ISSN: 1692-7257 - Volume 2 – Number 46 - 2025

RCTA
Revista Colombiana de Tecnologías de Avanzada
UNIPAMPLONA

Digital Object Identifier: 10.24054/rcta.v2i46.3783

Passive and customized standing technologies: a bibliometric analysis of their global development and contributions from Latin America

Tecnologías pasivas y personalizadas de bipedestación: análisis bibliométrico de su desarrollo global en busca de aportes desde América Latina

MSc. Harold Alberto Rodríguez Arias[1], PhD. Julio Cesar Rodríguez Ribón[2]

[1] ***Universidad Tecnológica de Bolívar,*** *Programa de Ingeniería Mecatrónica, Cartagena, Bolívar, Colombia.*
[2] ***Universidad de Cartagena,*** *Facultad, Departamento de Ingeniería de Sistemas, Cartagena, Bolívar, Colombia.*

Correspondence: *harias@utb.edu.co*

Received: *january 24, 2025.* ***Accepted:*** *june 21, 2025.* ***Published:*** *july 01, 2025.*

How to cite: *H. A. Rodríguez Arias and J. C. Rodríguez Ribón, "Passive and customized standing technologies: a bibliometric analysis of their global development and contributions from Latin America", RCTA, vol. 2, no. 46, pp. 22–31, Jul. 2025. Recovered from https://ojs.unipamplona.edu.co/index.php/rcta/article/view/3783*

Abstract: This article presents a bibliometric analysis of the scientific landscape surrounding passive and anthropometrically personalized standing technologies, with a focus on their global evolution and the notable lack of contributions from Latin America. Based on a systematic review of 435 peer-reviewed articles indexed in Scopus, IEEE Xplore, and Google Scholar between 2010 and 2025, the study applied thematic, geographic, and anthropometric customization filters. Findings indicate a highly concentrated body of research in Asia and Europe, with leading contributions from the University of Tsukuba and EPFL. Moreover, the analysis reveals a persistent gap in integrative approaches that bridge technical design with user-specific adaptation. No Latin American publications met the combined inclusion criteria, highlighting the urgent need to establish a regional research agenda aimed at developing accessible, user-tailored, and contextually relevant assistive standing technologies that address the region's specific ergonomic and socio-cultural demands.

Keywords: passive standing, anthropometric personalization, assistive technologies, bibliometric analysis, Latin America.

Resumen: Este artículo presenta un análisis bibliométrico del desarrollo científico relacionado con tecnologías pasivas y personalizadas de bipedestación, con énfasis en su evolución global y la ausencia de contribuciones desde América Latina, a partir de la revisión de 435 artículos indexados en Scopus, IEEE Xplore y Google Scholar (2010–2025), se aplicaron filtros temáticos, geográficos y de personalización antropométrica. Los resultados evidencian una producción altamente concentrada en Asia y Europa, liderada por la Universidad de Tsukuba y la EPFL, y una marcada ausencia de enfoques integradores entre diseño técnico y adaptación al usuario, no se identificaron artículos latinoamericanos ni estudios que combinen simultáneamente los criterios analizados, por lo que se concluye la necesidad de impulsar una agenda científica regional que promueva tecnologías asistivas accesibles, personalizadas y contextualizadas, respondiendo a las necesidades ergonómicas y sociales propias de la región.

Palabras clave: bipedestación pasiva, personalización antropométrica, tecnologías asistivas, análisis bibliométrico, América Latina.

1. INTRODUCTION

Standing is an essential function that directly influences individuals' autonomy, quality of life, and social inclusion. For people with motor disabilities—particularly wheelchair users—assistive devices that support the transition from sitting to standing are a critical resource [1], [2]. Although the development of powered exoskeletons has progressed significantly at the global level [3], their high cost, technological complexity, and limited accessibility constrain their adoption in regions such as Latin America [4], [5].

In this context, passive standing mechanisms emerge as viable alternatives due to their structural simplicity, low manufacturing cost, and ease of maintenance [2]. However, their effectiveness depends on ergonomic design that takes into account the user's individual anthropometric characteristics. In Latin America, where resources allocated to assistive technologies are limited, the development of customized passive devices could represent a key strategy to improve access to mobility solutions [1], [3].

Currently, the extent of research on passive standing mechanisms within the Latin American context is not well known. The lack of studies that integrate both the technological perspective and the local anthropometric specificities highlights a significant gap in the field of assisted rehabilitation [6], [7], [8].

This article aims to analyze the current state of research on passive standing mechanisms through a bibliometric study based on specialized databases, to identify the main trends and highlight opportunities for technological innovation in Latin America, emphasizing the need for personalized and accessible approaches in the design of these devices [9], [10], [11].

