espalda excesiva el nivel de riesgo fue siempre alto. El 35.90 % de las personas tuvieron un nivel de riesgo Alto de acuerdo con la Tabla 4 de Contingencia. El valor de chi cuadrada es de 23.46 y el valor de p=.000<0.005.

Tabla 4. Tabla de contingencia posición de espalda – Nivel de riesgo.

			Nivel Riesgo en Espalda		Total
			Alto	Moderado	
Posición espalda	neutra	Recuento	3	24	27
		% dentro de Posición espalda	11.1%	88.9%	100.0%
	flexión moderada	Recuento	10	1	11
		% dentro de Posición espalda	90.9%	9.1%	100.0%
	flexión excesiva	Recuento	1	0	1
		% dentro de Posición espalda	100.0%	0.0%	100.0%
Total		Recuento	14	25	39
		% dentro de Posición espalda	35.9%	64.1%	100.0%

En relación con el nivel de riesgo de la muñeca no existe una relación debido a la posición de la muñeca (p=1, p>0.05) y de igual modo no existe una relación entre la frecuencia de movimientos por minuto realizados por la muñeca (p=.010, p>0.05). En donde si existe una relación es debido a la duración de la tarea el tiempo en que está realizando los movimientos con la muñeca (p=0.00, p<0.05).

5. DISCUSION / CONCLUSION

La evaluación de puestos de trabajo utilizando la herramienta QEC permitió conocer el nivel de riesgo a la cual están expuestos los trabajadores de la empresa ensambles de partes. Mediante esta evaluación se concluyó que las muñecas y la espalda son las partes de cuerpo que más propensas son a desarrollar un TME, ya cuentan con una prevalencia de 64.10% y un 35.90% respectivamente. Las actividades que tuvieron un mayor riesgo de desarrollar un TME fueron las de empaque y movimiento de material.

El movimiento de material principalmente se realiza de manera manual dentro de las líneas de producción y es una actividad realizada por los materialistas, y si bien el tamaño de la carga no es considerado como pesada por la evaluación QEC sino más bien moderada con un peso entre 5 y 10 kg. El factor importante y a considerar debido a que en la evaluación el resultado fue de nivel de riesgo alto se debe al tiempo en que se trabaja en dicha empresa ya que las actividades las realizan en turnos de 12 horas. La evaluación ergonómica QEC considera como una actividad con duración prolongada aquella que se realiza por más de 4 horas al día, por lo que al estar realizando esta actividad por un tiempo de 8 horas más de lo recomendado por QEC esto es un factor que permite a la larga el desarrollo de una enfermedad de musculoesquelética.

El resultado de la evaluación realizada mediante la herramienta QEC, permitió estimar el nivel de riesgo laboral y detectar la existencia de posturas, frecuencias y duración de las actividades que ayudara a actuar proactivamente frente a la prevalencia de desarrollo de estas enfermedades en estas partes de cuerpo como las muñecas y la espalda.

Se sugiere la implementación y el desarrollo de programas de prevención como las pausas activas, estas deben de ser calculadas y programadas por parte de los ingenieros industriales que diseñan los puestos de trabajo (García y Sánchez, 2020). No es recomendable turnos de 12 horas de trabajo físico por parte de las personas, esto puede dividirse en turnos haciendo la misma actividad no más de 4 horas.

Es importante capacitar a las personas en relación con las pausas activas ya que estas permiten la circulación de la sangre, y la circulación de la sangre sirve para evitar la fatiga muscular. La rotación del personal en la realización de diferentes actividades, en conjunto con las pausas activas ayudara a evitar el desarrollo de TME en las muñecas y en la espalda.

A demás de las pausas activas calculadas para los trabajadores, el incluir los descansa pies en las mesas de trabajo ayudaran a reducir el cansancio y la fatiga por parte de los trabajadores. De igual forma modificar la altura de las mesas al nivel del codo de los operadores permitirá mejorar la posición de las muñecas al realizar los empaques.

Actualmente las mesas de trabajo están por debajo de los codos lo cual afecta la posición de las muñecas al estar realizando sus actividades, así como del cuello y espalda. La altura optima de operación es del suelo a los codos de los operadores, lo cual permite que tanto el cuello como la espalda no se estén dobladas y así limitar la circulación de la sangre y por lo tanto la presencia de la fatiga se haga presente (Sánchez, 2018).

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