ANALYSIS OF THE RELATIONSHIP FATIGUE - ANTHROPOMETRY-DESK DIMENSIONS IN STUDENTS OF INDUSTRIAL ENGINEERING PROGRAM

MC Jesús Rodolfo Guzmán Hernández[1], MC Joaquín Vásquez Quiroga[1],
Dr. Enrique Javier de la Vega Bustillos[2]

[1]Programa de Ingeniería Industrial
Universidad de Sonora Unidad Regional Norte, campus Caborca.
Ave Universidad y calle Irigoyen S/N C. P. 83600
Caborca, Sonora, México,
rguzman@caborca.uson.mx, jovaqui@caborca.uson.mx

[2]Maestría en sistemas Industriales
Instituto Tecnológico de Hermosillo
Ave. Tecnológico y Periférico Poniente S/N C.P. 83170
Hermosillo, Sonora, México
en_vega@ith.mx

RESUMEN

Actividades de los tutores del estudiante de Ingeniería Industrial ha puesto de manifiesto que algunos de ellos se quejan de cansancio, dolor de espalda y cuello después de clases. Mediante la aplicación de la encuesta Yoshitaka, H. (1978) a 56 estudiantes para detectar signos de fatiga al final de las clases, se encontró que 67,9% expresó sentir tensión muscular en los hombros y la espalda, y 89,3% expresó su necesidad de estirar los músculos. El objetivo de esta investigación fue estimar los parámetros antropométricos de altura poplítea, longitud nalga-poplíteo, altura de codo sentado y la anchura de la cadera de los estudiantes, así como las dimensiones de los escritorios utilizados y el cálculo de las relaciones entre ellos y comparándolos con las recomendaciones internacionales, demostrar que las mesas "tipo" utilizados por la población en estudio tiene desajustes con las medidas antropométricas de los usuarios y probablemente son causantes del cansancio y los dolores musculares citados. La muestra fue de 46 varones y 12 mujeres estudiantes de entre 19 y 23 años y se concluye que es necesario, para atender problemas de salud de estudiantes, adquirir escritorios ajustables o, al menos, mesas de diferentes dimensiones, de acuerdo con las medidas antropométricas de los usuarios, hombres y mujeres

Palabras clave: Antropometría; Mobiliario escolar; altura poplítea, posturas

ABSTRACT

Activities of tutors for students of Industrial Engineering has revealed that some them complain of fatigue, neck and back pain after classes. By applying the survey Yoshitaka, H. (1978) to 56 students to detect signs of fatigue at the end of classes it was found that 67.9% felt muscle tension on shoulders and back, and 89.3% needed to stretch their muscles . The objective of this research was to estimate the anthropometric parameters of popliteal height, buttock-popliteal length, sitting elbow height and width of the hip of students as well as the dimensions of the desks, and calculating relations between them and the comparison with international recommendations, demonstrate that the desks "type" used by the study population have mismatches with anthropometrics measures of the users and probably are the cause of fatigue and muscle aches cited. The sample was 46 males and 6 female students between 19 and 23 years and concluded that it is required, to meet student health problems, to acquire adjustable desks or, at least, desks of different dimensions, according to the anthropometric measurements of male and female users.

Keywords: Anthropometry, School furniture, Sitting posture.

1 INTRODUCTION

Illness that students in the University level frequently present on semi desert region of Sonora, are those arising from extreme temperatures. In winter, respiratory ailments ranging from colds to flu or respiratory infections are present. In the summer, dehydration and digestive disorders, which usually appear by consuming contaminated foods. Other annoyances are headaches and vision problems, caused by poor light when studying or not wearing glasses when they need them, as well as having changed the habits of sleep or long hours of exposure to the computer, let's also add the discomforts of muscle contractures of neck and back problems due to sitting a long time in inappropriate postures, resulting from bad habits or by using of furniture not consistent with their anthropometric characteristics. In relation to muscle contraction, Parcells (1999) indicates that eighty percent of the U.S. population seek medical attention for back problems at some point in their lives, and contrary to what one might guess, back problems are not confined to adults. A surprising number of children and adolescents are reported to have regular episodes of back pain and neck. Molenbroek (2003) citing Faassen (1978) Liebisch (1990), Snijders et al. (1995), states that headache, neck pain, back pain and deterioration in focusing on students, are the result of prolonged sedentary positions for educational purposes, so please pay attention to the design of school furniture. Discrepancies between anthropometric measurements of the pupils and the size of the desks in basic education schools are reported by Molenbroek (2003) quoting Parcells et al. (1999), Linton et al. (1994) and Aardoom (1987).