2. METHODOLOGY

This study adopts an exploratory bibliometric approach with the aim of characterizing the current state of research on passive standing mechanisms [12]. This approach is grounded in the principles of mixed methods studies, which allow for the integration of quantitative and qualitative data to provide a more robust understanding of the phenomenon under investigation [13], as well as to identify opportunities for technological development in the Latin American context. The global scientific output related to passive devices, anthropometric customization, and assistive technologies applied to the sit-to-stand transition was analyzed.

2.1. Sources of Information

To ensure broad and diverse coverage of the available literature, three databases with complementary characteristics were selected:

- **Scopus:** due to their interdisciplinary nature and extensive coverage of high-impact indexed scientific journals [14], [15], particularly in the fields of engineering, health, and technology.

- **IEEE Xplore:** for their specialized focus on electrical engineering, robotics, biomechanics, and intelligent systems, including numerous articles on exoskeletons and assistive technologies [16], [17].

- **Google Scholar:** for their usefulness in locating grey literature and studies not always indexed in traditional databases [18], including theses, regional conference proceedings, technical reports, and publications in Spanish [19].

This combination made it possible to capture both high-quality formal publications and emerging or non-traditional evidence relevant to the Latin American context.

2.2. Search Strategy

Search queries were formulated using Boolean operators (AND, OR) to combine key terms related to the subject of study. These searches were conducted between March and April 2025, using the following combinations [20]:

- ("Passive exoskeleton" OR "passive assistive device") AND ("bipedal stance" OR "sit-to-stand")
- ("Bipedal stance" AND "anthropometry" AND "customization")
- ("Assistive technology" AND "Latin America" AND "passive mechanism")

2.3. Inclusion and exclusion criteria

- **Inclusion Criteria:** Publications addressing passive assistive mechanisms, personalized design, ergonomics, applied anthropometry, or technologies for standing support, as well as studies related to rehabilitation, assisted mobility, or the design of physical devices [10], [21], [22].
- **Exclusion Criteria:** General reviews on active exoskeletons or non-passive technologies, studies not available in full text, or those focused exclusively on simulations unrelated to standing support [23], [24], [25].

2.4. Data Processing and Analysis

The results were organized into frequency tables and thematic summaries, and classified according to the source database, the number of results per search query, and their geographic distribution [21], [22]. To explore the relationships among key terms, authors, and institutions, the Data Analyst tool—a GPT designed for data analytics—was used to generate term maps and co-occurrence networks [27], [28].

***Table 1:** Number of Publications Retrieved per Search Equation in Each Database*

Search Equation	Scopus	IEEE Xplore	Google Scholar	Google Scholar (Spanish)
("Passive exoskeleton" OR "passive assistive device") AND ("bipedal stance" OR "sit-to-stand")	9	4	412	3
("Bipedal stance" AND "anthropometry" AND "customization")	0	0	5	0
("Assistive technology" AND "Latin America" AND "passive mechanism")	0	0	2	0

***Source:** Own elaboration*

Table 1 presents the number of publications retrieved per search equation and by database. This visualization highlights both well-established research lines and those that remain underexplored in the region [29].

Finally, a qualitative review of the selected articles was conducted, with emphasis on approaches to anthropometric customization, type of assistive application, and the presence or absence of studies focused on Latin America [20], [30].

3. BIBLIOMETRIC ANALYSIS

The bibliometric analysis was based on the integration of three main sources: Scopus, IEEE Xplore, and Google Scholar [31]. A total of 435 unique records were compiled, from which specific filtering criteria were applied to identify those most relevant to passive standing mechanisms, anthropometric customization, and Latin American relevance [32].

3.1. Application of filtering criteria

A cada artículo se le aplicaron cuatro criterios evaluativos:

- **Technical Filter (F_Technical)**: Presence of terms such as passive exoskeleton, bipedal stance, sit-to-stand, or passive assistive device [33], [34].
- **Regional Filter (F_Latam)**: Explicit mention of Latin America or countries in the region.
- **Customization Filter (F_Custom)**: Presence of terms such as customization, anthropometry, or ergonomics [35], [36].
- **Temporal Filter (F_YearRange)**: Publications between the years 2010 and 2025 [11], [14].

***Table 2:** Summary of Filtering Combinations*

F_Technical	F_Latam	F_Custom	F_Year Range	No. papers
FALSE	FALSE	FALSE	FALSE	143
FALSE	FALSE	FALSE	TRUE	211
TRUE	FALSE	FALSE	FALSE	45
TRUE	FALSE	FALSE	TRUE	31
FALSE	FALSE	TRUE	TRUE	2

***Source:** Authors' own elaboration*

As shown in Table 2, most of the articles meet only one or two criteria at most. Specifically, 211 articles were identified within the defined time range, and 45 with a technical focus—for example, the work by Umar et al. (2022) [37] on the design of exoskeletons for individuals with paraplegia.

