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LONGITUDINAL EFFECTS OF BODY WEIGHT SUPPORTED GAIT TRAINING ON FUNCTIONAL GAIT RECOVERY AFTER STROKE: A PILOT RANDOMIZED CONTROLLED TRIAL

Manoj Jayakumar[1], Senthil P[2], Prathap Suganthirababu[3], Vinodhkumar Ramalingam[4], Chella Perumal Palanisamy[5*]

[1]Saveetha College of Physiotherapy, Saveetha Institute of Medical and Technical Sciences (SIMATS), Thandalam, Chennai-602105, Tamil Nadu, India. mdevfranny@gmail.com, https://orcid.org/0009-0008-4722-1819
[2]VELS School of Physiotherapy, VELS Institute of Science, Technology & Advanced Studies (VISTAS), Chennai, Tamil Nadu - 600117, India. Senthilp101010@gmail.com, https://orcid.org/0000-0002-0472-0043
[3]Department of Neuroscience, Saveetha College of Physiotherapy, Saveetha Institute of Medical and Technical Sciences (SIMATS), Thandalam, Chennai-602105, Tamil Nadu, India. prathap.scpt@saveetha.com; https://orcid.org/0000-0002-1419-266X
[4]Department of Sports Sciences, Saveetha College of Physiotherapy, Saveetha Institute of Medical and Technical Sciences (SIMATS), Thandalam, Chennai-602105, Tamil Nadu, India. vinodhkumar.scpt@saveetha.com;, https://orcid.org/0000-0002-5269-0520
[5*]Phytochemistry and Pharmacotherapy Lab, Department of Dermatology, Saveetha Medical College & Hospital (SMCH), Saveetha Institute of Medical and Technical Sciences (SIMATS), Thandalam, Chennai, Tamil Nadu 602105, India. perumalbioinfo@gmail.com, https://orcid.org/0000-0002-3527-3477

ABSTRACT
Background: Restoring ambulatory function is a cornerstone of post-stroke rehabilitation. While Conventional Gait Training (CGT) remains the clinical standard, Body Weight Supported Gait Training (BWSGT) provides a high-repetition, task-specific environment that may enhance neuroplasticity.
Objective: To evaluate the efficacy and longitudinal trajectory of BWSGT versus CGT on functional gait stability in stroke survivors.
Methods: Ten subjects were randomized into BWSGT (n=5) or CGT (n=5). Interventions were administered 3 sessions/week for 12 weeks. The Functional Gait Assessment (FGA) was utilized as the primary outcome measure, recorded at Baseline (Week 0), Week 4, Week 8, Week 12 (post-intervention), and Week 16 (follow-up).
Results: Both groups demonstrated significant intra-group improvements by Week 12. However, at the 16-week follow-up, the BWSGT group showed continued improvement (17.5 ± 2.7) compared to a plateau in the CGT group (14.3 ± 2.7), representing a statistically significant inter-group difference ($p = 0.015$).
Conclusion: BWSGT is a feasible intervention that may offer superior long-term retention and "carry-over" effects compared to conventional methods, making it a robust tool for durable gait rehabilitation.

KEYWORDS: Postpartum Anemia, Maternal Anemia, Postnatal Period, Hemoglobin, Iron Deficiency, Maternal Health

