



Exoesqueletos, del laboratorio al medio laboral



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Agenda

- Tipos de exoesqueletos
- Literatura
- Ventajas
- Desventajas
- Conclusiones





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Exoesqueleto: definiciones

- Estructura o armazón artificial que recubre total o parcialmente el cuerpo de una persona y permite aumentar sus capacidades físicas.



Activos



Pasivos



- Primera patente relacionada con exoesqueleto en 1966.
- Primeros artículos en 1992 y 1999 enfocados a miembros superiores e inferiores.



Exoesqueletos

- Lo que inició como una alternativa para rehabilitación, ahora es una industria emergente que crece de manera exponencial como ayuda para realizar actividades industriales.



An Introduction to the Special Issue on *Occupational Exoskeletons*

Maury A. Nussbaum , Brian D. Lowe , Michiel de Looze , Carisa Harris-Adamson  & Marty Smets 

Pages 153-162 | Published online: 10 Jan 2020

 Download citation  <https://doi.org/10.1080/24725838.2019.1709695>

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Welcome to this special issue of the *IIE Transactions on Occupational Ergonomics and Human Factors*! Our primary motivation in developing this issue was the rapid emergence of exoskeleton technologies for occupational use. While exoskeletons have been developed and tested for some time for rehabilitation and military applications, it is only recently that technologies designed for occupational tasks have become available. Indeed, the number of exoskeletons intended for occupational use is increasing rapidly, from vendors and labs around the world. There are diverse

Related research

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Stefano Toxiri et al.

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Published online: 7 Aug 2019

[Exoskeletons for industrial application and their potential effects on physical work load](#) >

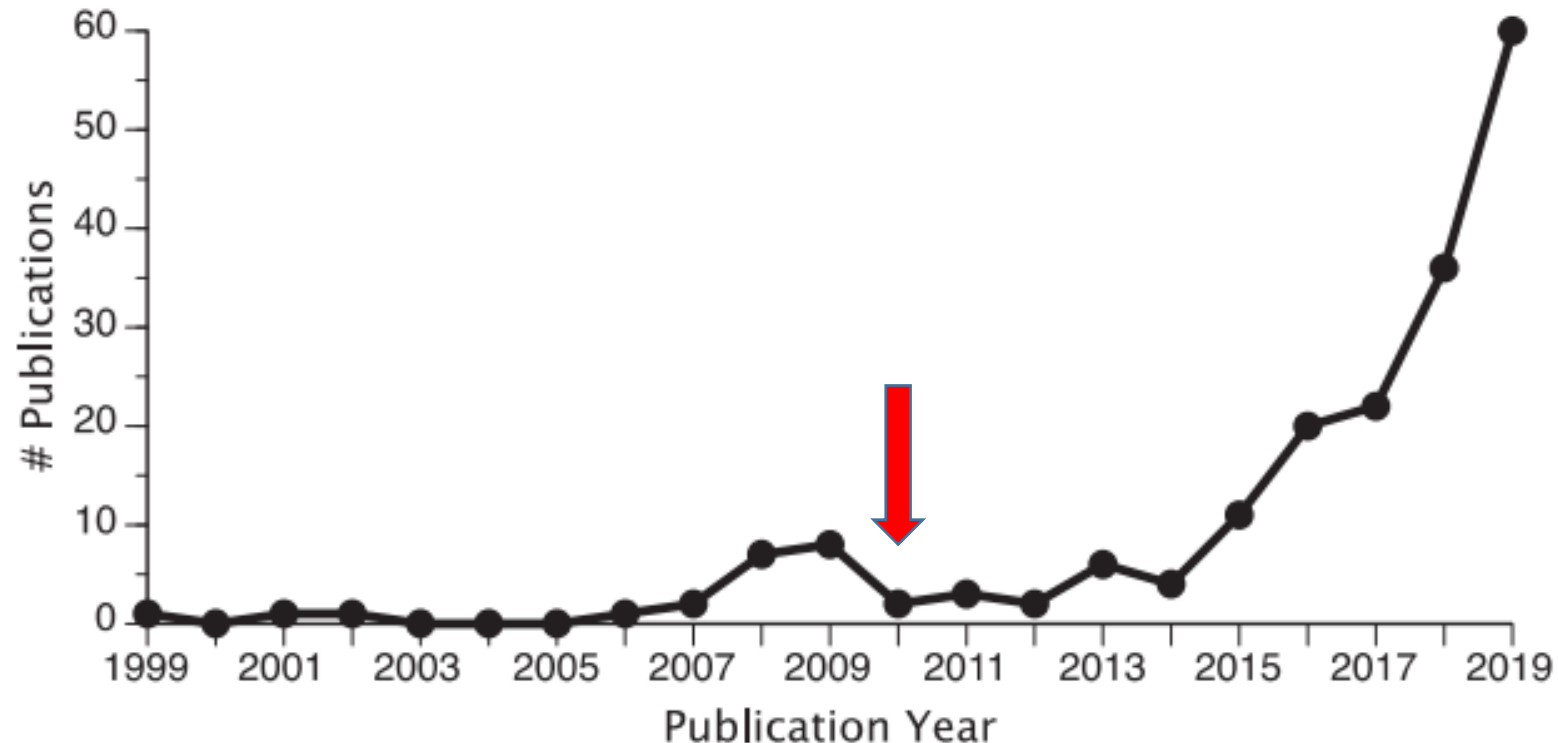
16 artículos publicados en el Special Issue