However, none of the combinations explored simultaneously meet three or more criteria, not even the intersection between technical focus and anthropometric customization. This finding reveals a significant fragmentation in literature, where studies tend to address isolated components but lack a comprehensive approach [31], [32] that integrates technological dimensions, geographic context, and user adaptation in the development of passive standing technologies [38].

3.2 Temporal Evolution and Concentration by Database

The distribution of relevant articles by year shows a steady output between 2016 and 2025, with peaks in 2018 and 2022. Most publications come from Scopus and Google Scholar, while IEEE has the lowest volume but the highest thematic precision.

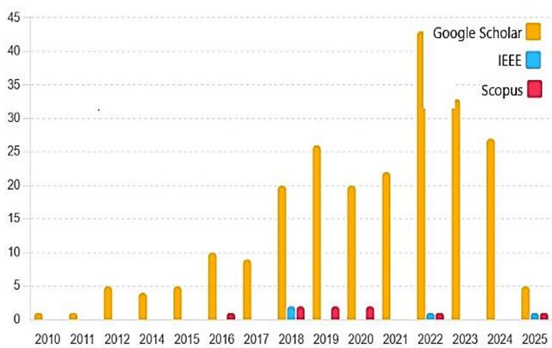

Fig. 1*. Annual evolution of relevant publications (2010–2025).*

Figure 1 shows that academic output on passive standing mechanisms has been increasing since 2016, with notable peaks in 2018 and 2022 [31]. Google Scholar accounts for the highest volume of publications, partly due to its coverage of grey literature, while Scopus and IEEE contain fewer entries but are more thematically aligned with the design and application of assistive technologies [7].

3.3 Analysis by authors, institutions, and countries

The most frequently cited authors were Kadone H., Suzuki K., and Granados-Páez D.F., primarily affiliated with the University of Tsukuba (Japan). Other prominent institutions were in China, South Korea, Germany, and the United States [39], [40]. Table 3 presents a consolidated analysis of the institutions that contribute most significantly to the development of passive standing mechanisms, revealing a highly centralized concentration. The University of Tsukuba (Japan) leads by a wide margin, followed by EPFL (Switzerland), both of which have well-established research lines in assistive robotics and advanced ergonomics [35], [41]. The remaining contributions come mainly from Asian institutions with strong traditions in mechanical engineering, particularly in China [42]. This scenario reflects a clear hegemony in scientific production, entirely disconnected from the Latin American context, underscoring the critical need to promote research within the region to develop solutions adapted to its anthropometric, economic, and social realities.

Table 3*. Leading institution*

Institución	País	No paper
University of Tsukuba	Japan	8
EPFL – Swiss Federal Institute of Technology	Switzerland	2
Xi'an Jiaotong University – College of Mechanical & Electrical Engineering	China	1
Xi'an University of Science and Technology – College of Mechanical Engineering	China	1
KAIST – Korea Advanced Institute of Science and Technology (Daejeon)	South Korea	1

Source: *Authors' own elaboration*

3.4 Thematic analysis by keywords

Among the most frequent terms were: sit-to-stand, lower-limb exoskeleton, postural control, mobility support, and ergonomic optimization [11]. No combinations were found with terms such as Latin America or custom anthropometry.

Figure 2 presents a word cloud generated from the textual analysis of articles with a technical focus on passive mechanisms. The most prominent terms—such as 'stand,' 'mobility,' 'support,' 'exoskeleton,' 'ergonomic,' and 'control'—clearly reflect the predominant interest in devices designed to assist postural transitions [43] and optimize mobility for users with physical limitations. These concepts point to developments centered on structural body support, particularly in the lower limbs.

It is worth noting the complete absence of terms related to the Latin American context or to anthropometric customization, which reinforces the evidence of a lack of contextualized studies adapted to the region's bodily and socioeconomic diversity [44]. This semantic and thematic gap highlights a clear opportunity to guide future research toward inclusive design and technological localization [45].

RCTA
Revista Colombiana de Tecnologías de Avanzada
UNIPAMPLONA

***Fig. 2**: Keyword cloud in technical articles on passive mechanisms*

3.5 Latin American Presence

Despite the total volume of articles reviewed, no study was identified with:

- Latin American institutional affiliation.
- Morphological analysis based on local populations.
- Publication in Spanish addressing passive standing mechanisms.

Only two peripheral studies were identified in Colombia and Peru, related to rehabilitation or assisted mobility [46], but without a direct connection to customized passive devices. This finding reinforces the conclusion regarding the regional gap in this line of research.

