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Effectiveness of Indigenous Low-Cost Manual Body Weight Supported Treadmill Training Vs Conventional Overground Gait Training in Improving Functional Ambulation & Gait Velocity in Acute Post-Stroke Hemiparetic Subjects: A Randomized Controlled Trial

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Abstract

Background

Gait restoration is a central component of stroke rehabilitation. Body weight supported treadmill training Manual (BWSTT) is a locomotor training strategy that allows early, task-specific, repetitive practice of complete gait cycles while a harness system unloads a portion of body weight. Although task-specific training improves gait after stroke, it remains unclear whether it produces meaningful gains in gait velocity and functional ambulation over and above conventional overground gait training (COGT).

Objective

To compare the effectiveness of Manual BWSTT with COGT in improving functional ambulation and gait velocity in subjects with acute post-stroke hemiparesis.

Methods

This prospective, single-blind, randomized controlled trial enrolled 60 subjects (40 men, 20 women; age 40–60 years) with acute hemiparesis (within 90 days of stroke onset), recruited from the outpatient department of Physiotherapy, Hi-Tech Medical College & Hospital, Bhubaneswar. Subjects were randomly allocated to an experimental group (Group A, n = 30), which received BWSTT (25-40% body weight support, progressed as tolerated) in addition to a conventional rehabilitation programme, or a control group (Group B, n = 30), which received the same conventional programme plus overground gait training alone. Both groups trained for 20 minutes of walking practice, 4 days a week, for 12 weeks (48 sessions). Outcomes are Functional Ambulation Category (FAC) and the 10-metre walk test (10MWT) were assessed at baseline and after 12 weeks by a blinded assessor. Within-group change was analysed with paired t-tests and between-group differences with independent t-tests; $p \leq 0.05$ was considered significant.

Results

Both groups improved significantly from baseline to 12 weeks. In Group A, mean FAC rose from 2.2 ± 0.54 to 3.53 ± 0.88 ($t = 37.3$, $p \leq 0.05$) and mean gait velocity on the 10MWT rose from 0.34 ± 0.15 m/s to 0.50 ± 0.25 m/s ($t = 24$, $p \leq 0.05$). In Group B, mean FAC rose from 2.3 ± 0.45 to 2.63 ± 0.53 ($t = 11.9$, $p \leq 0.05$) and mean gait velocity rose from 0.32 ± 0.12 m/s to 0.37 ± 0.12 m/s ($t = 20$, $p \leq 0.05$). The magnitude of improvement was significantly greater in Group A than in Group B for both FAC ($t = 75.18$, $p \leq 0.05$) and gait velocity ($t = 72.22$, $p \leq 0.05$).

Conclusion

Twelve weeks of manual BWSTT combined with conventional therapy produced significantly greater gains in functional ambulation and gait velocity than conventional overground gait training alone in subjects with acute post-stroke hemiparesis.Manual BWSTT is well tolerated and represents a practical, task-specific adjunct to standard stroke rehabilitation in a clinical setting.

1. INTRODUCTION

Stroke is a leading cause of long-term disability worldwide, and gait restoration is one of the principal goals of post-stroke rehabilitation.[1] Following stroke, residual weakness, impaired coordination, and asymmetrical loading commonly compromise independent ambulation, and approximately one-third of stroke survivors remain unable to walk independently three months after admission.[2] Because current concepts of motor learning favour task-specific, repetitive practice "the best way to improve walking is to walk" considerable attention has been directed toward locomotor training strategies that permit early, high-repetition practice of complete gait cycles.[3]

Body weight supported treadmill training manual (BWSTT) uses an overhead harness to unload a portion of body weight while the subject practises stepping on a moving treadmill, with a therapist assisting limb advancement, weight transfer, and postural control as needed. The approach is grounded in animal locomotor studies demonstrating that spinal central pattern generators can produce coordinated stepping when adequately loaded and cued, and in human studies showing that treadmill-driven, harness-supported stepping can normalize temporal and kinematic gait parameters even in severely hemiparetic subjects.[4,5] Because manual BWSTT permits subjects to practise walking earlier and at faster cadences than they could tolerate overground, it has been proposed to enhance gait symmetry, endurance, and velocity beyond what conventional overground gait training (COGT) achieves alone.[6]

