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# Patient-Related Predictors of Response to Lower Limb Exoskeleton-Assisted Gait Rehabilitation: A Review

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DISCOVERY SCIENTIFIC SOCIETY

## ABSTRACT

*Introduction*: Gait impairments are a main cause of disability. Conventional rehabilitation often requires an intense effort from the physiotherapist with repetitive, specific movements. Lower limb exoskeletons have become a useful tool for gait rehabilitation. They enable training repetitive movements and enhance neuroplasticity by providing controlled movement patterns. Several studies reported improvements in gait speed, walking distance, and other functional outcomes due to the use of these devices. Due to heterogeneity in patient populations, intervention protocols, and reported outcomes, we sought to study how to improve therapy fit and identify the patients who will benefit most from such a treatment option. It is essential to identify predictors of response to exoskeleton-assisted gait rehabilitation to improve decision-making and optimize treatment strategies. *Methodology*: We reviewed the selected literature in the databases: PubMed and Science Direct between January and March 2026. We focused on studies published from 2021 onward that were relevant to the study's topic. We emphasize systematic reviews and clinical trials. *Result and discussion*: Relatively few studies, particularly randomized trials and subgroup analyses, directly investigated predictors of treatment response. Baseline functional status, severity of impairment, and recovery phase were the most consistently identified positive response factors. Future research will help physicians better identify good responders for exoskeleton rehabilitation.

**Keywords:** exoskeleton, lower limb, gait rehabilitation, predictors

## 1. INTRODUCTION

Gait problems are a major cause of disability in patients with stroke, Spinal Cord Injury (SCI), and Multiple Sclerosis (MS) or other neurological conditions. The loss of walking ability significantly reduces functional independence, lowers quality of life, and increases the risk of falls and muscle atrophy. Studies show the general effectiveness of exoskeleton usage. It is safe and has measurable gait rehabilitation outcomes in multiple devices (Gołacki et al., 2025). In this meta-analysis, the researchers do not explore why some patients respond better than others, and the effectiveness of robot-assisted gait training is variable and often limited (Bin et al., 2023). The idea of identifying predictors of response is a step toward better therapy fit and does not overstate treatment effectiveness.

The goal of this review is to explore why some patients benefit more than others and what the implications of these differences are. This approach aligns with the principles of personalized medicine and does not introduce bias, provided that analyses are conducted transparently across patient groups. It is risky to assume uniform treatment effects across heterogeneous patient populations because this may introduce bias and because treatment response varies between patients. Previous studies failed to identify potential predictors of a better response to exoskeleton gait rehabilitation.

## 2. REVIEW METHODS

We carried out a literature review from January to March 2026 using PubMed and ScienceDirect. We searched for relevant papers using keywords alone and in combination, and checked titles and abstracts to identify studies related to our topic. We excluded papers that did not fit these criteria. Relevant studies included original research articles, such as randomized controlled trials (RCTs), as well as review papers focusing on predictors of the effectiveness of lower-limb exoskeletons in the rehabilitation of patients with gait impairments. We created the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow diagram (Figure 1).

