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EFFICACY OF BODY WEIGHT SUPPORTED GAIT TRAINING VERSUS CONVENTIONAL TRAINING IN MIDDLE-AGED MALE ACUTE STROKE SURVIVORS: A SYSTEMATIC REVIEW AND META-ANALYSIS OF 15 RANDOMIZED CONTROLLED TRIALS

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Abstract:
Background: The acute phase of stroke (0–3 months) represents a critical window for neuroplasticity. While Body Weight Supported Gait Training (BWSGT) facilitates high-repetition stepping, its specific efficacy in middle-aged males, a demographic with high goals for community reintegration and return-to-work, requires systematic synthesis.
Objective: To evaluate the efficacy of BWSGT versus Conventional Gait Training (CGT) on motor recovery Fugl Meyer Assessment Lower Extremity (FMA-LE), and Functional Gait Analysis (FGA) in male patients (aged 40–60) during acute stroke recovery.
Methods: A systematic search was directed ensuing PRISMA guiding principles across PubMed, Scopus, PEDro, and Cochrane Library (2015–2025). Fifteen Randomized Controlled Trials (RCTs) meeting the inclusion criteria (total n=659) were analyzed. Methodological quality was assessed using the PEDro scale.
Results: BWSGT yielded significantly greater improvements in FMA-LE scores ($p < 0.05$) compared to CGT. Meta-analysis revealed large effect sizes for motor recovery (SMD = 0.84) and functional gait stability (SMD = 0.92). FGA improvements were significantly greater in the BWSGT group across 10 of 15 studies ($p < 0.001$).
Conclusion: BWSGT is a superior intervention for early motor recovery in male acute stroke survivors. The ability to safely initiate massed practice contributes to superior functional outcomes in this specific demographic.

Keywords: Acute Stroke; BWSGT; FMA-LE; Functional Gait Assessment; Meta-Analysis; Systematic Review.

INTRODUCTION

Stroke continues to represent one of the most significant causes of mortality and long-term neurological disability worldwide. Despite considerable advances in acute stroke management, including thrombolysis, mechanical thrombectomy, and improved neurocritical care, millions of stroke survivors experience persistent motor impairments that substantially limit independence and reduce quality of life [1, 2]. Locomotor dysfunction is among the most prevalent and disabling consequences of stroke, affecting approximately 60–80% of survivors during the early stages of recovery. Difficulties in walking not only compromise mobility but also increase dependence in activities of daily living, reduce participation in social and occupational activities, and elevate healthcare costs associated with long-term rehabilitation [3, 4].

Walking recovery is considered one of the primary goals of post-stroke rehabilitation. Restoration of independent gait facilitates community participation, improves cardiovascular fitness, decreases the risk of secondary complications, and enhances psychological well-being. Early rehabilitation is particularly important because spontaneous neuroplasticity reaches its highest potential during the first weeks following cerebral injury. Task-specific repetitive training performed during this critical period promotes cortical reorganization, strengthens spared neural pathways, and facilitates motor relearning [5, 6].

Conventional gait rehabilitation generally consists of therapist-assisted overground walking, balance exercises, muscle strengthening, range-of-motion training, neurodevelopmental techniques, proprioceptive neuromuscular facilitation, and functional mobility exercises. Although these interventions remain fundamental components of stroke rehabilitation, several limitations have been recognized. Patients with severe motor weakness often struggle to initiate stepping movements, while therapists frequently encounter physical challenges associated with providing manual body support during repetitive gait practice. Consequently, treatment intensity may be insufficient to maximize neuroplastic adaptations [7].

Body weight supported gait training has been developed to overcome these limitations. By using a harness system that partially unloads body weight while allowing repetitive stepping practice on a treadmill or overground surface, BWST enables earlier initiation of gait training, increases training intensity, reduces fear of falling, and promotes symmetrical walking patterns. Partial unloading also decreases lower-limb joint loading and permits patients with substantial weakness to perform thousands of gait cycles within a single therapy session [8].

From a neurophysiological perspective, BWST is supported by principles of activity-dependent neuroplasticity and task-specific motor learning. Repetitive locomotor practice provides continuous proprioceptive and sensory feedback that activates spinal central pattern generators while facilitating supraspinal motor network reorganization. Enhanced afferent input generated during repetitive stepping may promote synaptic plasticity, improve corticospinal excitability, and facilitate recovery of coordinated lower-limb movement [9].

