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COMPARATIVE EFFECTS OF BACKWARD WALKING TRAINING AND STANDING BALANCE TRAINING ON WALKING SPEED AND BALANCE IN PATIENTS WITH SUB-ACUTE STROKE

Original Research

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ABSTRACT

Background: Stroke is a neurological disorder characterized by motor impairments and functional limitations, requiring timely rehabilitation to restore mobility and balance. In the sub-acute phase, effective interventions are crucial for optimizing recovery and reducing fall risks. Backward walking training (BWT) has emerged as a promising technique to enhance gait and balance by leveraging neuroplasticity. This study compares the effects of BWT and standing balance training (SBT) on walking speed and balance in individuals undergoing sub-acute stroke rehabilitation.

Objective: To evaluate and compare the effectiveness of backward walking training and standing balance training on improving walking speed and balance in patients during the sub-acute phase of stroke rehabilitation.

Methods: This randomized controlled trial was conducted on 60 sub-acute stroke patients aged 18–50 years, using non-probability convenience sampling. Participants were randomly assigned into two groups: Group A received BWT combined with task-oriented and standard rehabilitation, while Group B received SBT alongside similar therapies. Outcomes were measured at baseline, after the 2nd week, and at the 4th week using the 6-Minute Walk Test (6-MWT), 3-Meter Backward Walk Test (3-MBWT), and Berg Balance Scale (BBS). Statistical analyses included repeated measures ANOVA for intragroup comparisons and independent sample t-tests for intergroup differences, with significance set at $p < 0.05$.

Results: Group A showed significant improvements, with 6-MWT scores increasing from 0.24 ± 0.03 m/s at baseline to 0.31 ± 0.06 m/s at the 4th week, compared to Group B's increase from 0.22 ± 0.04 m/s to 0.25 ± 0.06 m/s ($p = 0.00$). For 3-MBWT, Group A improved from 0.15 ± 0.01 m/s to 0.21 ± 0.03 m/s, while Group B advanced from 0.15 ± 0.02 m/s to 0.18 ± 0.03 m/s ($p = 0.00$). BBS scores for Group A increased from 28.43 ± 4.34 to 42.03 ± 4.22, outperforming Group B, which improved from 27.32 ± 4.00 to 30.84 ± 3.77 ($p = 0.00$).

Conclusion: Backward walking training significantly outperformed standing balance training in improving both forward and backward walking speed, balance, and gait in sub-acute stroke patients, highlighting its potential as a key rehabilitation strategy.

Keywords: Balance training, Berg Balance Scale, Gait speed, Neuroplasticity, Rehabilitation, Stroke, Walking therapy.

INTRODUCTION

Stroke is a neurological disorder marked by impairments in motor control and significant functional limitations in locomotion due to vascular events. These events result in symptoms persisting for more than 24 hours and, in severe cases, can lead to death (1). Stroke is one of the most prevalent disorders of the nervous system, primarily caused by hypo-perfusion or micro-embolization of the brain (2, 3). Globally, it stands as the second leading cause of mortality, with high-income countries reporting disabling strokes occurring typically at an average age of 57, compared to 66 years in Africa. The annual incidence of stroke has been estimated at 316 per lakh population, with age-adjusted rates reaching 981 per lakh, and a 30% increase in stroke prevalence has been observed in low-income countries and parts of Asia over the last three decades (4).

In stroke survivors, particularly during the sub-acute phase, balance instability and falls are common, often resulting in severe activity limitations, communication impairments, and aphasia (5, 6). The sub-acute phase, occurring between two weeks to six months post-stroke onset, represents a critical recovery period. Rehabilitation during this phase is crucial for restoring functional independence and enhancing motor recovery (7, 8). Emerging evidence highlights the role of neuroplasticity in rehabilitation, emphasizing that novel and complex tasks can foster cortical neuronal remodeling. Backward walking training (BWT) has been identified as a promising intervention that leverages neuroplasticity by strongly activating neuronal circuits disrupted by stroke. Unlike forward walking, backward walking requires knee flexion and hip extension to propel the lower limbs, disrupting the dominant flexor synergy pattern often seen in post-stroke individuals and facilitating improved muscle activation and motor control (9, 10).