INTRODUCTION
Stroke remains one of the leading causes of long-term disability worldwide and represents a major public health burden due to its substantial impact on mobility, independence, quality of life, and healthcare expenditure. Although advances in acute stroke management have improved survival rates, nearly 70–80% of stroke survivors experience impaired walking ability during the early stages of recovery, while approximately 40–50% continue to demonstrate persistent gait abnormalities several months after the initial event. Deficits in gait are frequently accompanied by impaired balance, decreased walking speed, reduced endurance, asymmetrical weight bearing, abnormal lower-limb coordination, and an increased risk of falls. These impairments significantly restrict participation in activities of daily living, reduce community ambulation, and ultimately diminish overall functional independence. Consequently, restoration of safe and efficient walking remains one of the primary objectives of post-stroke rehabilitation [1-4].
Recovery of locomotor function following stroke relies largely on activity-dependent neuroplasticity, whereby repetitive, task-specific practice promotes cortical reorganization and facilitates the restoration of impaired motor pathways. Contemporary rehabilitation strategies emphasize intensive, repetitive, and goal-oriented gait training to stimulate neural recovery through motor learning mechanisms. According to principles of neuroplasticity, higher training intensity, increased repetition, task specificity, and progressive challenge are essential components for optimizing functional recovery. However, implementing these principles in conventional clinical practice remains challenging because stroke survivors often present with significant muscle weakness, impaired postural control, reduced endurance, spasticity, and fear of falling. These limitations frequently reduce the amount of meaningful gait practice that patients can safely perform during rehabilitation sessions [5, 6].
Conventional Gait Training (CGT) remains the standard approach in most rehabilitation centers and typically consists of overground walking practice combined with therapist-assisted weight shifting, balance exercises, muscle strengthening, and functional mobility training. While conventional therapy has demonstrated effectiveness in improving walking ability after stroke, its clinical application is often constrained by therapist fatigue, limited treatment intensity, variability in manual assistance, and concerns regarding patient safety. Furthermore, patients with severe motor impairment frequently

require multiple therapists to facilitate gait training, making intensive rehabilitation resource-intensive and difficult to sustain over prolonged treatment periods [7, 8].

Body Weight Supported Gait Training (BWSGT) has emerged as an innovative rehabilitation strategy designed to overcome many of these limitations. By partially unloading body weight using a suspension harness system, BWSGT enables patients to initiate stepping earlier in the recovery process while maintaining proper biomechanical alignment and reducing the physical demands placed on both patients and therapists. The unloading mechanism allows individuals to practice a substantially greater number of gait cycles with improved movement quality, enhanced symmetry, and reduced fear of falling. As body weight support is progressively decreased, patients gradually assume greater responsibility for postural control and lower-limb loading, thereby promoting motor recovery through progressive task-specific practice [9].

The physiological mechanisms underlying BWSGT extend beyond simple mechanical assistance. Repetitive stepping performed under body weight support provides continuous proprioceptive, vestibular, and visual sensory input that enhances activation of spinal central pattern generators, facilitates sensorimotor integration, and promotes cortical reorganization. These repetitive afferent signals contribute to improved timing of muscle activation, enhanced lower-limb coordination, increased weight acceptance during stance, and normalization of gait kinematics. Additionally, the safe training environment created by body weight support encourages patients to explore larger movement amplitudes and practice dynamic balance strategies without excessive concern regarding falls, thereby facilitating error-based motor learning and long-term retention of functional skills [10].

Over the past decade, numerous randomized controlled trials and systematic reviews have evaluated the effectiveness of BWSGT in individuals with stroke. Several investigations have demonstrated significant improvements in walking speed, gait endurance, balance performance, lower-limb motor function, and activities of daily living compared with conventional rehabilitation approaches. Meta-analyses further suggest that high-intensity body weight-supported treadmill training may produce superior improvements in functional ambulation, particularly among individuals in the acute and subacute stages of stroke recovery. Nevertheless, published evidence remains heterogeneous owing to differences in patient characteristics, timing after stroke, body weight unloading protocols, treadmill speeds, intervention durations, and outcome measures. Moreover, while many studies have reported immediate post-intervention improvements, relatively few have examined whether these gains are retained following completion of therapy, leaving uncertainty regarding the long-term sustainability of treatment effects [11].

An additional limitation of the existing literature is the predominant reliance on outcome measures such as walking speed, the 10-Meter Walk Test, the 6-Minute Walk Test, the Timed Up and Go Test, and the Berg Balance Scale. Although these assessments provide valuable information regarding mobility and balance, they may not adequately capture the complex dynamic balance demands encountered during functional walking in real-world environments. The Functional Gait Assessment (FGA) is a comprehensive clinical assessment specifically developed to evaluate dynamic postural stability during increasingly challenging locomotor tasks, including gait with horizontal and vertical head turns, pivot turns, obstacle negotiation, changes in walking speed, tandem walking, and stair climbing. The FGA has demonstrated excellent inter-rater reliability, test-retest reliability, responsiveness, and validity across diverse neurological populations, including individuals recovering from stroke. Consequently, it provides a clinically meaningful measure of functional gait performance and community mobility [12].

