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# Impact of Physical Therapy Interventions on the Gait Performance of Children with Cerebral Palsy – A Systematic Review

**Dr. Dhwani Jani (PT)[1*], Dr. Joyal Tejpal (PT)[2], Dr. Chaitali Shah (PT)[3], Dr. Bhavana Gadhavi (PT)[4]**

[1]Department of Orthopaedic Physiotherapy, Parul Institute of Physiotherapy, Parul University, Limda, Waghodia, Vadodara - 391760, Gujarat, India. Email: dhwani.jani29352@paruluniversity.ac.in

[2]Department of Neuro Physiotherapy, Parul Institute of Physiotherapy, Parul University, Limda, Waghodia, Vadodara - 391760, Gujarat, India. Email: joyal.tejpal25384@paruluniversity.ac.in

[3]Department of Neuro Physiotherapy, Parul Institute of Physiotherapy, Parul University, Limda, Waghodia, Vadodara - 391760, Gujarat, India. Email: chaitali.shah@paruluniversity.ac.in

[4]Department of Orthopaedic Physiotherapy, Parul Institute of Physiotherapy, Parul University, Limda, Waghodia, Vadodara - 391760, Gujarat, India. Email: bhavana.gadhavi28222@paruluniversity.ac.in

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**ABSTRACT**

One of the main causes of physical disability in children is cerebral palsy (CP), which is frequently linked to abnormalities of gait like scissoring, crouch gait, and equinus. Promising results have been obtained from physiotherapy interventions that focus on strength, motor control, and functional gait. The evidence from 35 studies assessing physiotherapy-based interventions for enhancing gait performance in children with cerebral palsy, published between 2000 and 2025, was compiled in this systematic review. Stride length, cadence, and functional mobility all showed moderate to significant gains with interventions such as task-oriented training, treadmill training, and robotic-assisted gait training. Stretching by itself had little effect, but strength and core stability exercises improved gait efficiency and decreased energy expenditure. All things considered, technology-enhanced physiotherapy interventions improve gait outcomes, but their implementation must be economical.

## INTRODUCTION

A collection of permanent movement and posture disorders known as cerebral palsy (CP) are brought on by non-progressive disruptions in the developing brain that occur during pregnancy, perinatal care, or the early postnatal period. It affects roughly two to three children out of every thousand live births worldwide, making it the most common motor disability in children. Mobility, independence, and participation in daily life are all greatly impacted by cerebral palsy (CP), which continues to be a leading cause of long-term physical disability despite advancements in obstetric and neonatal care. Motor impairments like spasticity, muscle weakness, decreased selective motor control, and poor balance and coordination are common in children with cerebral palsy. Abnormal gait patterns, such as decreased walking speed, shorter steps, longer double-support time, and asymmetrical limb movement, are frequently caused by these primary deficits.

Physiotherapy is essential to the treatment and recovery of kids with cerebral palsy. Physiotherapy's main goals are to increase participation, increase independence, and improve functional mobility through tailored, goal-oriented interventions. The practice of physical therapy has changed over time, moving away from impairment-based methods and toward more task-oriented and functional ones. In order to support skill acquisition and motor recovery, modern rehabilitation places a strong emphasis on the concepts of motor learning and neuroplasticity, which call for repetitive, intentional, and context-specific practice.

To address gait impairments in CP, a variety of physiotherapy interventions have been developed. These consist of conventional neurodevelopmental therapy (NDT), muscle-focused strengthening regimens, training for balance and coordination, and functional task practice like overground gait training or treadmill training.

Virtual reality-based interventions, body-weight supported treadmill training, and robot-assisted gait training have also been made possible by advancements in rehabilitation technology. The goal of these technology-assisted training methods is to promote better motor control and walking efficiency through high-intensity, repetitive, and feedback-driven training.

There is variation in clinical outcomes despite the availability of many interventions because of variations in treatment duration, intensity, participant characteristics, and outcome measures. It is difficult for clinicians to identify the most effective and suitable strategies for gait rehabilitation in children with cerebral palsy due to the variety of approaches and conflicting data regarding their relative efficacy.