Dr. Maury Nussbaum



Publicaciones científicas relacionadas con exoesqueletos

- Artículos publicados por año
- Relevancia ocupacional
- Año 2019 incluye los artículos publicados en el Special Issue



Crecimiento exponencial del número de investigaciones

2018

13100

Aproximadamente 13,100 resultados (0.08 s)

Exoskeleton and end-effector robots for upper and lower limbs rehabilitation: narrative review

F Molteni, G Gasperini, [G Cannaviello](#), E Guanziroli - PM&R, 2018 - Elsevier

... Robotic **exoskeletons** for upper and lower limbs, based on ... of literature published on **exoskeleton** devices for upper and ... task, feedback from the **exoskeleton**, and fine motion ...

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Exoskeletons—a review of industrial applications

R Bogue - Industrial Robot: An International Journal, 2018 - emerald.com

... robotic **exoskeletons** that are aimed at industrial applications. ... According to ABI Research, the robotic **exoskeleton** market will ... robotic **exoskeleton** developments and their applications. ...

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Upper limb rehabilitation using robotic **exoskeleton** systems: a systematic review



2019

14200

Aproximadamente 14,200 resultados (0.09 s)

A review on lower limb rehabilitation **exoskeleton** robots

[D Shi](#), [W Zhang](#), [W Zhang](#), [X Ding](#) - Chinese Journal of Mechanical ..., 2019 - Springer

... prototypes of lower limb **exoskeleton** rehabilitation robots are ... of lower limb **exoskeleton** rehabilitation robot research. ... control of lower limb rehabilitation **exoskeleton** robots. From the ...

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Industrial **exoskeleton** technology: Classification, structural analysis, and structural complexity indicator

[A Voilqué](#), [J Masood](#), [JC Fauroux](#)... - 2019 Wearable ..., 2019 - ieeexplore.ieee.org

... Our literature review reveals 62 **exoskeleton** solutions with ... **exoskeleton**, a kinematic diagram and connectivity graph. We demonstrate this approach on five arm support **exoskeletons** ...

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Human-**exoskeleton** joint misalignment: A systematic review

[R Mallat](#), [M Khalil](#), [G Venture](#), [V Bonnet](#)... - ... on advances in ..., 2019 - ieeexplore.ieee.org

... **exoskeletons** are gaining increasing attention in both assistance and rehabilitation fields. The

2021

17100

Aproximadamente 17,100 resultados (0.08 s)

Hand **exoskeleton** systems, clinical rehabilitation practices, and future prospects

P Tran, [S Jeong](#), KR Herrin... - IEEE Transactions on ..., 2021 - [ieeexplore.ieee.org](#)

... and review of hand **exoskeleton** studies based on ... **exoskeletons** can successfully complete simple ADL tasks but lack the precision for fine motor control, 2) most hand **exoskeletons** ...