Furthermore, understanding the trajectory of recovery during rehabilitation is equally important as determining overall treatment effectiveness. Serial longitudinal assessments provide valuable insights into the temporal pattern of functional improvement, identify potential plateau phases, and determine whether therapeutic gains are maintained after structured rehabilitation has ceased. Such information is essential for clinicians when designing individualized rehabilitation programs, determining optimal treatment duration, and predicting long-term functional outcomes. However, longitudinal investigations evaluating changes in Functional Gait Assessment scores following BWSGT remain scarce, particularly those incorporating post-intervention follow-up assessments to evaluate retention of motor learning [13].

Therefore, the present pilot randomized controlled trial was designed to compare the effects of Body Weight Supported Gait Training and Conventional Gait Training on functional gait performance in individuals with post-stroke hemiparesis. Using the Functional Gait Assessment as the primary outcome measure, participants were evaluated longitudinally at baseline, during the intervention period, immediately following treatment, and at a four-week follow-up to characterize the trajectory of recovery and determine the durability of treatment-induced improvements. We hypothesized that participants receiving Body Weight Supported Gait Training would demonstrate significantly greater improvements in functional gait performance together with superior long-term retention of motor gains compared with those receiving Conventional Gait Training.

2. METHODOLOGY

2.1. Participants

Ten subjects with a diagnosis of hemiparesis post-stroke were recruited. Informed consent was obtained from all participants, and the study was approved by the Institutional Review Board (IRB).

Inclusion Criteria: Clinical diagnosis of stroke, presence of hemiparesis, ability to follow multi-step commands, and medical clearance for exercise.

Exclusion Criteria: Severe cardiovascular instability, fixed lower extremity contractures, or other neurological conditions affecting balance.

2.2. Study Design

Participants were randomized into two groups: the Experimental Group (BWSGT) and the Control Group (CGT).

2.3. Intervention Protocol

Both groups received therapy 3 times per week for 12 weeks.

- BWSGT Group: Participants used a harness system (treadmill or overground). Unweighting began at 30–40% of body weight and was progressively reduced based on the patient's ability to maintain knee extension and postural control during the stance phase.
- CGT Group: Focused on neurodevelopmental facilitation, weight-shifting, and over-ground walking assistance provided by a physical therapist.

2.4. Outcome Measures

The Functional Gait Assessment (FGA) was used to assess postural stability and the ability to perform complex walking tasks (e.g., walking with head turns, pivot turns, and steps). Assessments were performed at Baseline, Week 4, Week 8, Week 12, and Week 16. The FGA was selected due to its excellent inter-rater reliability (ICC = 0.94) and sensitivity in detecting gait changes in stroke survivors [3].

2.5. Statistical Analysis

Continuous variables were expressed as Mean ± Standard Deviation (SD). An independent samples t-test was performed to compare the means between groups at each time point. A p-value of < 0.05 was considered statistically significant.

3. RESULTS

3.1 Functional Gait Assessment (FGA) Trajectory

Baseline FGA scores showed no significant difference between the BWSGT (6.3 ± 2.7) and CGT (7.4 ± 3.2) groups (p = 0.412), indicating a balanced baseline.

- **Intra-group Improvement:** Both groups showed a positive response to treatment. By the end of the 12-week intervention, the BWSGT group improved by 147.6% from baseline, while the CGT group improved by 93.2%.
- **Longitudinal Retention:** Between Week 12 and Week 16 (no active intervention), the BWSGT group continued to improve (mean increase of 1.9 points), while the CGT group showed no change (mean score remained at 14.3).

3.2 Statistical Comparison

As shown in Table 1, the difference between groups became increasingly pronounced over time. The most significant finding occurred at the Week 16 follow-up, where the BWSGT group's superiority was statistically confirmed (p = 0.015).