Activities of the mentoring program for students of Engineering have revealed that some of them complain of fatigue, back pain and neck after school. while conducting an informal investigation some pictures were taken of students sitting at a desk type attitude of being engaged in the classroom (Figure 1) and it could be seen that in some cases, the dimensions of the desks were small and in others large compared to anthropometry of students, which prevented them from taking a neutral position which minimizes the effort of the muscle tissue and enhances circulation and recovery of the body.

To quantify the incidence of muscle pain in the students we proceeded to estimate the proportion of students who felt physical discomfort after a day of classes, we took a random sample of 56 students after a day of classes, and assigned the questionnaire Yoshitaka H. (1978) "Three characteristic patterns of subjective fatigue symptoms" and found that 67.5% of

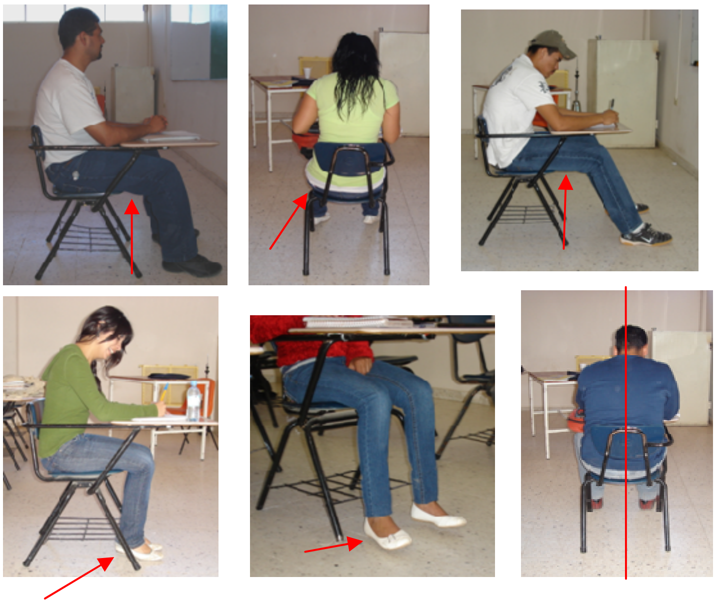

Fig. 1 Photo of students sitting at desks

them reported feeling tension in their shoulders and back pain, 89.3% showed willingness to stretch and 50% difficulty straightening their body. Moreover, most students of Engineering take between 6 and 7 subjects per semester, this means that they spend an average of 5.4 discontinuous hours to academic activities in the classroom in seated position, so the discomfort of their muscles are probably caused by the mismatch between the size of desks and anthropometric measures of the students. The intent of this work is to provide consistent evidence of the existence of factors that could negatively interfere in the academic performance of students and secondly, because there isn't a published anthropometric data of the student population at the University of Sonora, to provide information to the Anthropometric data base that is being built for the ergonomics discipline group of the University of Sonora, campus Caborca.

2 OBJECTIVES

The aim of this study was to estimate the proportion of mismatches between anthropometric measurements of students with type desks used by them, assuming that these desks and anthropometry of the students do not have a healthy relationship, according to the international recommendations. The research was conducted in the student population of Industrial Engineering at the University of Sonora, Northern Unit, Campus Caborca, and there is no reason to believe that the anthropometric data of the school population in the study population differ from other study school programs at the University of Sonora, however, there may be differences in the type and size of racks used in other curricula, so perhaps the results might or might not indicate an important problem at the institution. Furthermore this research was limited to the analysis of the relationships associated with the anthropometric height, width and depth of seat and table top, the table-length support with abdomen length, size of the table with hands or any preferential and backed up with Lordotic curvature were not examinated.