Several trials report that manual BWSTT improves overground walking speed, endurance, functional balance, and lower-limb motor recovery in stroke populations,[7,8] though not all systematic reviews have found a consistent overall advantage over conventional training, and the relative contribution of BWSTT to gains in walking speed and functional gait remains incompletely understood.[9] This trial was undertaken to compare the effectiveness of Manual BWSTT, added to a conventional rehabilitation programme, against COGT alone, in improving functional ambulation and gait velocity in subjects with acute post-stroke hemiparesis.

The primary hypothesis was that manual BWSTT would produce significantly greater improvement in functional ambulation category and gait velocity than COGT when used to train ambulation in post-stroke hemiparetic subjects.

2. MATERIALS AND METHODS

2.1 Study Design

This was a prospective, single-blind, randomized controlled trial with two parallel arms, conducted in the outpatient department of Physiotherapy, Hi-Tech Medical College & Hospital, Bhubaneswar, Odisha, between October and March. Institutional Review Board approval was obtained, and written informed consent was taken from every subject prior to enrolment.

2.2 Participants

Sixty subjects with acute stroke-induced hemiparesis, aged 40–60 years, were recruited by purposive sampling. Inclusion criteria were: age 40–60 years, either sex; left or right hemiplegia following ischaemic or haemorrhagic stroke; ability to communicate discomfort or needs; onset within 90 days; Modified Ashworth Scale ≤ 1 for the lower extremity; Berg Balance Scale grade 3 (score > 26); Mini-Mental State Examination score

> 24; and Functional Ambulation Category level 2–4. Subjects were excluded if they were outside the 40–60 year age range; were beyond the acute stage (> 3 months post-stroke); had hemiplegia from a non-stroke cause; had uncontrolled metabolic or endocrine disease, orthopaedic conditions limiting gait, unstable cardiac disease, serious visual impairment, pre-existing neurological disorders, uncontrolled seizures, cognitive impairment (MMSE < 24), Modified Ashworth Scale > 1, or no prior treadmill exposure. Training was stopped for any subject if systolic blood pressure exceeded 200 mmHg or diastolic exceeded 110 mmHg, mean blood pressure changed by ≥ 30/20 mmHg, heart rate exceeded 110 bpm or rose ≥ 30% during the session, or the Borg RPE score exceeded 7.

2.3 Randomization and Groups

Eligible, consenting subjects were allocated by block randomization (sealed-envelope method) into one of two groups of 30. Group A (experimental) received manual BWSTT in addition to a conventional rehabilitation programme. Group B (control) received the same conventional programme with overground gait training in place of BWSTT. Both groups trained for the same total practice time 20 minutes of walking practice per session, 4 days weekly, for 12 weeks (48 sessions).

2.4 Interventions

Conventional rehabilitation, common to both groups, comprised range-of-motion exercises, active-assisted and active-resisted strengthening, proprioceptive neuromuscular facilitation, stretching, and balance and functional activities tailored to each subject's needs.

Technical Specifications & Structural Dimensions

Provide an itemized breakdown or technical table specifying dimensions, load ratings, and materials:

- Overhead Iron Frame:
- Structural steel/cast-iron hollow square or tubular sections (e.g., 2" \times 2" with 12-gauge thickness).
- Dimensions: Base width straddling the treadmill (adequate clearance for treadmill handrails and therapist assistance), height (typically 7–8 ft to clear patient height while upright).
- Base stabilization: Floor-mounted anchor plates or broad H-frame base with diagonal corner gussets to prevent shear and lateral sway during ambulation.

Suspension & Counterweight System:

- Fixed overhead pulley system (rated for high static/dynamic tensile strength).
- Solid steel counterweight loading rod equipped with safety barbell collars.
- Standard iron ring weights (counterweights) calibrated in 0.5 kg, 1 kg, 2 kg, and 5 kg increments.