Table 1: FGA Scores (Mean ± SD) and Inter-group Analysis

	6.3 (± 2.7)	7.4 (± 3.2)	0.412
	10.3 (± 2.9)	10.2 (± 2.8)	0.938
	13.0 (± 2.5)	12.2 (± 2.8)	0.510
	15.6 (± 2.7)	14.3 (± 2.7)	0.295
	17.5 (± 2.7)	14.3 (± 2.7)	0.015*

*Indicates statistical significance (p < 0.05)

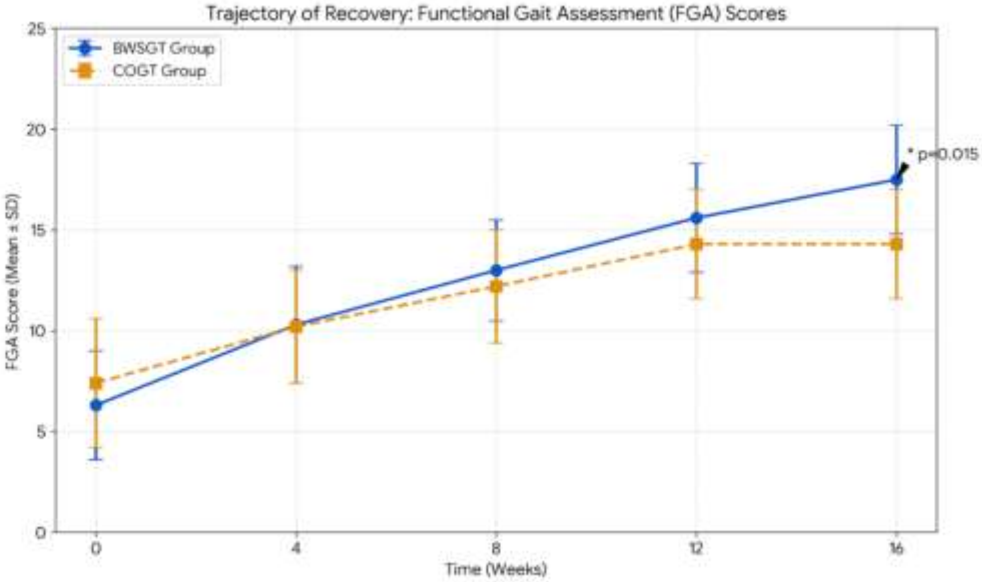

Figure 1. Comparison of mean Functional Gait Assessment (FGA) scores between the Body Weight Supported Gait Training (BWSGT) and Conventional Gait Training (COGT) groups over 16 weeks. Error bars represent standard deviation. Note the statistically significant difference at the Week 16 follow-up ($p < 0.05$), indicating superior retention in the BWSGT group.

4. DISCUSSION

The present pilot randomized controlled trial investigated the longitudinal effects of Body Weight Supported Gait Training (BWSGT) compared with Conventional Gait Training (CGT) on functional gait recovery among individuals with post-stroke hemiparesis using the Functional Gait Assessment (FGA). Although both interventions produced progressive improvements throughout the 12-week rehabilitation period, participants who received BWSGT demonstrated superior long-term recovery, with continued improvements observed during the four-week follow-up after completion of treatment. In contrast, the CGT group exhibited a plateau in functional performance during the follow-up period. These findings suggest that while both rehabilitation approaches effectively improve gait performance, BWSGT may induce more durable motor adaptations that continue beyond the supervised intervention period [14, 15].

The absence of statistically significant differences between groups at baseline confirms that the randomization process successfully produced comparable participant characteristics prior to treatment. Likewise, similar improvements observed during Weeks 4 and 8 indicate that both interventions were capable of enhancing gait performance during the early stages of rehabilitation. Progressive increases in FGA scores throughout the intervention period demonstrate that repetitive gait practice, irrespective of delivery method, contributes positively to recovery of dynamic balance and walking function after stroke. Nevertheless, the larger magnitude of improvement observed in the BWSGT group at Weeks 12 and 16 suggests that body weight support provides additional therapeutic benefits beyond those achieved through conventional overground gait training [16, 17].