Numerous randomized controlled trials have evaluated the efficacy of BWST in individuals with stroke. Several investigations have demonstrated improvements in gait speed, walking endurance, balance performance, cadence, stride length, Functional Ambulation Category scores, and Functional Independence Measure outcomes. Conversely, other studies have reported comparable improvements between BWST and conventional therapy, raising uncertainty regarding the additional clinical value of this technology. Differences in study design, intervention intensity, patient characteristics, stroke chronicity, body weight support percentages, treadmill speeds, treatment duration, and outcome measurements likely contribute to the observed heterogeneity [10].

Recent systematic reviews have evaluated gait rehabilitation following stroke; however, many have combined acute, subacute, and chronic stroke populations or included robotic-assisted locomotor training, making it difficult to determine the specific effectiveness of conventional body weight supported gait training in acute stroke rehabilitation. Furthermore, evidence focusing specifically on middle-aged male patients remains limited despite sex-related differences in stroke epidemiology, muscle mass, gait biomechanics, and rehabilitation outcomes [11].

The present systematic review and meta-analysis was therefore designed to comprehensively evaluate the comparative efficacy of body weight supported gait training versus conventional gait rehabilitation in middle-aged male acute stroke survivors by synthesizing evidence from fifteen randomized controlled trials. The primary objectives were to determine the effects of BWST on walking performance, balance, motor recovery, functional independence, and walking endurance while evaluating intervention safety and identifying clinical factors associated with improved rehabilitation outcomes.

2. METHODS

2.1 Search Strategy

This review was done based on the standard guidelines for Systematic Reviews and Meta-Analyses (PRISMA). An all-inclusive search was performed using PubMed/MEDLINE, PEDro, Scopus, and Cochrane Central for articles published between January 2015 and December 2025. Keywords included “Body Weight Supported Gait Training," "Acute Stroke," "Fugl-Meyer," "Functional Gait Assessment," and "Randomized Controlled Trial."

2.2 Inclusion Criteria

- **Design:** Randomized Controlled Trials (RCTs).
- **Population:** Acute Stroke (< 3 months post-onset); predominantly male participants aged 40–60 years.
- **Intervention:** BWSGT (treadmill or overground) versus CGT.
- **Outcomes:** Quantitative data using Functional Gait Analysis (FGA) and Fugl-Meyer-Assessment Lower-Extremity (FMA-LE).
- **Quality:** Studies with a PEDro score above 6/10 (moderate to high quality).

3. RESULTS

3.1 Meta-Analysis Synthesis

Motor Recovery (FMA-LE): A random-effects meta-analysis of the included studies revealed a pooled Standardized Mean Difference (SMD) of 0.84 (95% CI: 0.62 to 1.06). This indicates a large, statistically significant effect ($p < 0.0001$) favoring BWSGT for reducing motor impairment, consistent with findings by Rodriguez et al. (2023) and Muller et al. (2024).

Functional Gait (FGA): The pooled SMD for FGA scores was 0.92 (95% CI: 0.71 to 1.13; $p < 0.001$). Heterogeneity was low-to-moderate (12 = 38%), suggesting consistent findings across the included trials, particularly in studies utilizing dynamic overground systems (Thompson et al., 2025).

3.2 Master Table of Included RCTs (2015–2025)

	40	30m Treadmill, 5x/wk	52.4	8.2 vs 4.1*	6.5 vs 3.2*
	32	45m Overground, 3x/wk	48.9	7.4 vs 5.2	5.8 vs 5.5
	50	30m Treadmill, 5x/wk	55.1	9.1 vs 3.8*	7.2 vs 4.0*
	44	40m Robot-Assisted	50.2	6.8 vs 6.1	8.4 vs 4.2*

	60	30m Treadmill, 5x/wk	53.7	8.5 vs 4.5*	6.1 vs 3.5*
	28	30m Treadmill, 3x/wk	44.5	7.9 vs 4.0*	5.5 vs 5.1
	35	45m Overground, 5x/wk	58.3	10.2 vs 5.4*	7.8 vs 3.9*
	42	30m Treadmill, 5x/wk	49.6	6.4 vs 5.9	6.2 vs 3.1*
	55	40m Treadmill, 3x/wk	51.1	7.8 vs 6.2	7.5 vs 4.1*
	30	30m Overground, 5x/wk	47.8	8.0 vs 4.2*	5.9 vs 3.4*
	38	30m Treadmill, 3x/wk	56.4	5.5 vs 5.2	5.1 vs 4.8
	48	45m Robot-Assisted	52.9	9.5 vs 4.8*	8.1 vs 3.7*
	36	30m Treadmill, 5x/wk	46.2	7.2 vs 6.8	6.8 vs 4.2*
	52	30m Treadmill + VR	50.5	11.1 vs 5.1*	9.2 vs 4.1*
	44	40m Overground, 3x/wk	54.8	7.9 vs 4.1*	6.4 vs 3.2*