4. DISCUSSION

4.1 Thematic fragmentation and lack of integration

The results of the bibliometric analysis reveal significant fragmentation in the literature on passive standing mechanisms [47]. Although 45 articles with a technical focus were identified, none simultaneously combined this focus with anthropometric customization or regional context, indicating a lack of comprehensive approaches [48]. The finding that only 41 articles specifically address postural transition or bipedal stance confirms that this subtopic represents the dominant core; however, it is approached in an isolated and technical manner, without consideration of user-specific ergonomic variables [49].

4.2 Geographic concentration of scientific production

The institutional analysis revealed that scientific production is highly concentrated in a few academic hubs located in Asia and Europe [50]. The University of Tsukuba (Japan) leads by a wide margin in the number of publications, followed by EPFL (Switzerland) and a few Chinese and South Korean institutions with only a single publication each [51]. No Latin American institution was identified as having made relevant contributions to the topic, highlighting a critical absence of regional participation in the development of passive assistive technologies [52].

4.3 Latin American gap: a challenge and an opportunity

The absence of institutions, articles, or collaborations from Latin America reveals a structural gap in knowledge generation within this field. This situation not only limits regional technological advancement but also perpetuates dependence on imported solutions, which do not always address the ergonomic, anthropometric, or socioeconomic needs specific to Latin American countries [53], nor the psychosocial impact associated with the use of non-adapted technologies [54]. Nevertheless, this deficiency represents a strategic opportunity to establish locally driven research lines, adapted to the regional context and oriented toward inclusion, personalization, and sustainability.

4.4 Misalignment between technology and user adaptation

The semantic analysis of the articles revealed a clear predominance of functional terms such as support, mobility, exoskeleton, and ergonomic, with no significant presence of concepts related to personalization, custom anthropometry, or contextual design. This confirms that current developments prioritize structural functionality over individual adaptability, limiting their applicability to populations with diverse morphologies or specific disability conditions—including preventable clinical risks such as pressure ulcers [55], [56]. This misalignment represents a critical gap that must be addressed in future interdisciplinary research.

4.5 The need for a regional scientific agenda

In light of this scenario, there is an urgent need to establish a Latin American research agenda that integrates technical design, anthropometric customization, and sociocultural context. This agenda should promote the development of low-cost, ergonomically adaptable passive mechanisms, with a focus on the realities of local users [57].

Additionally, it could foster collaboration among universities, rehabilitation centers, and technology sectors to advance toward scientific and technological autonomy in the field of postural assistance.

5. CONCLUSIONS

This bibliometric and thematic study has systematically identified the current state of the scientific literature on passive standing mechanisms, with an emphasis on their integration with anthropometric customization and regional context.

The results reveal a scientific output highly concentrated in a small group of institutions, with the University of Tsukuba (Japan) as the dominant contributor, followed by EPFL (Switzerland) and several Asian university centers. In contrast, no participation from Latin American institutions was identified, highlighting a concerning absence in the development of assistive technologies adapted to local realities.

A considerable thematic fragmentation was also observed: studies tend to focus on purely technical or biomechanical aspects, such as the sit-to-stand transition and structural assistance, without accounting for users' anthropometric variability or their environment. The lack of proposals that integrate personalization and context limits the real-world applicability of the developed devices and excludes populations with specific needs, such as those in Latin America.

This scenario highlights the urgent need to promote interdisciplinary and locally relevant research that integrates engineering, ergonomics, rehabilitation, and user-centered design. It underscores the importance of establishing a Latin American scientific agenda to address the design of passive standing mechanisms from a comprehensive, inclusive, and sustainable perspective.

6. CLOSING REMARKS AND FUTURE OUTLOOK

This study not only reveals thematic and geographic concentration in research on passive standing mechanisms but also clearly exposes a structural gap in Latin American scientific participation. This absence should not be viewed solely as a deficiency, but rather as a strategic opportunity for the region: the possibility of leading initiatives that integrate accessible technology, anthropometric customization, and contextual sensitivity.

In the face of Asian and European hegemony in this field, it becomes essential to develop a regional research agenda that integrates biomedical engineering with human movement sciences, ergonomics, and inclusive design. Such an agenda would not only help reduce external technological dependence but also generate relevant, culturally adapted solutions tailored to the realities of Latin American users, who continue to face barriers in mobility, rehabilitation, and postural autonomy.

Researchers, universities, and healthcare centers in Latin America are thus invited to fill this gap with leadership and an interdisciplinary vision, actively contributing to a field of high social, scientific, and technological relevance.