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Lower limb rehabilitation **exoskeleton** robot: A review

J Zhou, S Yang, Q Xue - Advances in Mechanical ..., 2021 - [journals.sagepub.com](#)

... hip joint **exoskeleton**, the flexible hip assistive **exoskeleton** with ... Developed a robotic hip **exoskeleton** called GEMS driven by ... The **exoskeleton** can improve the gait function of users and ...

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The influence of using **exoskeletons** during occupational tasks on acute physical stress and strain compared to no **exoskeleton**—A systematic review and meta ...

M Bär, [B Steinhilber](#), MA Rieger, T Luger - Applied Ergonomics, 2021 - Elsevier

2022

18500

Aproximadamente 18,500 resultados (0.07 s)

[HTML] Characterization and evaluation of human–**exoskeleton** interaction dynamics: A review

[S Massardi](#), [D Rodriguez-Cianca](#), [D Pinto-Fernandez](#)... - *Sensors*, 2022 - mdpi.com

... pressures) exchanged between a human and an **exoskeleton** during the execution of a task. Considering the recent and rapid growth of **exoskeletons** in the last year, we decided not to ...

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From sensing to control of lower limb **exoskeleton**: A systematic review

[Y Sun](#), [Y Tang](#), [J Zheng](#), [D Dong](#), [X Chen](#)... - *Annual Reviews in Control*, 2022 - Elsevier

... **exoskeletons** in recent years and studied the influences of different sensor signals and controller modeling on the **exoskeleton** ... comfort in lower limb **exoskeleton** control are discussed, ...

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An industrial **exoskeleton** user acceptance framework based on a literature review of empirical studies

[SA Elprama](#), [B Vanderborght](#), [A Jacobs](#) - *Applied ergonomics*, 2022 - Elsevier

... **exoskeletons**. Also, our framework can be used to study the ongoing introduction of **exoskeletons** ... policy decisions companies interested in implementing **exoskeletons** should consider. ...

☆ Guardar  Citar Citado por 81 Artículos relacionados Las 5 versiones

Personalizing **exoskeleton** assistance while walking in the real world

[P Slade](#), [MJ Koebender](#), [SL Delo](#), [SH Collins](#) - *Nature*, 2022 - nature.com

2023

18900

Aproximadamente 18,900 resultados (0.07 s)

[HTML] Optimizing **exoskeleton** design with evolutionary computation: An intensive survey

[F Stroppa](#), [A Soylemez](#), [HT Yuksel](#), [B Akbas](#), [M Sarac](#) - Robotics, 2023 - mdpi.com

... , and we argue that such methods are widely used in **exoskeleton** design and control. ... studies for **exoskeleton** design. We compare the state of the art in designing **exoskeletons** based ...

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Opportunities and challenges in the development of **exoskeletons** for locomotor assistance

[C Sivi](#), [LM Baker](#), [BT Quinlivan](#)... - Nature biomedical ..., 2023 - nature.com

... key advances in **exoskeleton** technology in the early twenty-first century and highlight recent **exoskeleton** designs, offering clinical insight into how **exoskeletons** can improve gait ...

☆ Guardar ⓘ Citar Citado por 148 Artículos relacionados Las 15 versiones

[HTML] Side-effects and adverse events of a shoulder-and back-support **exoskeleton** in workers: A systematic review

[SE Kranenborg](#), [C Greve](#), [MF Reneman](#)... - Applied ergonomics, 2023 - Elsevier

... **exoskeletons** used in this review: a full body **exoskeleton** with a supernumerary arm and a



2024

20,600

Aproximadamente 20,600 resultados (0.08 s)

Experiment-free **exoskeleton** assistance via learning in simulation

[S Luo](#), [M Jiang](#), [S Zhang](#), [J Zhu](#), [S Yu](#)... - Nature, 2024 - nature.com

... **Exoskeletons** have enormous potential to improve human ... -aware musculoskeletal and **exoskeleton** models and data-driven ... on a custom hip **exoskeleton** that automatically generates ...

☆ Guardar  Citar Citado por 44 Artículos relacionados Las 18 versiones

Interactive control of lower limb **exoskeleton** robots: A review

[YP Zhang](#), [GZ Cao](#), [LL Li](#), [DF Diao](#) - IEEE Sensors Journal, 2024 - ieeexplore.ieee.org

... a rigid dynamic **exoskeleton** with at least one active joint. In contrast to soft **exoskeletons** [43], [44] and unpowered **exoskeletons** [45], [46], dynamic **exoskeletons** can provide users with ...