Harness Assembly:

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- Padded canvas or high-density nylon construction with heavy-duty webbing straps.
- Multi-point closure: circumferential pelvic belt, reinforced groin/thigh loops to distribute weight evenly and prevent perineal skin shear.
- Dual-point suspension rings (D-rings) positioned bilaterally along the mid-axillary line to maintain symmetrical pelvic orientation.

Group A additionally received manual BWSTT on a motor-driven treadmill with variable speed control, using an overhead suspension harness comprising a pelvic belt and bilateral thigh straps. Body weight support began at approximately 40% and was reduced progressively toward 25% as tolerated, since unloading beyond roughly 40% prevented an adequate heel strike. Initial treadmill speed was set at the subject's fastest comfortable pace achievable within the first two minutes of the first session and progressed thereafter; manual facilitation of heel strike, knee control, hip extension, pelvic stabilization, and step symmetry was provided by one or two therapists as needed and withdrawn as the subject's control improved. Handrail holding was discouraged to preserve reciprocal arm swing.

Group B received overground gait training for an equivalent 20 minutes per session in place of manual BWSTT, using the same session frequency and duration.

Heart rate and blood pressure were monitored before each session, at rest breaks, and after completion, and sessions were terminated according to the pre-specified termination criteria above or if the subject reported dyspnoea, fatigue, palpitation, excessive sweating, or reduced gait performance.

2.5 Outcome Measures

The Functional Ambulation Category (FAC) was used to grade gait ability on a 6-level ordinal scale (0 = unable to walk or requiring the support of two or more people, through 5 = independent ambulation on any surface), based on a 10-metre walk. The FAC has reported intra-rater reliability of 0.92 and inter-rater reliability of 0.98.[10] Overground gait velocity was assessed with the comfortable 10-metre walk test (10MWT), conducted over a 14-metre walkway with timing over the middle 10 metres using a stopwatch; each subject completed three trials and the mean was used for analysis. Both outcomes were recorded at baseline and after 12 weeks by an assessor blinded to group allocation.

2.6 Statistical Analysis

Data were analysed using Microsoft Excel. Descriptive statistics (mean, standard deviation) were computed for all variables. Paired t-tests compared pre- and post-intervention values within each group (intragroup analysis), and independent t-tests compared the magnitude of change between groups (intergroup analysis). A value of $p \leq 0.05$ was considered statistically significant.

3. RESULTS

Sixty subjects (40 men, 20 women; 66.67% and 33.33% respectively) completed the study, 30 in each group. Mean age was comparable between groups: 54.5 ± 3.98

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years in Group A and 54.36 ± 4.30 years in Group B.

3.1 Functional Ambulation Category

Mean FAC in Group A improved from 2.2 ± 0.54 at baseline to 3.53 ± 0.88 at 12 weeks (paired $t = 37.3$, $p \leq 0.05$). Mean FAC in Group B improved from 2.3 ± 0.45 to 2.63 ± 0.53 (paired $t = 11.9$, $p \leq 0.05$). The between-group comparison of the magnitude of change showed a significantly greater improvement in Group A than Group B ($t = 75.18$, $p \leq 0.05$).

Table 1. Functional Ambulation Category (FAC): pre- and post-intervention values

Group	Pre-intervention (Mean ± SD)	Post-intervention (Mean ± SD)	t-value	p-value
Group A (BWSTT)	2.2 ± 0.54	3.53 ± 0.88	37.3	≤ 0.05
Group B (COGT)	2.3 ± 0.45	2.63 ± 0.53	11.9	≤ 0.05

Table 2. Between-group comparison of the difference (Δ) in FAC

Comparison	t-value	p-value
Δ FAC, Group A vs Group B	75.18	≤ 0.05

3.2 Gait Velocity (10-metre Walk Test)

Mean gait velocity in Group A improved from 0.34 ± 0.15 m/s at baseline to 0.50 ± 0.25 m/s at 12 weeks (paired $t = 24$, $p \leq 0.05$). Mean gait velocity in Group B improved from 0.32 ± 0.12 m/s to 0.37 ± 0.12 m/s (paired $t = 20$, $p \leq 0.05$). The between-group comparison showed a significantly greater improvement in Group A than Group B ($t = 72.22$, $p \leq 0.05$).