One of the most important findings of this study is the sustained improvement demonstrated by the BWSGT group during the follow-up period after active therapy had ceased. Between Week 12 and Week 16, participants receiving BWSGT continued to improve their Functional Gait Assessment scores, whereas participants in the conventional group maintained essentially unchanged performance. This divergence strongly suggests that BWSGT promotes motor learning rather than merely temporary improvements in motor performance. According to contemporary theories of motor learning, repeated exposure to task-specific practice under progressively challenging conditions facilitates consolidation of newly acquired motor skills within cortical and subcortical neural networks. Once these neural adaptations become established, patients continue refining movement patterns during everyday functional activities even in the absence of structured rehabilitation. The continued improvement observed in the present study is therefore consistent with long-term neuroplastic adaptations rather than short-lived training effects [18-21].

Several neurophysiological mechanisms may explain the superior outcomes associated with BWSGT. Partial unloading of body weight allows patients to perform stepping movements with reduced mechanical constraints while preserving appropriate lower-limb kinematics. The reduction in weight-bearing demands enables individuals with muscle weakness or impaired postural control to complete substantially greater numbers of gait repetitions without excessive fatigue. Repetitive stepping provides continuous proprioceptive feedback from muscles, joints, and plantar mechanoreceptors, thereby enhancing sensory integration within the central nervous system. Simultaneously, rhythmic locomotor activity repeatedly activates spinal central pattern generators and facilitates corticospinal reorganization through activity-dependent neuroplasticity. Together, these adaptations improve interlimb coordination, stance stability, weight transfer, and timing of muscle activation, resulting in more efficient gait patterns over time [22].

Another important advantage of BWSGT is the provision of a safe rehabilitation environment that minimizes fear of falling while encouraging active participation. Fear of falling frequently limits walking confidence among stroke survivors and reduces willingness to explore larger movements or challenge postural stability during rehabilitation. The harness support system used in BWSGT allows patients to practice increasingly difficult gait tasks without the immediate risk of injury. This psychological reassurance enables greater movement variability and promotes error-based motor learning, an essential component of skill acquisition. Patients can repeatedly experience minor postural errors and immediately correct them, thereby strengthening adaptive balance responses that subsequently transfer into community ambulation. The superior Functional Gait Assessment scores observed at the follow-up assessment may therefore reflect both biomechanical improvements and enhanced confidence during dynamic walking tasks [23].

The observed improvements are consistent with current evidence supporting task-specific locomotor rehabilitation after stroke. Multiple systematic reviews have demonstrated that body weight supported treadmill training improves walking speed, lower-limb motor recovery, endurance, and activities of daily living compared with conventional physiotherapy, particularly when delivered at high intensity during the subacute phase of recovery. Recent meta-analyses have further concluded that repetitive stepping under body weight support increases locomotor efficiency by enabling greater training intensity while reducing compensatory movement patterns. The present findings extend this growing body of evidence by demonstrating that improvements achieved through BWSGT are not confined to the active intervention period but may continue after formal rehabilitation has ended, suggesting enhanced retention of motor learning [24].

The longitudinal design of the present study represents an important methodological strength. Most previous randomized trials have evaluated outcomes immediately following treatment, providing limited information regarding the durability of rehabilitation-induced improvements. By incorporating repeated assessments at baseline, Weeks 4, 8, and 12, together with a four-week post-treatment follow-up, this study provides a more comprehensive understanding of the trajectory of gait recovery. The continued increase in Functional Gait Assessment scores observed in the BWSGT group indicates that therapeutic gains were retained and potentially reinforced through independent practice during daily activities. Conversely, the plateau observed in the conventional group suggests that improvements achieved through therapist-assisted overground training may be more dependent upon ongoing supervised practice. These observations have important implications for designing rehabilitation programmes that seek not only immediate functional improvements but also sustained long-term recovery [25].

The Functional Gait Assessment proved to be a particularly appropriate outcome measure for evaluating intervention effectiveness. Unlike assessments that focus solely on walking speed or endurance, the FGA evaluates multiple components of dynamic balance required for safe community mobility, including gait with head movements, pivot turning, obstacle negotiation, narrow-base walking, and stair climbing. These tasks closely resemble challenges encountered during everyday ambulation and therefore provide a more comprehensive assessment of functional walking ability. Improvements observed in FGA scores likely reflect enhanced postural control, anticipatory balance adjustments, sensory integration, and adaptability during complex locomotor tasks. Consequently, the superiority of BWSGT demonstrated using the FGA suggests clinically meaningful improvements that extend beyond simple increases in gait velocity [26].