☆ Guardar  Citar Citado por 17 Artículos relacionados Las 2 versiones

AI-based methodologies for **exoskeleton**-assisted rehabilitation of the lower limb: a review

[O Coser](#), [C Tamantini](#), [P Soda](#), [L Zollo](#) - Frontiers in Robotics and AI, 2024 - frontiersin.org

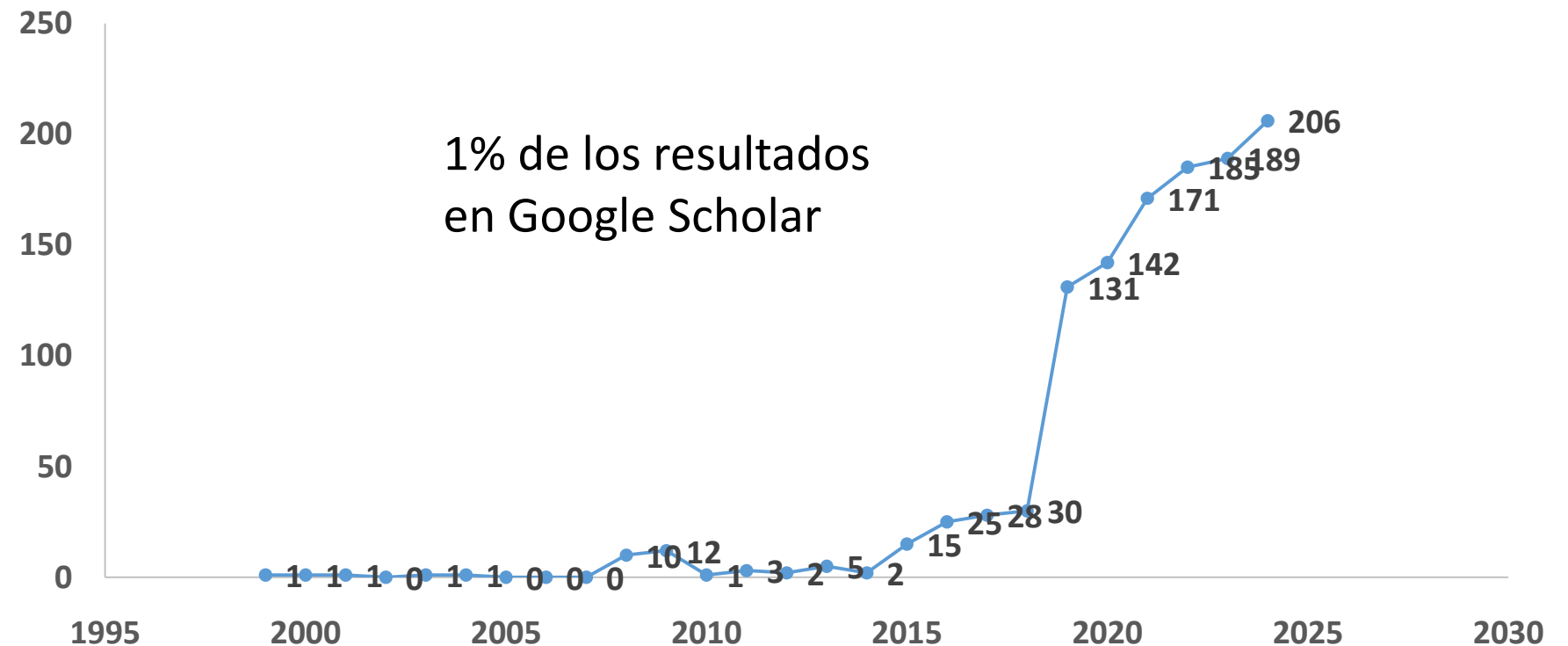


Publicaciones relacionadas con exoesqueletos enfocadas en estudios ocupacionales

Crecimiento constante de la investigación relacionada con exoesqueletos.