3 FRAME OF REFERENCE

3.1 Body weight and muscle activity in sitting position

Parcells (1999) citing Zacharkow D. (1988) argues that, the adverse effects of body weight and muscle activity in sitting position for inadequate school furniture have been known for a long time. He Also expresses that the dynamics of a seated position can be better understood by studying the mechanical parts of the body and the external support system involved. For example, 75% of total body weight is supported to be seated in an area of only 4 plg2 (26 cm2) of surface. This small area is under ischial tuberosities of the pelvic. The heavy burden is concentrated in this area, according to Tichauer E. (1978), causes a compression between 85-100 pounds per square inch (psi). Structurally, the tuberosities are two-point supports system that is inherently unstable, so the center of gravity of a person sitting on top of that zone can not be directly on the tuberosities and the area is insufficient to stabilize which makes it necessary to use the legs, feet, back in contact with other surfaces, as well as muscle forces to produce equilibrium P. Branton Et al (1969). Haffin (1999) states: The legs, when sitting, distribute and reduce the load on the buttocks and the back of the thighs. The legs must rest firmly on the floor or foot support, thus the weight of the lower leg is not supported by the front of the thigh resting on the seat. If pressure is applied on the thigh near the knee swelling can occur in the legs and pressure on the sciatic nerve. Winkel and Jorgensen (1986) state that in general, the legs increase their volume between 2.3 and 4% in a workday. In relation to muscle activity, Chaffin (1999) notes that electromyography has been used in some investigations to study the muscular activity of the back in sitting position. In these studies yamaguchi et. al. (1972) found that muscle activity detected by electromyography in the lumbar area decreases when armrests and seats tilted to the back are used this probably is because the load is transferred to the backrest. Likewise Åkerblom (1948) found that support in the lumbar region is more effective than a stand in the back. Bendix et. al. (1987) found no differences in muscle activity between seats slope tilted backward or forward, or adjustable tilt. Lunderbold (1951) found that the length of tables high or low relative to the leg lengths of users increases muscle activity, and so does the vertical length between the seat and the table.

3.2 Relationship popliteal height and seat height

Chaffin (1999) says that, when the seat height is very low, the knee bending angle becomes sharp, and the weight of the trunk should be transferred to the seat through the back of the thigh, it is transferred through a small area on the isquial tuberosities on the pelvis (Keegan, 1953, Floyds and Roberts, 1958, Kroemer 1971, Kroemer and Robinett 1969). When the seat height is so high that the feet do not touch the ground pressure on the back of the thigh is not very comfortable (Åkerblom 1948.1969, Schoberth 1962, Bush 1969) and the person tends to go to the front of the seat of the chair, allowing to support feet on the floor but the support is not used properly, resulting in low back pain if the position is for a long time (Burant and Grandjean 1963, Kroemer 1963.1971). Feet should rest firmly on the floor or on the foot support so the weight of the lower leg is not supported by the thighs that rest on the seat. In addition to ISO 9241-5: 2003 states: It is not acceptable to assume that people stay with the legs vertical it is convenient, therefore, that the lower leg can reach the ground in front of the knee, so that it presents a greater articulation angle of 90 º.

3.3. Buttock-knee length with a deep seat
In the ISO 9241-5: 2003 notes: seat depth is important both to ensure that the legs can be placed without compressing the back of the knees and to be able to rely fully on the back. The back of the knee is a fairly sensitive skin and tendons have little protection, so the depth of the seat should be slightly shorter than the length between the back of the knee and thigh. A big depth of the seat does not an appropriate use of back support which causes curvature of the spine (kyphosis) and may lead to no comfort.

3.4 Relationship wide hips and wide seat
In the ISO 9241-5: 2003 A.2.3 states: Besides the obvious need to ensure that a reasonable proportion of the population of potential users can easily get up and sit down, this is one of the most important way to ensure that the user lessens the burden by taking the postural position. Due to the flattening of the buttocks and the tendency to open her legs while sitting, the anthropometric measure width of the hips should be lower than what should be allowed for width of the seat. There must be added, on each side, an extra width for movement of the arms if the seat is equipped with armrests.

3.5 Relationship elbows height with work table height
Chaffin (1999) noted that the height of the table in relation to the person, is very important not only for the bottom but it affects the shoulders and torso height, depending on the position and supporting arms. A work surface, located above the elbow, causes arm abduction, resulting an increase in the stress of the shoulders, arms and necks. For prolonged work, it is recommended that the shoulder's abduction angle is between 15^0 and 20^0. Bendix (1987) recommends that the height of the desk must be between 3 and 4 cm above the elbow height of the person in sedative position.