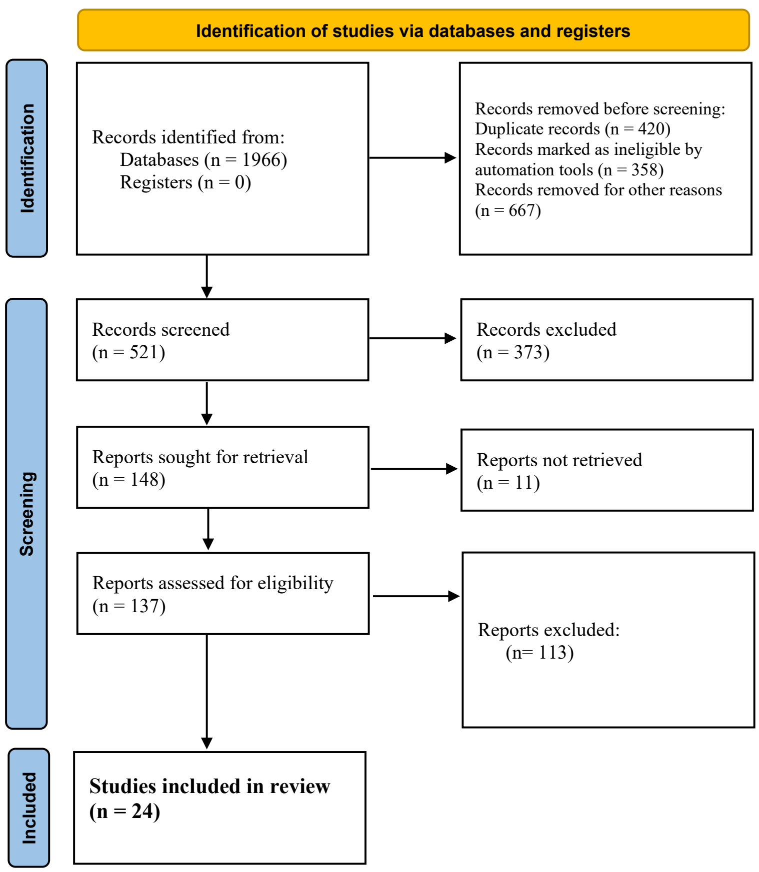


**Figure 1**. PRISMA consort chart of selected studies

## 3. RESULTS AND DISCUSSION

**Clinical predictors of response**

According to the researchers, the most important factor affecting treatment response is the patient's starting level of function. Patients who have better initial mobility, partial maintenance of motor function, early start of intervention and less severe neurological impairment tend to achieve greater objective improvements in functional outcomes (Chang et al., 2026). Conversely, people with more severe impairments or complete motor deficits generally show more limited gains.

Negative factor for both classic rehabilitation and exoskeleton-assisted rehabilitation is co-morbidity. Initial muscle strength is particularly important in the classic approach. Some factors of good response to the therapy are related to exoskeleton-patient interaction. It is important to have adequate ability to generate motor signals, good biomechanic fit, and the patient who is willing to work with new technology. These findings highlight the importance of residual motor capacity in enabling effective interaction with robotic assistance. Patients with complete Spinal Cord Injury (SCI) do not show significant motor benefits (Hu et al., 2024). In contrast the patients with incomplete SCI, even in chronic cases, improve measurably (Echemendía del Valle et al., 2023; Edwards et al., 2022), including physical activity (Belsey et al., 2026). Researchers did not directly compare complete and incomplete SCI, and did not evaluate the impact of this factor as a predictor. A recent meta-analysis reported only minor overall improvements in the gait parameters following exoskeleton-assisted training in patients with SCI, with substantial heterogeneity across publications (Liu & Chen, 2024).

**Neurophysiological Mechanisms**

Exoskeletons support the motor components of rehabilitation and also activate brain motor function (Zhang et al., 2025). Researchers suggest that a patient's neuroplastic potential may predict how well they respond to treatment.

Exoskeleton training that uses AI algorithms and brain–computer interface (BCI) control has been linked to better motor function and greater neural engagement. Researchers believe that having preserved neuronal pathways and the ability to actively use cortical networks may influence treatment outcomes (Hu et al., 2026). Robot-assisted gait rehabilitation also affects the autonomic nervous system, and can improve urodynamic function (Ziętek et al., 2026). Researchers have studied its effects on neuropathic pain, but the results are still inconclusive (White et al., 2025).

**Intervention and Device-related Factors**

The subacute phase of injury characterizes increased neuroplasticity; hence, the timing of the intervention may be important. Patients who underwent exoskeleton-assisted rehabilitation in the subacute phase of stroke showed better outcomes than patients treated with conventional rehabilitation (Huo et al., 2024). However, direct comparisons with patients in the chronic post-stroke phase are needed.