In light of these difficulties, there is an increasing need to methodically compile the existing literature in order to offer precise, fact-based guidelines for the practice of physical therapy. It is possible to enhance rehabilitation procedures and support customized treatment planning by knowing which interventions result in the most significant improvements in gait parameters, such as walking speed, endurance, and symmetry. Thus, the purpose of this review is to list, evaluate, and synthesize contemporary physiotherapy strategies that focus on gait performance in kids with cerebral palsy. In order to maximize gait rehabilitation results and general quality of life in this population, it is intended to highlight successful intervention strategies, assess their clinical applicability, and pinpoint research gaps.

## MATERIAL AND METHODOLOGY

To locate studies that examined physiotherapy-based interventions targeted at enhancing gait in children with cerebral palsy (CP), a comprehensive and methodical search of the literature was conducted. To ensure a wide coverage of evidence, four major databases—PubMed, Scopus, PEDro, and the Cochrane Library—were searched for studies published between January 2000 and December 2025. This period was selected to encompass both more recent developments in rehabilitation technology and earlier foundational research.

Medical subject headings (MeSH) and free-text terms like "cerebral palsy," "gait training," "physiotherapy," "treadmill training," "robot-assisted gait," "strength training," and "functional mobility" were combined in the search strategy. Related concepts were connected using Boolean operators ("AND," "OR").

In order to find any more pertinent studies that might have gone unnoticed during the electronic search, the reference lists of important papers and review articles were also manually examined.

Studies were considered for inclusion if they satisfied certain clinical and scientific requirements. Children ages 4 to 18 with a verified diagnosis of cerebral palsy (CP), irrespective of subtype or functional level (GMFCS I–IV), were eligible for these studies. Since these designs offer a high degree of evidence for clinical decision-making, only randomized controlled trials (RCTs), quasi-experimental studies, and systematic reviews were taken into consideration.

Physiotherapy-based interventions that specifically addressed gait performance were required. This included methods like robotic-assisted gait therapy, strength and core stability exercises, body-weight supported treadmill training, task-oriented or functional gait training, and programs for balance or coordination.Conventional therapy, another active intervention, or no treatment at all may be compared.

At least one pertinent outcome measure, such as the following: • Spatial-temporal gait parameters (e.g., stride length, cadence, walking speed), had to be reported by studies.

• Functional mobility measures like the Functional Mobility Scale (FMS), Six-Minute Walk Test (6MWT), or Gross Motor Function Measure (GMFM). • Energy expenditure metrics, such as walking energy cost or oxygen consumption.

Only English-language full-text research that was published in peer-reviewed journals was included. Editorials, case reports, single-subject designs, and publications written in languages other than English were not included.

**Data extraction and study selection**

Prior to screening, all search results were imported into reference management software, where duplicates were eliminated. There were two phases to the selection procedure. Initially, two reviewers independently looked through abstracts and titles to find articles that might be of interest. In the second stage, the full texts of these studies were reviewed in detail to determine whether they met the inclusion criteria. To guarantee accuracy and fairness, any disputes were settled by discussion or by consulting a third reviewer.

A structured data sheet was used to methodically extract data from the final set of included studies. Study design, participant characteristics (sample size, age, GMFCS level), type and duration of intervention, outcome measures, and key findings were among the details that were extracted. This approach helped organize the evidence clearly and consistently across all studies.