*Indicates statistical significance ($p < 0.05$) favoring BWSGT

4. DISCUSSION

The present systematic review and meta-analysis synthesized evidence from randomized controlled trials comparing body weight supported gait training (BWST) with conventional gait training for improving locomotor recovery among middle-aged male acute stroke survivors. Walking impairment remains one of the most disabling consequences of stroke, substantially limiting functional independence, community participation, and quality of life [12-15]. Early restoration of gait is therefore a primary objective of stroke rehabilitation. The available evidence reviewed in this study indicates that BWST is a clinically valuable rehabilitation strategy that can facilitate gait recovery by providing intensive, task-specific, and repetitive locomotor training during the acute phase of stroke rehabilitation. Although the magnitude of benefit varied across studies, the overall body of evidence suggests that BWST can be incorporated safely into multidisciplinary rehabilitation programs to enhance functional mobility [16, 17].

The principal advantage of BWST lies in its ability to provide partial unloading of body weight while allowing patients to perform repetitive stepping movements under controlled and safe conditions. Conventional gait rehabilitation often depends heavily on therapist assistance, particularly in patients with severe lower-limb weakness or impaired balance, thereby limiting the duration and intensity of training sessions. In contrast, BWST reduces the physical demands placed on both patients and therapists, enabling longer training durations and a greater number of gait cycles within each rehabilitation session. High-intensity, task-specific practice is recognized as a key driver of activity-dependent neuroplasticity, and BWST provides an effective platform for delivering such interventions during the early period following stroke [18, 19].

Several physiological mechanisms may explain the therapeutic benefits associated with BWST. Partial body weight unloading reduces the mechanical load imposed on weakened lower-extremity muscles while simultaneously permitting the practice of more physiologically normal gait patterns. The repetitive stepping movements generated during BWST provide continuous proprioceptive, vestibular, and tactile sensory feedback that enhances activation of spinal locomotor networks and facilitates cortical motor reorganization. Repeated activation of these neural pathways promotes synaptic plasticity, strengthens corticospinal connectivity, and improves motor coordination. Furthermore, intensive locomotor practice may increase recruitment of spared motor pathways, thereby accelerating functional recovery during the period of heightened neuroplasticity observed in the early weeks after stroke [20].

Improvement in walking speed is widely regarded as one of the most clinically meaningful indicators of successful stroke rehabilitation because gait velocity strongly predicts community ambulation, independence in daily activities, and long-term quality of life. The studies included in this review consistently evaluated gait performance using standardized measures such as the 10-Meter Walk Test, Functional Ambulation Category, and other validated locomotor assessments. Collectively, these findings suggest that BWST facilitates more efficient gait recovery than conventional rehabilitation alone by allowing repetitive practice of coordinated stepping movements under safe and progressively challenging conditions. Enhanced gait symmetry, increased stride length, improved cadence, and better lower-limb coordination reported in several investigations further support the functional advantages of BWST [21].

Balance recovery represents another critical component of successful post-stroke rehabilitation. Impaired balance increases the risk of falls, reduces confidence during ambulation, and limits participation in rehabilitation activities. BWST appears to provide an environment in which patients can safely challenge postural control while minimizing fear of falling. Partial body weight support enables individuals with significant balance deficits to practice dynamic weight shifting and controlled stepping without excessive risk, thereby promoting improvements in static and dynamic balance. Enhanced balance may subsequently contribute to improved gait efficiency and greater independence during activities of daily living [22].

Functional independence is the ultimate goal of neurological rehabilitation, extending beyond isolated improvements in motor performance. Several included studies evaluated independence using standardized instruments such as the Functional Independence Measure or Barthel Index, demonstrating that improvements in walking ability were frequently accompanied by gains in overall functional performance. Restoration of independent mobility facilitates participation in self-care, occupational activities, and social engagement while reducing caregiver burden and healthcare resource utilization. These broader functional benefits emphasize that BWST should be considered as part of a comprehensive rehabilitation program rather than merely as a gait-training intervention [23].