Further advances in technology should improve clinical outcomes - modern exoskeleton control algorithms use real-time gait prediction and intention recognition. It provides better support and leads to better gait symmetry and coordination outcomes (Li et al., 2025). Device-related factors and control strategies should improve rehabilitation results and users' satisfaction. Nevertheless, improving patients' interaction with the device does not directly determine success (Qin et al., 2021; Zhou et al., 2021).

**Overall findings**

Outcomes suggest that exoskeleton-assisted gait rehabilitation is associated with some improvements in gait performance and functional outcomes. Albeit the magnitude of benefit varies considerably between patients (Mehrholz et al., 2025; Bin et al., 2023). The variability appears to be influenced, at least in part, by baseline patient characteristics (Lee et al., 2023).

Researchers checked outcomes using several standardized measures: inter alia the 6-Minute Walk Test (6MWT), the Functional Ambulation Category (FAC), and quality of life (QoL) scales. We presented a detailed summary of the included studies in Table 1.

**Table 1**. Summary of Included Studies - Patient-Related Predictors of Response to Exoskeleton-Assisted Gait Rehabilitation

| Study | Design | Population Number | Condition | Intervention | Outcomes | Key Results | Predictors of response |
|---|---|---|---|---|---|---|---|
| Lee et al., 2023 | RCT | Adults, 44 | Stroke | Exoskeleton-assisted gait training. | 6MWT, FAC, QoL. | Significant improvement in walking distance and function. | Baseline functional status, treatment intensity. |
| Huo et al., 2024 | RCT | Adults, 40 | Subacute stroke | Unilateral exoskeleton training. | Balance, gait, neuroplasticity. | Improved gait and balance vs control. | Subacute phase, neuroplastic potential |
| Chang et al., | Subgroup | Adults, | Stroke | Torque- | Gait function | Identified responders | Baseline |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2026 | analysis (RCT-based) | 55 | | assisted exoskeleton | | vs non-responders | impairment, motor function. |
| Hu et al., 2026 | Pilot RCT | Adults, 20 | SCI | BCI-controlled exoskeleton training | Motor function, gait | Functional improvement and neural recovery | Neural engagement, residual pathways |
| Echemendía del Valle et al., 2023 | Prospective cohort | Adults, 30 | SCI | Gait training program (incl. robotic elements) | Gait performance. | Improved walking ability. | Training duration, baseline status |
| (Rodríguez-Fernández et al., 2021) | Systematic review | Mixed neuro 87 studies. | Stroke, SCI, MS | Wearable exoskeletons | Gait, independence | Consistent improvement, high heterogeneity | Not defined; suggests the patient variability |
| de Miguel-Fernández et al., 2023 | Systematic review | 159 studies. | Brain injury | Control strategies of exoskeletons. | Gait performance | Adaptive control improves outcomes | Device-patient interaction |
| Herrera-Valenzuela et al., 2023 | Qualitative study | Adults, 15. | SCI | Exoskeleton use | User experience | Identified usability barriers | Patient needs, comfort, adaptation |
| Mehrholz et al., 2025 | Systematic review | Adults >1000 (pooled) | Stroke | Electromechanical gait training | Walking independence | Improved independent walking | Time since stroke, severity. |

# 4. CONCLUSION

Due to differences in responses to exoskeleton-assisted gait rehabilitation and results often dependent on the patient's profile, we observed some dependencies. The most consistent predictors of better rehabilitation outcomes are higher baseline functional status, less severe neurological impairment, and earlier stages of injury recovery. Moreover, preserved motor function and efficient patient-device interaction enhance the positive therapeutic response. Patient stratification and personalization of rehabilitation protocols are the correct path for future development. However, current evidence is limited. Future research should focus on large RCTs with longer follow-up periods, especially those identifying patient-related predictors of response, to improve treatment success rates. Combining clinical predictors with advanced data models may be a key step toward more effective and better-tailored rehabilitation.

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All authors reviewed the manuscript and approved its final version for publication.

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**Conflict of interest**
The authors declare that they have no conflicts of interest, competing financial interests or personal relationships that could have influenced the work reported in this paper.

**Data and materials availability**
All data associated with this study will be available based on the reasonable request to corresponding author.

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