Nacimiento y consolidación de una industria en constante cambio

Estimación del número de artículos publicados con relevancia ocupacional



Otros números especiales



Impact Factor: 2.9 / 5-Year Impact Factor: 3.8

 Free access | Editorial | First published online May 1, 2020

Introduction to the *Human Factors* Special Issue on User-Centered Design for Exoskeleton

[Kermit G. Davis](#) , [Christopher R. Reid](#), [...], and [Delia Treaster](#)  [View all authors and affiliations](#)

[Volume 62, Issue 3](#) | <https://doi.org/10.1177/0018720820914312>

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A special issue of *Sensors* (ISSN 1424-8220). This special issue belongs to the section "**Physical Sensors**".

Deadline for manuscript submissions: **closed (31 May 2023)** | Viewed by 20492



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A special issue of *Applied Sciences* (ISSN 2076-3417). This special issue belongs to the section "**Robotics and Automation**".

Deadline for manuscript submissions: **closed (30 April 2023)** | Viewed by 33174

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Special Issue on Wearable Robotics and Assistive Technology

Publisher: IEEE

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Daniel P. Ferris  ; Kara Mcarthur [All Authors](#)

1

Cites in
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Abstract

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Abstract:

This special issue highlights some of the best work presented at the 4th International Symposium on Wearable Robotics (WeRob2018), held October 16–20, 2018, in Pisa, Italy. The papers focus on new technologies in the areas of neural interfaces, soft wearable robots, sensor and actuator technologies, and robotic exoskeletons. Based