ACKNOWLEDGMENTS

Special recognition is given to the Universidad Tecnológica de Bolívar (UTB), whose institutional and financial support was fundamental to the development and international projection of this research. Gratitude is also extended to the Universidad de Cartagena for its valuable academic and financial support, which made the research stay at the University of Tsukuba (Japan) possible.

A heartfelt acknowledgment is also extended to the University of Tsukuba for its generous hospitality, for granting access to its specialized laboratories, and for providing a highly collaborative research environment—essential to the progress achieved in anthropometric data modeling, simulation, and analysis.

Finally, I wish to express my deepest gratitude to my wife Karen and my daughter Manuela, who—despite the distance between Colombia and Japan—provided unwavering emotional support throughout the research stay. Their constant presence, though physically and geographically distant, was a fundamental pillar during the most demanding academic moments. Beyond emotional companionship, their love and resilience directly inspired the creation of the Humanic Kinematic Motion (HKM) module, conceived as a way to translate into technology the desire to improve the quality of life of those who face physical barriers, with the same determination and sensitivity that define our family bond.

REFERENCES

[1] A. Jiménez, C. Grisales, J. S.-E. I. de, y undefined 2019, “Diseño de un sistema cerebro-máquina de miembro superior para la asistencia a la rehabilitación de personas con accidente cerebro-vascular”, *acofipapers.org*, Consultado: el 27 de abril de 2025. [En línea]. Disponible en: https://acofipapers.org/index.php/eiei/article/view/277

[2] M. Garabini *et al.*, “A fully soft and passive assistive device to lower the metabolic cost of sit-to-stand”, *frontiersin.org*, vol. 8, ago. 2020, doi: 10.3389/FBIOE.2020.00966/FULL.

[3] L. P. Quinto, S. B. Gonçalves, y M. T. Silva, “Design of a passive exoskeleton to support sit-to-stand movement: A 2D model for the dynamic analysis of motion”, *Springer*, vol. 22, pp. 299–303, 2019, doi: 10.1007/978-3-030-01887-0_57.

[4] A. Jimenez, A. B.-R. IngEam, y undefined 2018, “Sistemas para la ayuda en la recuperación y la rehabilitación del ACV”, *app.eam.edu.co*, 2018, Consultado: el 27 de abril de 2025. [En línea]. Disponible en: http://app.eam.edu.co/ojs/index.php/ingeam/article/view/219

[5] E. Gerber, “A Biomechanist’s Guide to Defying Gravity: An Exploration of the Physiological Link between Sensorineural Function and Postural Control”, 2022, Consultado: el 27 de abril de 2025. [En línea]. Disponible en: https://search.proquest.com/openview/51e9acb790b3bb43bf66532164f8aa1b/1?pq-origsite=gscholar&cbl=18750&diss=y

[6] Y. Z.-P. of the I. of Mechanical y undefined 2024, “User experience of lower extremity exoskeletons and its improvement methodologies: A narrative review”, *journals.sagepub.com*, dic. 2024, doi: 10.1177/09544119241291194.

[7] Y. Long, Z. Cai, y H. Guo, “AES-SEA and bionic knee based lower limb exoskeleton design and LQR-Virtual tunnel control”, *Springer*, 2025, doi: 10.1007/S42235-025-00678-9.

[8] Q. Meng *et al.*, “Flexible lower limb exoskeleton systems: A review”, *journals.sagepub.com*, vol. 50, núm. 4, pp. 367–390, 2022, doi: 10.3233/NRE-210300.

[9] A. Francis *et al.*, “Principles and guidelines for evaluating social robot navigation algorithms”, *dl.acm.org*, vol. 14, núm. 2, pp. 1–65, jun. 2025, doi: 10.1145/3700599.

[10] C. Marquez-Chin, N. Kapadia-Desai, y S. Kalsi-Ryan, “Brain–computer interfaces: Neurorehabilitation of voluntary movement after stroke and spinal cord injury”, 2022, Consultado: el 27 de abril de 2025. [En línea]. Disponible en: https://books.google.com/books?hl=es&lr=&id=AYVyEAAAQBAJ&oi=fnd&pg=PP1&dq=(%22Passive+exoskeleton%22+OR+%22passive+assistive+device%22)+AND+(%22bipedal+stance%22+OR+%22sit-to-stand%22)&ots=sdvNab9cBl&sig=iE554ucgedZ6UqA_FFojflENbkA

[11] F. Ghafouri, M. Honarvar, M. J.-I. J. of Biomedical, y undefined 2020, “An Investigation of Dynamic Behavior of a Pointed-Mass Convex-Sole Biped Walker with and without a Passive Controller”, *ijbme.org*, vol. 14, núm. 1, pp. 1–11, 2020, doi: 10.22041/IJBME.2020.111036.1506.