4 PROCEDURE

In fall of 2008, to be able to realize this research and beginning from the assumption to estimate the proportion of pupils who do not have a healthy relationship between physical size and dimensions of the desks used by a confidence interval of 90% with an estimation error of ± 0.08%, we calculated a maximum sample size of 67 students of a population of 180 students of Industrial Engineering, given the proportionality of gender, a sample of 52 students was selected of whom 46 were men and 6 women between 19 and 23 years old, 15 anthropometric measurements were taken in sitting position and stand up; they were wearing common clothes, with casual shoes or tennis shoes, jeans and polo shirts. For this research measures of interest were popliteal height, buttock-knee length, width of the hip and seat-elbow height at 90^0. On the other hand the dimensions of the desk used were obtained. With this information the analysis of the corresponding relations was realized comparing them with the published recommendations and this way to demonstrate that the desk used by the population in study has mismatches with anthropometric measurements of the users and are probably the cause of fatigue and muscle pain, maybe affecting academic achievement.

5 ANALYSIS OF RESULTS

5.1 Definition of criteria

Based on anthropometric measurements of their population in different countries recommendations have been developed on the dimensions of the chairs for work done in sitting position, especially the recommendation to use adjustable chairs so that each user can regulate them and achieve comfort and possibilities of changes in posture. Two recommendations are shows in Table 1.

Table 1 Dimensions recommended for office chairs

	BIFMA 2002	ANSI/HFES 100-2007
Seat heigth	Adjustable from 39.2 to 49.75 cm	Adjustable from 39.0 to 55.0 cm
Seat width	Minimum 45 cm	Minimum 45.25 cm
Seat length (depth)	Minimum 42.25 cm	Minimum 42.25 cm
Seat slope angle	from 0^0 to 40^0 backward	from 0^0 to 10^0 backward
Backrest height	More 30.5 cm	More 44.25 cm
Backrest width	at least 35.5 cm	at least 35.6 cm
Backrest-seat angle	at least 90^0 between thigh and torso	at least 90^0 between thigh and torso
Lumbar support	Between 14.75 y 24.5 cm height of the most forward point of the support	Between 14.75 y 23.25 cm height of the most forward point of the support
Armrest height	form 17.25 to 24.5 cm	From 17.75 to 26.5 cm

source: Fernandez and Marley, Applied occupational ergonomics, International journal of Industrial Engineering Press, Cincinnati OH, 2007

In relation to the height of the working surface in seated position, there are some recommendations like the ones published by Chaffin (1999), the standards of the German rules, Switzerland and Europe, which recommend 65 to 75, 67 to 78 and 67 to 77 cm from the floor respectively, also Fernandez (2007) who, quoting Ayoub (1973) recommended for men between 72.5 to 77.5 cm and from 68.75 to 73.75 cm. for women long soil-work surface. All these recommendations were generated based on the anthropometric population of their respective countries. In the Mexican nation, according to Prado (2009), there are a few research publications of anthropometric measurements with an ergonomic approach, there is one Mexico city by Sanchez Monroy, (no year of publication), another in the United States-Mexico border by Chen et. H., (1999) and one on school children in the Metropolitan Zone of Guadalajara, Jalisco of Prado et. H., (2001), the book Anthropometric dimensions of Latin American Population was published recently by Avila, et. al.(2007) which includes anthropometric information of the population of the city of Guadalajara, Jalisco, Mexico. Since there is no anthropometric data of the Mexican population, there are no published recommendations for the dimensions of chairs and work surface heights for workstations and furniture used in the classroom, including desks. In this situation, in most sections of the analysis results, the criteria published by Parcells, et. H. (1999), because recommendations are not based on anthropometric dimensions population but are recommendations percentage ranges of anthropometric dimensions of the user.

5.2 Analysis of relationship popliteal height and seat height
Parcells et. al. (1999) defined on the basis of existing research that, a mismatch in the height and popliteal height seating is provided for any seat whose height is> 95% or <88% of popliteal height of the subject. This allows a clear knee between 5% and 12% of popliteal height. Under this criterion it was found that 78.85% of all students in the sample show a disagreement between popliteal height and seat height of the desk. The latter exceeds in 97.6% of the cases the upper limit recommended. Also the author states that in order to determine how the results are sensitive to changes in the definition, using a stricter definition of a mismatch: seat height with> 99% or <80% of popliteal height. Under this new approach it was found that 76.92% of all students in the sample, show a disagreement between popliteal height and seat height of the table because the latter exceeds in all cases the upper limit set. With both approaches can be seen that there is a disagreement between the two dimensions because the seat height is desks beyond the upper limit.