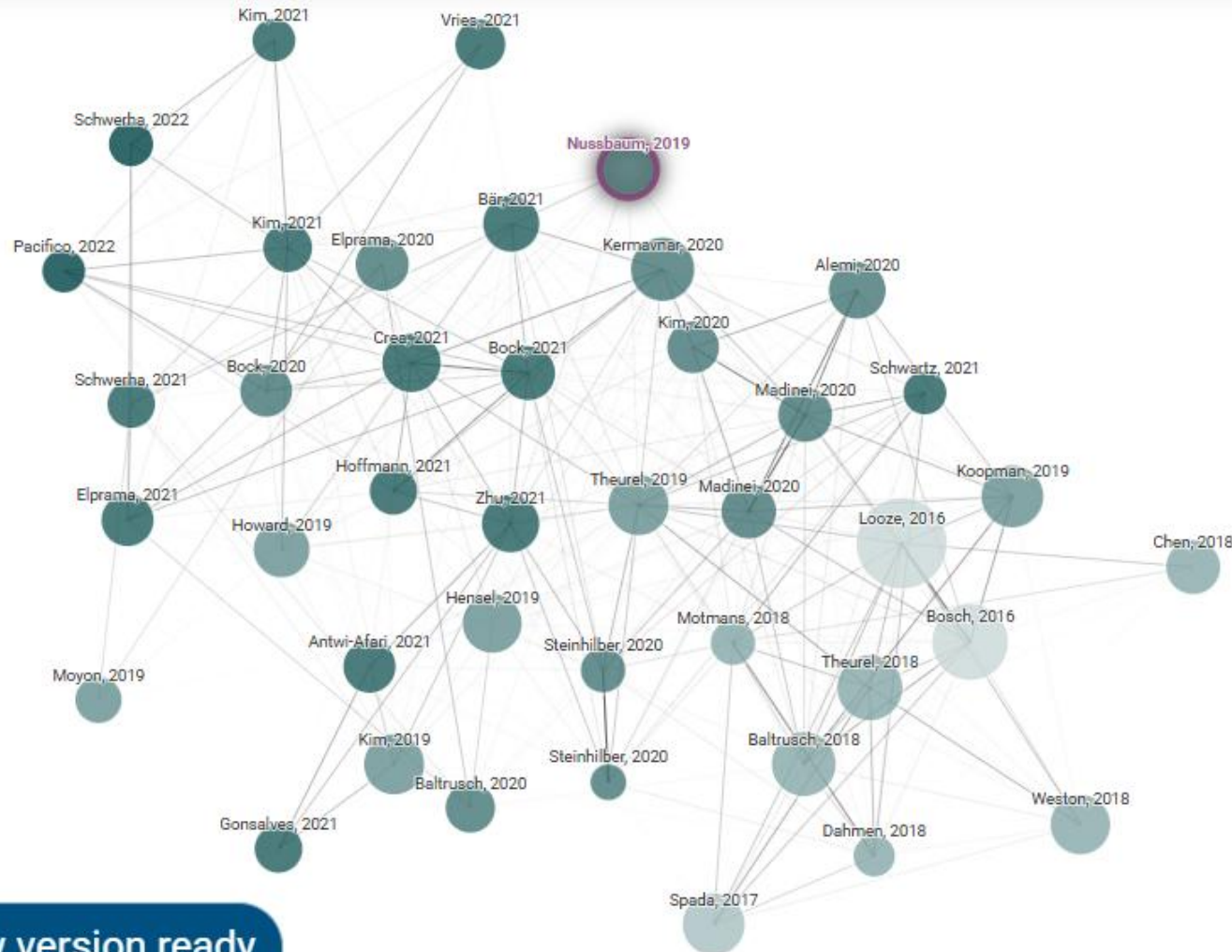
Dr. Juan Luis Hernández Arellano



An Introduction to the Special Issue on *Occupational Exoskeletons*

Autores	Maury A Nussbaum, Brian D Lowe, Michiel de Looze, Carisa Harris-Adamson, Marty Smets
Fecha de publicación	2019/10/2
Origen	IISE Transactions on Occupational Ergonomics and Human Factors
Volumen	7
Número	3-4
Páginas	153-162
Editor	Taylor & Francis
Descripción	As noted, the contributions provided in this issue are quite diverse. As an approach to presenting these contributions, integrating them into the broader state of knowledge, and sharing our own collective impressions and opinions, we offer the following discussion on the broad topics of “The Past,” “The Present,” and “The Future” of occupational exoskeletons. In the former, we summarize some of the major historical developments in this area, as well as the specific contributions provided by review papers in this issue. Subsequently, we highlight the contributions of several of the papers here that have expanded the state-of-the art in terms of testing and evaluation methods, and that have provided important new evidence regarding the potential benefits and limitations of the occupational use of exoskeletons. Many of the authors here also provide interesting indications of where they think future developments can and ...
Citas totales	Citado por 116

Connected papers



An Introduction to the Special Issue on Occupational Exoskeletons

M. Nussbaum + 3 authors M. Smets

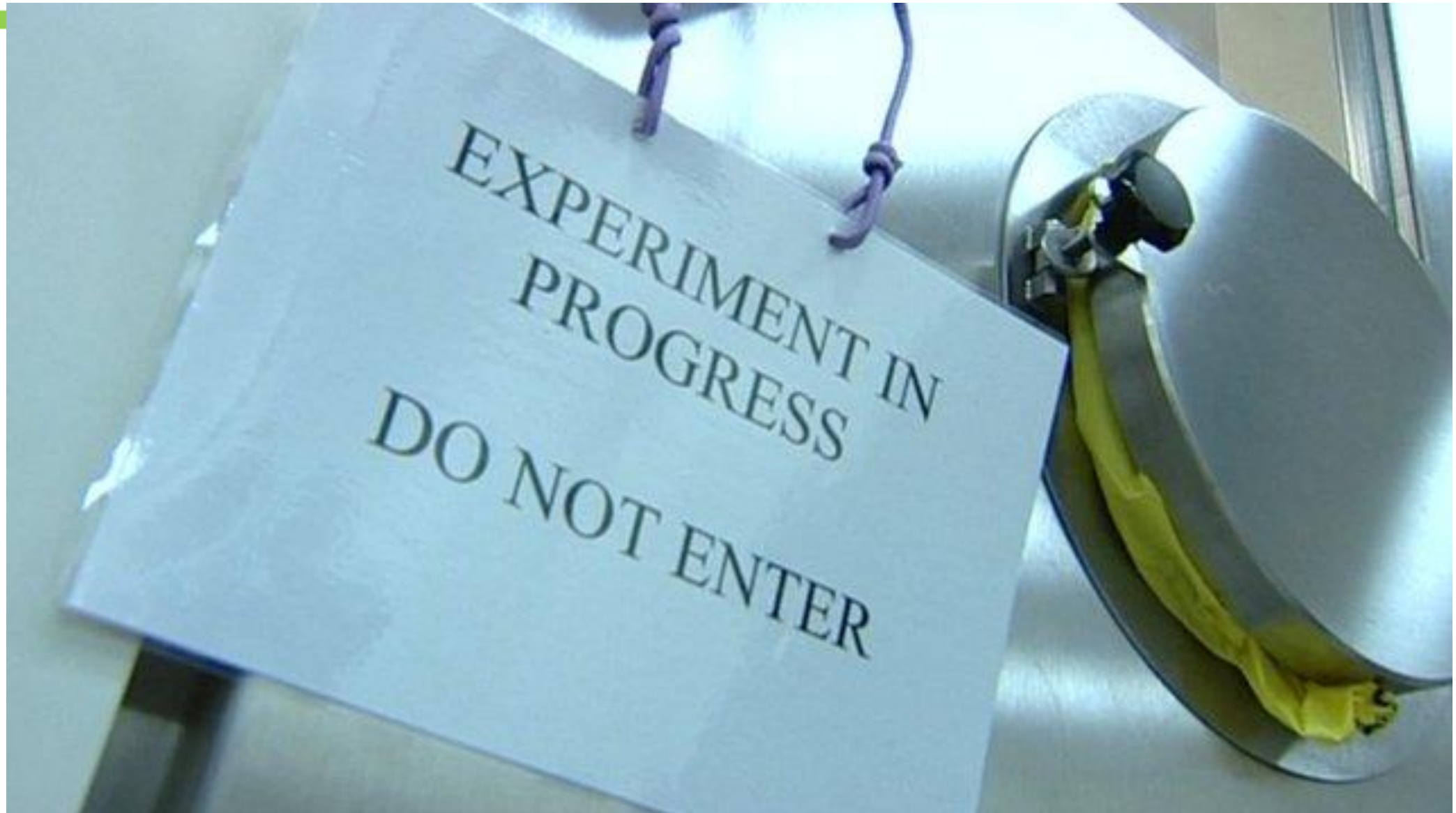
2019, IISE Transactions on Occupa...