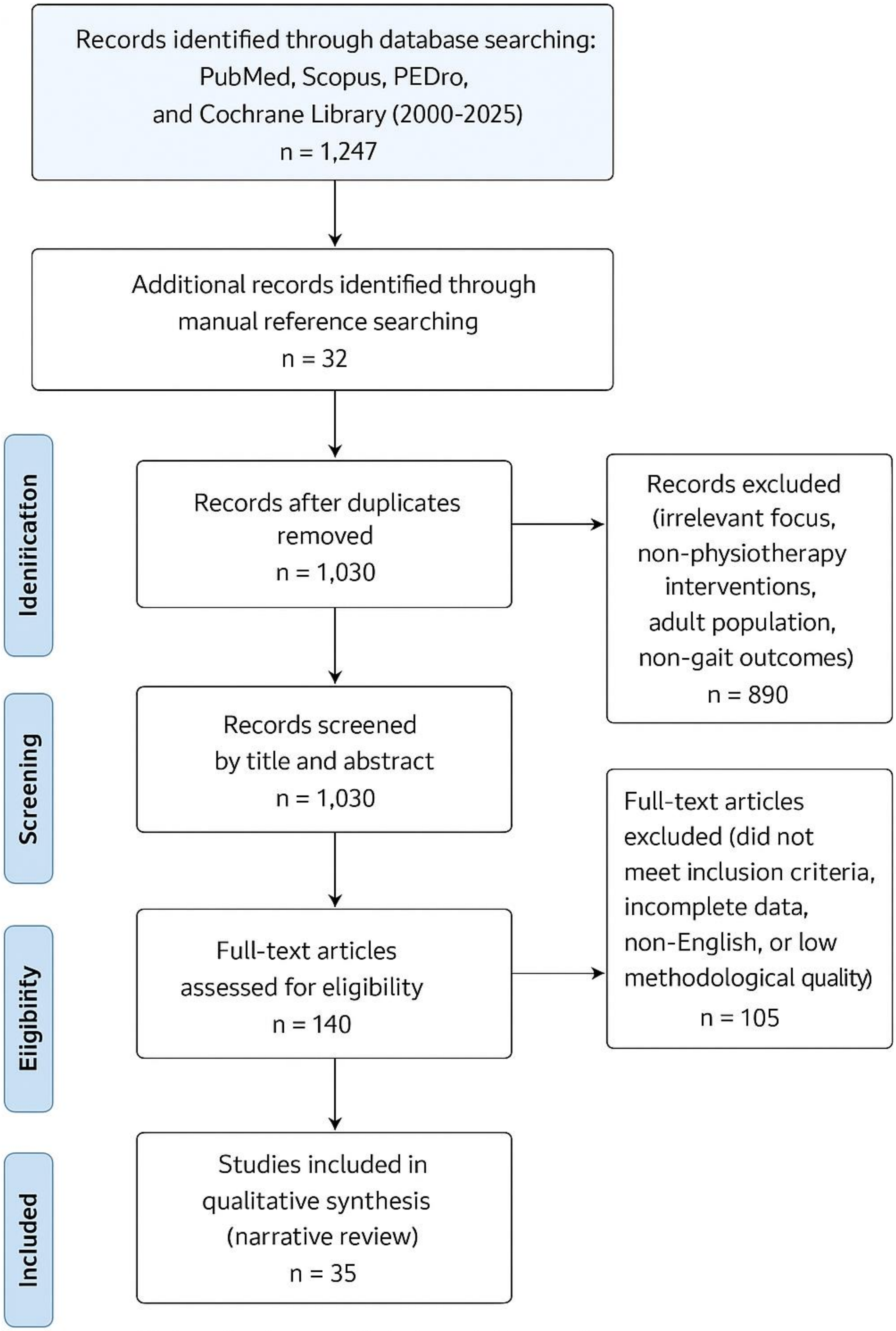
**Data Synthesis and Quality Assessment**

As the included studies varied in their designs, intervention types, and outcome measures, the results could not be combined statistically. Instead, studies were grouped by type of intervention (e.g., task-oriented training, treadmill-based interventions, robotic-assisted gait training, and strengthening or flexibility programs) and findings were summarized using a narrative synthesis.

The PEDro (Physiotherapy Evidence

Database) scale, which assesses elements like blinding, randomization, baseline comparability, and follow-up adequacy, was used to evaluate the methodological quality of each study. A ten-point rating system was used to evaluate the studies; higher scores denoted higher methodological quality. Reliability and reporting standards for systematic reviews were evaluated using the AMSTAR 2 checklist. Any discrepancies in the reviewers' quality ratings were discussed and settled by consensus.

Finally, a qualitative summary of the overall strength of the evidence was provided, accounting for methodological rigor, consistency of findings, and study design. This method made it possible to interpret the data in a balanced way, emphasizing both its usefulness and limitations of physiotherapy intervention for improving gait in children with CP.