[12] G. Guevara, E. Verdesoto, y N. Castro, “Metodologías De Investigación Educativa”, 2020, *RECIMUNDO: Revista Científica de la Investigación y el Conocimiento*. Consultado: el 21 de mayo de 2025. [En línea]. Disponible en: https://dialnet.unirioja.es/servlet/articulo?codigo=7591592

[13] O. Bentahar y R. Cameron, “Design and implementation of a mixed method research study in project management”, *Electronic Journal of Business Research Methods*, vol. 13, núm. 1, 2015.

[14] M. Tymkovych *et al.*, “8th European Medical and Biological Engineering Conference: Proceedings of the EMBEC 2020, November 29–December 3, 2020 Portorož, Slovenia”, 2020, doi: 10.1007/978-3-030-64610-3_14.

[15] Elsevier, “Scopus content coverage guide”, 2025. [En línea]. Disponible en: https://www.elsevier.com/__data/assets/pdf_file/0007/69451/scopus-content-coverage-guide.pdf

[16] F. Ballen-Moreno, D. Gomez-Vargas, K. Langlois, J. Veneman, C. A. Cifuentes, y M. Múnera, “Fundamentals for the Design of Lower-Limb Exoskeletons”, *Springer*,

pp. 93–120, sep. 2021, doi: 10.1007/978-3-030-79630-3_3.

[17] I.E.E.E., "IEEE Xplore Digital Library: About.https://ieeexplore.ieee.org/Xplore/home.jsp", 2025.

[18] J. L. Ortega, "Google Scholar: El buscador académico para todos", *El Profesional de la Información*, vol. 23, núm. 3, pp. 264–268, doi: 10.3145/epi.2014.may.13.

[19] I. Halim *et al.*, "A Review on Ergonomics Factors Determining Working in Harmony with Exoskeletons.", *medic.upm.edu.my*, vol. 19, núm. 6, pp. 311–327, 2023, doi: 10.47836/mjmhs.19.6.41.

[20] D. Scherb, S. Wartzack, y J. Miehling, "Modelling the interaction between wearable assistive devices and digital human models—A systematic review", *frontiersin.org*, vol. 10, ene. 2023, doi: 10.3389/FBIOE.2022.1044275/FULL.

[21] F. Ballen-Moreno, … D. G.-V.-I. H. and, y undefined 2021, "Fundamentals for the Design of Lower-Limb", *books.google.com*, Consultado: el 27 de abril de 2025. [En línea]. Disponible en: https://books.google.com/books?hl=es&lr=&id=zI5DEAAAQBAJ&oi=fnd&pg=PA93&dq=(%22Passive+exoskeleton%22+OR+%22passive+assistive+device%22)+AND+(%22bipedal+stance%22+OR+%22sit-to-stand%22)&ots=EOwbuH8yIa&sig=RGqfPJYhXDnenTOpbADKOCZ4BQ8

[22] M. Gull, ; Ahsan, T. ; Bak, S. Bai, M. A. Gull, y T. Bak, "Dynamic modeling of an upper limb hybrid exoskeleton for simulations of load-lifting assistance", *journals.sagepub.com*, vol. 236, núm. 5, pp. 2147–2160, mar. 2022, doi: 10.1177/09544062211024687.

[23] F. Ferrari, "An EMG-triggered cooperative controller for a single-joint hybrid FES-robotic system", 2022, Consultado: el 27 de abril de 2025. [En línea]. Disponible en: https://www.politesi.polimi.it/handle/10589/208644

[24] S. Chow, "Design and development of a non-powered exoskeleton device to cater to the physical needs of puppeteers", 2022, Consultado: el 27 de abril de 2025. [En línea]. Disponible en: https://theses.lib.polyu.edu.hk/handle/200/12233

[25] C. Elisa Panero, S. Laura Gastaldi, F. Bottiglione, P. di Bari, y I. Fabrizio Billi, "Powered exoskeleton for trunk assistance in industrial tasks", 2020, Consultado: el 27 de abril de 2025. [En línea]. Disponible en: https://tesidottorato.depositolegale.it/bitstream/20.500.14242/66253/1/Panero_powered_exoskeleton_for_trunk_assistance_in_industrial_tasks_final.pdf

[26] T. Triwiyanto, W. Caesarendra, V. Abdullayev, A. A. Ahmed, y H. Herianto, "Single lead EMG signal to control an upper limb exoskeleton using embedded machine learning on raspberry pi", *journal.umy.ac.id*, vol. 4, núm. 1, 2023, doi: 10.18196/jrc.v4.i1.17364.

[27] Y.-S. Li-Baboud *et al.*, "Evaluation methods and measurement challenges for industrial exoskeletons", *mdpi.com*, 2023, doi: 10.3390/s23125604.