69 Citations

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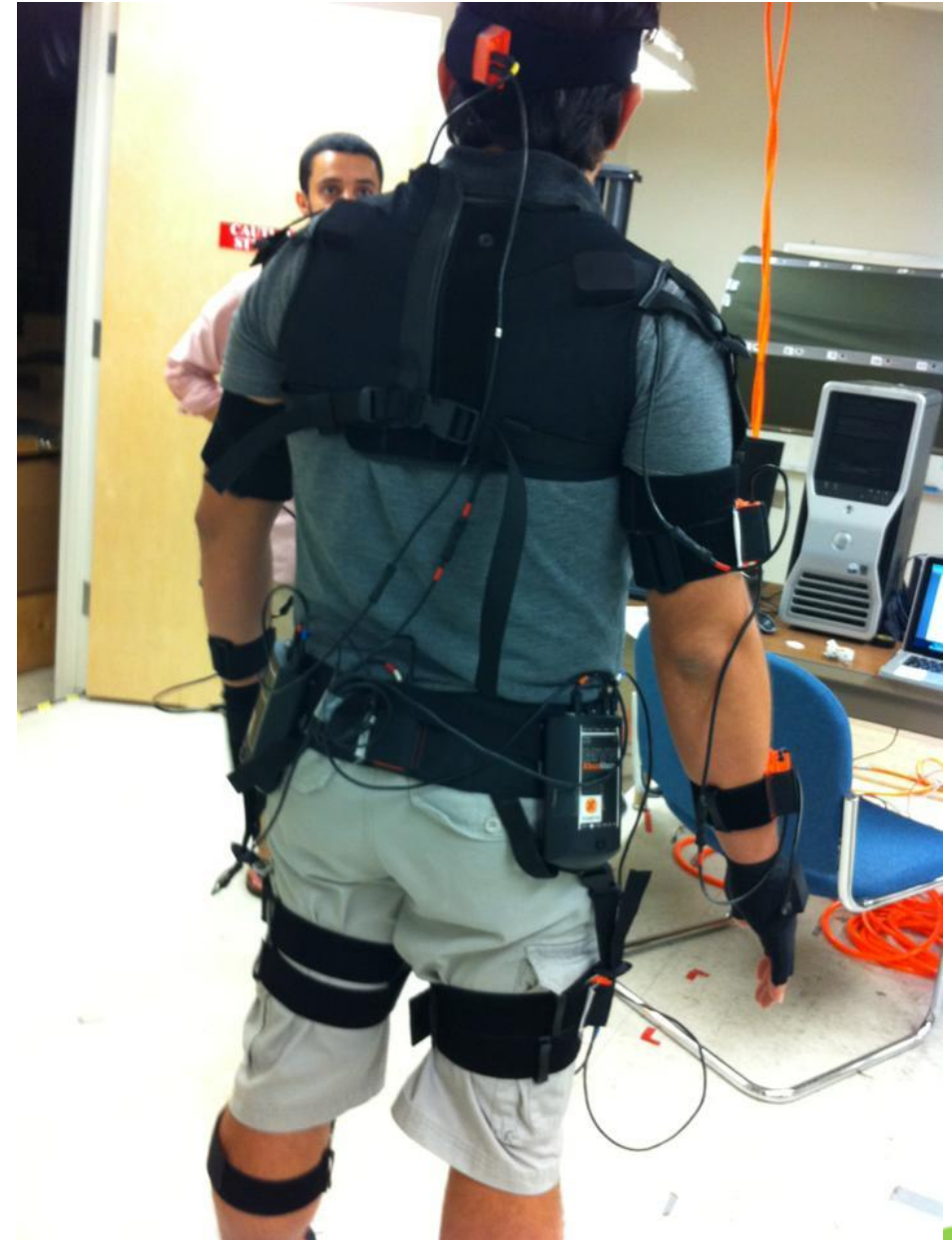
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Maury A. Nussbaum , Brian D. Lowe ,
Michiel de Looze , Carisa
HarrisAdamson and Marty Smets
Department of Industrial and Systems
Engineering, Virginia Tech, Blacksburg,
VA, USA; National Institute for
Occupational Safety and Health,
Cincinnati, OH, USA; TNO, Leiden, The
Netherlands; Occupational and