From a clinical perspective, the present findings support the integration of Body Weight Supported Gait Training into comprehensive stroke rehabilitation programmes, particularly for individuals with impaired balance, reduced confidence, or limited walking endurance. The ability to safely deliver high-intensity, repetitive gait practice may allow clinicians to maximize rehabilitation efficiency while reducing therapist physical demands. Furthermore, the continued improvements observed after completion of supervised therapy indicate that BWSGT may facilitate more independent functional recovery, potentially reducing the need for prolonged rehabilitation services. Such long-term retention of motor gains may ultimately contribute to greater community participation, reduced fall risk, improved quality of life, and lower healthcare costs [27, 28].

Although the present investigation provides encouraging preliminary evidence, several limitations should be acknowledged. First, the sample size was intentionally small because this was designed as a pilot randomized controlled trial. The limited number of participants reduces statistical power and restricts the generalizability of the findings to the broader stroke population. Second, participants were recruited from a single rehabilitation setting, which may limit external validity across different healthcare systems and rehabilitation environments. Third, the follow-up period was limited to four weeks after completion of treatment. Longer follow-up intervals of six months or one year would provide a more comprehensive understanding of long-term retention and community reintegration. Fourth, only the Functional Gait Assessment was used as the primary outcome measure. Incorporating additional objective assessments such as gait speed, six-minute walk distance, Timed Up and Go, Berg Balance Scale, lower-limb strength, spatiotemporal gait analysis, and patient-reported quality-of-life measures would provide a more comprehensive evaluation of functional recovery. Finally, the study did not include biomechanical, electromyographic, or neurophysiological assessments capable of directly confirming the neural mechanisms responsible for the observed improvements [29].

Future multicentre randomized controlled trials involving larger participant cohorts are required to validate these preliminary findings and establish standardized clinical protocols for Body Weight Supported Gait Training. Future investigations should compare different levels of body weight unloading, treadmill speeds, session frequencies, and intervention durations to determine the optimal therapeutic dosage. Integration of wearable motion sensors, three-dimensional gait analysis, electromyography, and functional neuroimaging may further elucidate the neurophysiological mechanisms underlying motor recovery. Additionally, future studies should evaluate cost-effectiveness, patient satisfaction, long-term fall prevention, and community participation to determine the broader clinical value of incorporating BWSGT into routine stroke rehabilitation practice [30, 31].

Overall, the findings of this pilot randomized controlled trial provide preliminary evidence that Body Weight Supported Gait Training offers meaningful advantages over Conventional Gait Training in promoting sustained functional gait recovery after stroke. While both interventions improved gait performance during the active rehabilitation period, BWSGT demonstrated superior retention of motor gains during follow-up, supporting its role as a neuroplasticity-driven rehabilitation strategy capable of producing durable improvements in dynamic balance and functional mobility. These results contribute to the growing body of evidence supporting intensive task-specific locomotor rehabilitation and provide a strong rationale for larger randomized clinical trials evaluating long-term functional outcomes following Body Weight Supported Gait Training.

5. CONCLUSION

This pilot randomized controlled trial demonstrated that both Body Weight Supported Gait Training (BWSGT) and Conventional Gait Training (CGT) improved functional gait performance in individuals with post-stroke hemiparesis. However, BWSGT produced superior long-term improvements, with Functional Gait Assessment (FGA) scores continuing to increase during the four-week follow-up, whereas the CGT group reached a plateau. These findings suggest that BWSGT facilitates sustained motor recovery through intensive, task-specific practice that promotes neuroplasticity, dynamic balance, and motor learning. The provision of a safe, body weight-supported environment enables greater gait repetition and enhances confidence during rehabilitation, potentially contributing to improved functional mobility and retention of therapeutic gains. Although limited by the small sample size and single-center design, this study provides promising preliminary evidence supporting the integration of BWSGT into stroke rehabilitation. Larger multicenter trials with extended follow-up are warranted to confirm these findings and optimize clinical protocols.

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