[28] P. Kuber, A. Kulkarni, E. R.-A. Sciences, y undefined 2024, "Machine learning-based fatigue level prediction for exoskeleton-assisted trunk flexion tasks using wearable sensors", *mdpi.com*, vol. 2024, p. 3563, 2024, doi: 10.3390/app14093563.

[29] N. Modi, J. S.-D. and R. Assistive, y undefined 2022, "A survey of research trends in assistive technologies using information modelling techniques", *Taylor & Francis*, vol. 17, núm. 6, pp. 605–623, 2022, doi: 10.1080/17483107.2020.1817992.

[30] H. Lee, S. H. Kim, y H. S. Park, "Novel Soft Actuators and Advances in Sensors for Healthcare Applications", *taylorfrancis.com*, vol. 8, ago. 2020, doi: 10.3389/FBIOE.2020.00966.

[31] N. Li *et al.*, "Designing unpowered shoulder complex exoskeleton via contralateral drive for self-rehabilitation of post-stroke hemiparesis", *Springer*, vol. 20, núm. 3, pp. 992–1007, may 2023, doi: 10.1007/S42235-022-00299-6.

[32] P. Dhatrak, J. Durge, R. K. Dwivedi, H. K. Pradhan, y S. Kolke, "Interactive design and challenges on exoskeleton performance for upper-limb rehabilitation: a comprehensive review", *Springer*, 2024, doi: 10.1007/S12008-024-02090-9.

[33] S. D. Ghazaryan, M. G. Harutyunyan, Y. L. Sargsyan, N. B. Zakaryan, y V. Arakelian, "Design of Multifunctional

Assistive Devices with Various Arrangements of Gravity Compensation”, *Springer*, vol. 115, pp. 193–228, 2022, doi: 10.1007/978-3-030-95750-6_8.

[34] M. Goršič, Y. Song, A. Johnson, … B. D.-2021 43rd A., y undefined 2021, “Simultaneously varying back stiffness and trunk compression in a passive trunk exoskeleton during different activities: A pilot study”, *ieeexplore.ieee.org*, 2021, doi: 10.1109/EMBC46164.2021.9630081.

[35] D. Prattichizzo *et al.*, “Human augmentation by wearable supernumerary robotic limbs: review and perspectives”, *iopscience.iop.org*, 2021, doi: 10.1088/2516-1091/AC2294/META.

[36] C. Copilusi, S. Dumitru, I. Geonea, A. Margine, y D. Popescu, “Virtual Prototyping Validation of a Leg Exoskeleton Mechanism from Dynamic Considerations”, *Springer*, pp. 187–198, 2024, doi: 10.1007/978-3-031-62684-5_17.

[37] U. Umar, H. S. Minhas, N. Naseer, H. Nazeer, S. Iqbal, y M. N. Ahmed, “Design and Simulation of Lower-Limb Exoskeleton to Assist Paraplegic People in Walking”, en *2022 8th International Conference on Control, Decision and Information Technologies, CoDIT*, pp. 855 – 860. doi: 10.1109/CoDIT55151.2022.9804158.

[38] B. Quinlivan, “Soft Exosuits for Improved Walking Efficiency and Community Based Post-Stroke Gait Rehabilitation”, 2021, Consultado: el 27 de abril de 2025. [En línea]. Disponible en: https://search.proquest.com/openview/58c5102f80e89325c3398ee50fe71193/1?pq-origsite=gscholar&cbl=18750&diss=y

[39] N. Elkmann, R. Behrens, M. Hägele, U. Schneider, y S. Oberer-Treitz, “Biologized Robotics and Biomechatronics: Opportunities and Challenges in Human-Robot Collaboration”, *Springer*, pp. 199–223, ene. 2020, doi: 10.1007/978-3-662-59659-3_11.

[40] K. Pornpipatsakul, N. A.- Robotics, y undefined 2023, “Estimation of knee assistive moment in a gait cycle using knee angle and knee angular velocity through machine learning and artificial stiffness control strategy”, *mdpi.com*, 2023, doi: 10.3390/robotics12020044.

[41] Y. Eguchi, *Posture change support by passive exoskeleton and Research on standing movement equipment. Graduate School of Systems and Information Engineering*. University of Tsukuba Department of Intelligent Systems, 2019.