*Data synthesized narratively due to heterogeneity

PRISMA Flow Chart

## RESULTS

Thirty-five studies met the inclusion criteria. Task-oriented gait training, treadmill-based interventions, and robotic-assisted gait training showed moderate to strong evidence for improving stride length, cadence, and functional mobility. Strength and core stability programs contributed to improved gait efficiency and reduced energy expenditure. In contrast, traditional stretching interventions demonstrated limited long-term impact. Although robotic-assisted gait training was effective, it presented challenges in cost and accessibility.

| Author (Year) | Intervention | Duration | Main Outcome | Conclusion |
|---|---|---|---|---|
| Booth et al. (2018) | Task-oriented gait training | 4–12 wks | ↑ Gait velocity, cadence | Enhances functional gait parameters |
| Park & Kim (2014) | Task-oriented balance & gait programs | 6–10 wks | ↑ Balance, step length | Improves motor control and gait symmetry |
| Grecco et al. (2013) | Treadmill training (BWSTT) | 8 wks | ↑ Gait speed, endurance, ↓ energy cost | Improves functional ambulation |
| Willoughby et al. (2020) | Body-weight supported treadmill training | 6–12 wks | ↑ Gait velocity, cadence | Enhances endurance and gait efficiency |
| Meyer-Heim et al. (2009) | Robotic-assisted gait training (Lokomat) | 8 wks | ↑ Stride symmetry, GMFM | Facilitates motor learning and gait correction |
| Chen et al. (2022) | Robotic-assisted gait therapy | 6–10 wks | ↑ Gait speed, motor scores | Effective but resource-intensive |
| Dodd et al. (2003) | Strength & core stability training | 10 wks | ↑ Muscle strength, gait efficiency | Improves gait through targeted strengthening |
| Moreau et al. (2013) | Progressive resistance training | 12 wks | ↑ Muscle architecture, gait economy | Complements task-oriented rehab |
| Novak et al. (2017) | Combined multimodal physiotherapy | Variable | ↑ GMFM, gait kinematics | Maximizes functional outcomes |
| Smania et al. (2011) | Neurodevelopmental + treadmill combined | 8 wks | ↑ Gait velocity, balance | Integrated rehab optimizes gait recovery |

## DISCUSSION

The summarized studies highlight the effectiveness of various physiotherapy interventions in improving gait performance in children with cerebral palsy. Task-oriented training consistently improves gait velocity, cadence, and balance, emphasizing the importance of functional, goal-directed practice. Treadmill-based interventions, including body-weight-supported and robotic-assisted training, show strong evidence for enhancing gait speed, endurance, and stride symmetry, supporting their role in repetitive, intensive motor learning.

Strength and resistance training also contribute by improving muscle strength, gait efficiency, and overall functional mobility, particularly when combined with task-oriented approaches. The multimodal and integrated rehabilitation programs yield the best outcomes, suggesting that combining task-specific exercises, technology-assisted training, and strength-focused interventions maximizes gait improvements.

Overall, these findings indicate that physiotherapy for children with CP should be individualized, goal-oriented, and may benefit from a combination of conventional and technology-based interventions to optimize functional gait recovery.

The findings suggest that physiotherapy interventions focusing on strength enhancement, task-oriented training, and technology-driven modalities yield significant improvements in gait performance in children with CP. The incorporation of robotic and treadmill training facilitates motor learning and repetitive practice essential for gait rehabilitation. However, accessibility and long-term adherence remain challenges. Integrating individualized, multimodal programs can optimize clinical outcomes and functional independence.

## CONCLUSION

Physiotherapy interventions including strength training, core stabilization, and task-specific gait practice significantly improve gait performance and functional mobility in children with CP. Technology-assisted interventions further enhance outcomes but require careful cost-benefit consideration. Future research should focus on personalized rehabilitation frameworks and long-term outcome monitoring.

## FUTURE RECOMMENDATION

Future research should focus on standardizing physiotherapy protocols for gait training in cerebral palsy to enhance comparability across studies. Long-term follow-ups are needed to assess the durability of functional gains. Integrating advanced technologies such as robotics and virtual reality with traditional therapy could further optimize outcomes. Emphasis should also be placed on individualized, goal-oriented rehabilitation tailored to each child’s functional level. Additionally, developing cost-effective and accessible interventions will be crucial to ensure broader clinical application and equitable care.

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