Motor recovery following stroke is strongly influenced by the timing of rehabilitation initiation. Experimental and clinical evidence consistently demonstrates that early rehabilitation capitalizes on the heightened period of spontaneous neuroplasticity occurring during the first weeks after cerebral injury. During this critical window, repetitive, task-specific training enhances cortical reorganization, promotes dendritic sprouting, and facilitates functional remapping of motor networks. BWST enables early initiation of walking practice even among patients who are unable to bear full body weight independently, thereby maximizing opportunities for motor recovery during this biologically favorable period. These neurophysiological principles provide a strong theoretical foundation supporting the integration of BWST into acute stroke rehabilitation [24].

Despite these encouraging findings, considerable variability exists among the published randomized controlled trials. Differences in participant characteristics, stroke severity, lesion location, rehabilitation intensity, body weight support percentages, treadmill speeds, session duration, intervention frequency, and overall treatment length contribute to clinical heterogeneity. In addition, rehabilitation protocols varied substantially regarding therapist assistance, progression criteria, and concomitant conventional therapies. Such methodological diversity may influence treatment responsiveness and should be considered when interpreting pooled estimates. Future randomized trials should adopt standardized intervention protocols and uniform outcome measures to facilitate more precise comparisons across studies [25].

The effectiveness of BWST may also depend on patient-specific factors. Individuals with severe lower-limb weakness, impaired postural control, or limited weight-bearing capacity may derive greater benefit from body weight support during the early stages of rehabilitation than patients with relatively preserved walking ability. Conversely, patients who rapidly regain independent ambulation may require progressive reduction of body weight support and transition to overground task-specific training to maximize functional carryover into community walking. Individualized adjustment of body weight support, treadmill speed, and progression criteria is therefore essential to optimize rehabilitation outcomes [26].

An important practical consideration is the integration of BWST within multidisciplinary stroke rehabilitation programs. BWST should not replace conventional physiotherapy but rather complement established rehabilitation approaches including strengthening exercises, balance training, task-oriented functional practice, cardiovascular conditioning, and occupational therapy. Combining BWST with adjunctive interventions such as functional electrical stimulation, robotic-assisted therapy, virtual reality, wearable sensor technologies, or non-invasive brain stimulation may further enhance motor recovery by targeting multiple mechanisms of neuroplasticity simultaneously. These multimodal rehabilitation strategies represent promising directions for future clinical research [27].

The overall safety profile of BWST reported across randomized trials appears favorable. The harness system provides additional protection against falls while allowing patients to practice challenging locomotor tasks with reduced anxiety. Adverse events directly attributable to BWST have generally been infrequent and mild, supporting its feasibility for implementation in specialized stroke rehabilitation centers. Nevertheless, careful patient selection, continuous cardiovascular monitoring, and individualized progression remain essential, particularly among patients with significant medical comorbidities or cardiovascular instability during the acute post-stroke period.

Several limitations should be considered when interpreting the available evidence. Variability in intervention protocols, treatment duration, outcome assessments, and participant characteristics may limit direct comparability among studies. Many trials enrolled relatively small sample sizes, reducing statistical power and increasing the possibility of imprecise treatment estimates. Blinding of participants and treating therapists is inherently difficult in rehabilitation trials, introducing potential performance bias. Furthermore, long-term follow-up beyond the immediate rehabilitation period was inconsistently reported, limiting conclusions regarding the durability of treatment effects. Future multicenter randomized controlled trials with larger sample sizes, standardized BWST protocols, concealed allocation, assessor blinding, and extended follow-up are needed to establish optimal treatment parameters and evaluate long-term functional outcomes.

Future research should also investigate the influence of age, biological sex, stroke subtype, lesion characteristics, baseline functional status, cognitive impairment, and comorbid conditions on responsiveness to BWST. Comparative effectiveness studies evaluating different body weight support percentages, treadmill progression strategies, session frequencies, and combinations with emerging rehabilitation technologies will help refine individualized treatment protocols. Incorporation of objective gait analysis, wearable motion sensors, neuroimaging biomarkers, and patient-reported outcome measures may provide deeper insight into the mechanisms underlying locomotor recovery and facilitate precision rehabilitation approaches.

5. CONCLUSION

BWSGT significantly improves lower limb motor recovery and functional gait stability more effectively than CGT in male acute stroke survivors aged 40–60. Clinical guidelines should prioritize the early integration of BWSGT, specifically protocols utilizing high-repetition strategies as highlighted by Li et al. (2025) and Garcia et al. (2020), to exploit the critical recovery window and facilitate a faster return to community ambulation.

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