5.3 Analysis of relationship buttock-popliteal length and seat depth
Just as in the previous analysis Parcells (1999) determined that a misalignment of the buttock-knee length and depth Seat is for any seat depth that is> 95% or <80% of the buttock-knee length of the subject Under this criterion it was found that 98.07% of all students in the sample, show a disagreement between their buttock-popliteal length and seat depth of the desk as the latter is smaller in 95.3% of the cases to the lower limit established. Also according to Parcells (1999), to determine how the results are sensitive to changes in the definition, using a stricter definition of a mismatch: seat depth> 99% or <80% of the length of the buttock-popliteal subject. Under this new approach the same percentage of mismatch was found in the implementation of the above criteria.

5.4 Analysis of relationship hip width and width of seat
There is no recommendation by Parcell (1999) in relation to the gap between hip width the seat width, however, Melo (2009) states: An important element in the magnitude of the pressure under the buttocks is the form of the supporting surface, a flat surface provides less contact for the exchange of muscular load while a curved surface (anatomical) allows a greater contact area and when containing the muscle mass prevents deformation was so there is more mass (more fiber), less traumatizing to the muscle, which causes the body to rest. In the literature there were found a number of recommendations, Mondelo (2002) recommends a seat higher than 48 cm. Fernandez (2007) recommends hips wide plus 5 cm., ISO 9241-5: 2003 indicates that the seat width must be greater than the width of the hips, ANSI / HFS indicate that should be 45 cm, Molenbroek et. H. (2003) recommended a seat width equivalent to 99 percentile value plus 15%. This study found that in 69.23% of the participants has a width of the hip over the 36 cm. that is the measure of the width of the seat which is a mismatch in any of the recommendations, the seat also has a curved surface that hip length exceeds the width of seat, the side edges of the same curvature, rather than being

a supporting surface to hold the muscles become edges that compress the thigh and buttock with the weight of the portion of hip width in excess of the seat. Moreover, the width of the table type seating is limited by the right side, for the support of the work table 4 cm. distant from the seat so the user, in most of the cases can not accommodate their hips as equidistant from the center of the seat.

5.5 Analysis of relationship elbow height at 90^0 and work surface height

As the analysis of the previous relationships we found that there are several recommendations in height ranges that working surfaces must have. For this investigation, and considering that there are not anthropometric measures of the population, using the recommendations made by Chaffin (1999) who notes that the table height should depend on the user's elbow height for what he recommends The height of the desk, the activity in writing, should be between 3 and 4 cm. above the elbow height of each person in a sedative position. Under this criterion the results are found in Table 2.

Table 2 Results of relationship Elbow height at 90^0-table height

	frequency	%	Table height
acceptable	12	23.08	Between the range
not acceptable	14	26.92	Very high
	4	7.69	Equal to of elbows height
	15	28.85	Slightly lower
	7	13.46	very low

6 CONCLUSIONS AND RECOMMENDATIONS

The results obtained in this investigation show that there is consistent evidence to conclude that the dimensions of the desks used by the Industrial Engineering students of the study population present a mismatch with the anthropometric characteristics of students and, considering that in some cases this mismatch is very strong, can be an important factor which influences the academic productivity of the same.

The main indicators of bad adjustment were:

- Over 60% of students had a mismatch with the seat height, the seat is too high.
- Over 98% of students had a mismatch with the depth of the seat, the seat is too short.
- The 69.23% of students had a length greater than the width of the hips of the seat, the seat is very narrow.
- In 77% of the cases the height of the table presents a mismatch, of these, 34.61% higher than what is recommended and 42.31% lower than recommended for the type of work being done.

Given the above findings and considering that this is a relatively small sample in relation to the size and diversity of environments within the University of Sonora is recommended to develop an anthropometric database of students on the basis of it, at the time of renewal of furniture, take into consideration this information either to gain adjustable furniture or possibly acquire, in size, three types of desks, large, medium and small so that students have the options and find the most suited to their anthropometry.

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