[42] P. Liang, “Development of Next Generation Assistive Wearable Device”, 2024, Consultado: el 27 de abril de 2025. [En línea]. Disponible en: https://search.proquest.com/openview/70ecf90df3b593c346cabf8868d65cb1/1?pq-origsite=gscholar&cbl=2026366&diss=y

[43] D. F. P. Granados, H. Kadone, y K. Suzuki, “Unpowered Lower-Body Exoskeleton with Torso Lifting Mechanism for Supporting Sit-to-Stand Transitions”, en *IEEE International Conference on Intelligent Robots and Systems*, pp. 2755–2761. doi: 10.1109/IROS.2018.8594199.

[44] A. L. Ármannsdóttir *et al.*, “Assessing the involvement of users during development of lower limb wearable robotic exoskeletons: a survey study”, *journals.sagepub.com*, vol. 62, núm. 3, pp. 351–364, may 2020, doi: 10.1177/0018720819883500.

[45] S. Stansfield, B. Schelhaas, N. Hogan, y M. Yang, “Understanding the User Perception Gap: Older Adults and Sit-to-Stand Assistance”, *asmedigitalcollection.asme.org*, vol. 6, 2023, doi: 10.1115/detc2023-116642.

[46] M. Rutka, W. M. Adamczyk, y P. Linek, “Effects of Physical Therapist Intervention on Pulmonary Function in Children With Cerebral Palsy: A Systematic Review and Meta-Analysis”, *Phys Ther*, vol. 101, núm. 8, doi: 10.1093/ptj/pzab129.

[47] D. N. Wolf, S. J. Fine, C. C. Ice, P. R. Slaughter, K. M. Rodzak, y K. E. Zelik, “Integrating exosuit capabilities into clothing to make back relief accessible to workers unserved by existing exoskeletons: design and preliminary evaluation”, *Taylor & Francis*, vol. 11, núm. 3–4, pp. 94–107, 2023, doi: 10.1080/24725838.2023.2295859.

[48] S. Crea *et al.*, “Occupational exoskeletons: A roadmap toward large-scale adoption. Methodology and challenges of bringing exoskeletons to workplaces”, *cambridge.org*, vol. 2, p. 11, 2021, doi: 10.1017/wtc.2021.11.

[49] F. Ballen-Moreno, M. Bautista, T. Provot, M. Bourgain, C. A. Cifuentes, y M. Múnera, “Development of a 3D relative motion method for human–robot interaction assessment”, *mdpi.com*, 2022, doi: 10.3390/s22062411.

[50] M. TANAKA, X. X.-J. A. R. Q. JARQ, y undefined 2025, “Evaluation Methods for the Assist Suit and Agricultural Applications”, *jircas.go.jp*, vol. 59, núm. 2, pp. 101–118, 2025, doi: 10.6090/jarq.23S20.

[51] S. Ivaldi *et al.*, “Using exoskeletons to assist medical staff during prone positioning of mechanically ventilated COVID-19 patients: a pilot study”, *Springer*, vol. 263, pp. 88–100, 2021, doi: 10.1007/978-3-030-80744-3_12.

[52] P. Rea, E. Ottaviano, y M. Ruggiu, “The use of CPS for assistive technologies”, *Springer*, vol. 305, pp. 316–326, 2022, doi: 10.1007/978-3-030-83368-8_31.

[53] P. Herrera-Saray, I. Peláez-Ballestas, L. Ramos-Lira, D. Sánchez-Monroy, y R. Burgos-Vargas, “Problemas con el uso de sillas de ruedas y otras ayudas técnicas y barreras sociales a las que se enfrentan las personas que las utilizan. Estudio cualitativo desde la perspectiva de la ergonomía en personas discapacitadas por enfermedades reumáticas y otras condiciones”, *Reumatol Clin*, vol. 9, núm. 1, pp. 24–30, doi: 10.1016/j.reuma.2012.05.010.

[54] T. P. García, B. G. González, L. N. Rivero, J. P. Loureiro, E. D. Villoria, y A. P. Sierra, “Exploring the Psychosocial Impact of Wheelchair and Contextual Factors on Quality of Life of People with Neuromuscular Disorders”, *Assistive Technology*, vol. 27, núm. 4, pp. 246–256, doi: 10.1080/10400435.2015.1045996.

[55] S. L. Groah, M. Schladen, C. G. Pineda, y C.-H. J. Hsieh, “Prevention of Pressure Ulcers Among People With Spinal Cord Injury: A Systematic Review”, *PM&R*, vol. 7, núm. 6, pp. 613–636, doi: 10.1016/j.pmrj.2014.11.014.

[56] N. Hamilton, W. Weimar, y K. Luttgens, *Kinesiology : scientific basis of human motion*. McGraw-Hill, 2012.

[57] U. S. D. Justice Civil Rights Division, *ADA Standards for Accessible Design Title III Regulation 28 CFR Part 36*. Https://Www.Ada.Gov/Law-and-Regs/Design-Standards/1991-Design-Standards/.