Laboratorio (ventajas)

- Condiciones controladas
- Condiciones óptimas
- Decido qué variables estimular
- Mido/registro las variables
- Se cuenta con estudiantes
- Genero e interpreto datos
- Ética
- Experimento



Laboratorio (desventajas)

- Tiempo de simulación es limitado (20 min de simulación es una vida)
- No se cuenta con trabajadores
- Se cuenta con estudiantes
- Requiere de mucho tiempo de planeación
- Requiere de mucho tiempo de post proceso de datos









Comentarios de los participantes en laboratorio

- Siento menos peso/no sentí el peso (miembros superiores)
- Me ayuda a levantar
- Hombres: neutralizó el peso
- Mujeres: puedo terminar la prueba, sin el exo no llego a la mitad
- Siento más seguridad
- Siento la espalda derecha
- Debe mejorar la comodidad
- Con el exo terminé el recorrido



Comentarios de los trabajadores

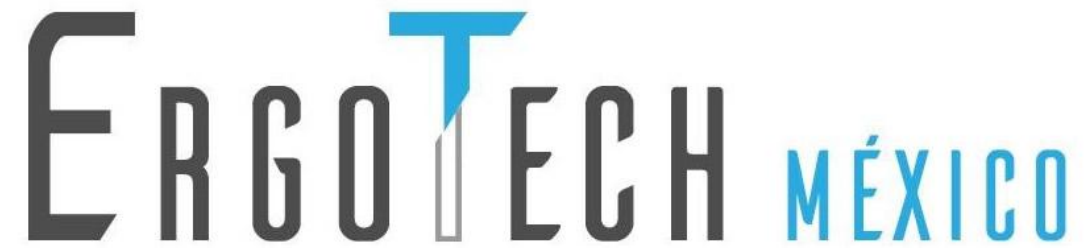
- Genera expectativa
- Trabajadores jóvenes lo usan
- Trabajadores mayores no lo usan
- No te lo lleves, déjalo conmigo
- No lo usaría todo el turno, empezaría el turno sin el equipo y a media jornada me lo pondría.
- Sentí calor (levantamientos en ligares específicos)



Conclusiones

- Seguiremos trabajando en el desarrollo de exoesqueletos
- Con la implementación de nuevos materiales, los pesos disminuyen y el confort aumenta
- Los estudios en laboratorio deben considerar mas variables y mas tiempo de simulación
- Llevar trabajadores al laboratorio





¡Gracias!

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