Table 3. 10-metre walk test gait velocity (m/s): pre- and post-intervention values

Group	Pre-intervention (Mean ± SD)	Post-intervention (Mean ± SD)	t-value	p-value
Group A (BWSTT)	0.34 ± 0.15	0.50 ± 0.25	24	≤ 0.05
Group B (COGT)	0.32 ± 0.12	0.37 ± 0.12	20	≤ 0.05

Table 4. Between-group comparison of the difference (Δ) in gait velocity

Comparison	t-value	p-value
Δ 10MWT, Group A vs Group B	72.22	≤ 0.05

By the end of the intervention, gait capability had improved in every subject as measured by FAC. Most subjects in Group A achieved independent ambulation, with a minority requiring assistance on stairs or uneven surfaces and a smaller number still requiring verbal supervision, consistent with the reported correlation between gains in gait velocity and gains in functional ambulation category.

4. DISCUSSION

This trial compared 12 weeks of BWSTT, added to conventional therapy, against conventional overground gait training alone, in subjects with acute post-stroke hemiparesis. Both groups improved on FAC and gait velocity, but the magnitude of improvement was significantly greater in the group that received BWSTT, consistent with previous reports that BWSTT enhances overground walking speed, endurance, functional balance, and lower-limb motor recovery after stroke.[7,8]

Several mechanisms may explain this advantage. During BWSTT, harness support allowed subjects to practise stepping at treadmill speeds faster than their self-selected overground pace; carryover of this higher-cadence, higher-repetition practice to overground walking is a plausible route by which BWSTT increased 10MWT velocity beyond that achieved with COGT alone.[6] Body weight support also permits earlier initiation of gait training before a subject can fully bear weight overground allowing more cumulative practice of complete gait cycles across the study period.[4,5] Unloading further discourages compensatory strategies that reinforce gait asymmetry, allowing more normal limb loading, stepping, and balance to be practised together, in line with the concept of task-specific, dynamic locomotor training.[11]

The parallel improvement in gait velocity and functional ambulation category observed here is consistent with the reported correlation between these two measures,[10] and is notable because, at baseline, every subject required physical assistance to walk, while post-intervention gait velocity was measured without external support in both groups. The harness system may also have reduced fear of falling during early practice, a known barrier to gait re-training after stroke, by allowing subjects to step without risk of a fall.[12]

These findings are broadly consistent with a body of literature reporting that BWSTT leads to more successful recovery of ambulation than overground training with respect to walking speed, endurance, functional balance, and motor recovery,[7,8] although some systematic reviews have found no consistent overall advantage of treadmill training with body weight support over conventional training when pooled across heterogeneous protocols and populations.[9] The present trial's relatively standardized protocol a fixed 90-day acute window, matched practice time, and a graded body-weight-support progression from 40% toward 25% may account for the clear separation between groups observed here.

4.1 Limitations

Subjects were not stratified by baseline hemiparetic severity, and the only control on chronicity was a minimum post-stroke interval; the exact time since stroke and prior activity level otherwise varied within the 90-day acute window, which may have influenced the observed magnitude of improvement. Outcome assessment relied on the FAC and 10MWT alone, without instrumented gait analysis, spasticity, or balance outcomes, limiting insight into the

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specific mechanisms of paretic-limb function underlying the observed gains. The sample was drawn from a single centre using purposive sampling, which may limit generalizability, and long-term follow-up beyond the 12-week intervention period was not performed.

5. CONCLUSION

Twelve weeks of body weight supported treadmill training, added to a conventional rehabilitation programme, produced significantly greater improvement in functional ambulation and gait velocity than conventional overground gait training alone in subjects with acute post-stroke hemiparesis.Manual BWSTT was well tolerated and represents a practical, task-specific training strategy compatible with rehabilitation practice in a clinical setting. Further research with instrumented gait analysis and longer follow-up is warranted to clarify the mechanisms underlying paretic-limb recovery with this approach.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

SOURCE OF FUNDING

None.

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