Backward walking also engages higher levels of energy expenditure, oxygen consumption, and cardiorespiratory and metabolic responses compared to forward walking (11). These unique biomechanical and physiological demands have been associated with enhanced coordination, neuromuscular efficiency, and functional gait improvements, potentially benefiting the mechanisms underlying forward walking. While research has explored the effects of backward walking and standing balance training (SBT) individually in acute stroke populations, there is a dearth of studies examining their comparative benefits in sub-acute stroke rehabilitation, especially when combined with task-oriented training (12).

Given the increasing burden of stroke-related disabilities and the need for cost-effective, accessible rehabilitation strategies, this study aims to address the gap by comparing the effects of BWT and SBT on walking speed and balance in individuals in the sub-acute phase of recovery. The findings are intended to guide practitioners in designing comprehensive and effective rehabilitation programs that promote early improvements in balance, gait, and motor recovery, ultimately enhancing the quality of life for sub-acute stroke patients. The objective of this research is to rationally evaluate the differential impact of these interventions, contributing valuable insights to the field of stroke rehabilitation.

METHODS

This randomized controlled trial was conducted at Madinah Teaching Hospital, Faisalabad, over a nine-month period following ethical approval from the University of Lahore Institutional Review Board (Ref. No. IRB-UOL-FAHS/740-V/2020). The study aimed to assess and compare the effects of backward walking training (BWT) and standing balance training (SBT) on walking speed and balance in patients with sub-acute stroke. The sample size was calculated as 60 participants (30 in each group), with an additional 20% allowance for dropout, resulting in a final recruitment target of 70 participants (35 in each group). The sample size calculation followed a standard formula incorporating parameters such as level of significance, power, expected means, and standard deviations for both groups.

Participants were recruited using non-probability convenience sampling. Eligibility criteria included individuals aged 18 to 50 years who had experienced their first stroke within the past 45 days, were able to maintain an upright standing posture with moderate assistance, had vision within functional limits, could comprehend oral commands, and were expected to remain in the region for the study duration. Exclusion criteria were not explicitly mentioned, which may be considered a methodological limitation. Each participant provided informed consent, including permission to use anonymized images.

After screening, participants were randomly allocated to two groups using a sealed-envelope method consistent with CONSORT guidelines. Group A received task-oriented training, including grasping objects and constraint-induced movement therapy (CIMT), combined with BWT. Group B received similar task-oriented training combined with SBT. Both interventions were delivered for 60 minutes, three times per week, over four weeks.

In Group A, BWT was implemented to improve balance and mobility patterns by focusing on backward stepping, which challenges postural stability and promotes neuromuscular activation. Participants started with 100 meters of backward walking per session, with weekly increments of 20 meters, reaching 160 meters by the fourth week. The therapist provided initial assistance and gradually reduced support as participants demonstrated improved gait control and balance. Specific therapeutic strategies included aiding limb advancement and weight transfer while maintaining postural stability. For patients losing balance more than 50% of the time, hand-held assistance was reintroduced to ensure safety and continuity of training.

Figure 1 Backward walking training (BWT)

Group B participants underwent SBT designed to enhance static and dynamic balance through progressive weight-shifting and postural exercises. Weekly progression included tasks such as weight-shifting from side to side, forward and backward, standing with feet apart or together, and reaching for objects within or beyond the base of support. These exercises targeted postural control and functional reach, with task complexity increasing incrementally over the four-week period.

Figure 2 Standing balance training (SBT)

Outcome measures were assessed using the 6-Meter Walk Test (6-MWT) for gait speed, the 3-Meter Backward Walk Test (3-MBWT) for backward walking speed, and the Berg Balance Scale (BBS) for static and dynamic balance. Evaluations were conducted at baseline, the second week, and the fourth week. The tests were performed with minimal orthotic or assistive devices to accurately reflect functional capabilities. Data were analyzed using SPSS version 23.0. Descriptive statistics summarized qualitative variables as frequencies and percentages, while quantitative data were presented as mean ± standard deviation. Normality of data was assessed using Kolmogorov-Smirnov and Shapiro-Wilk tests, confirming normal distribution. Repeated measures ANOVA was used for within-group comparisons, while independent sample t-tests were applied for between-group differences, with a significance threshold set at $p < 0.05$.

RESULTS

The study included 60 participants divided equally into two groups, Group A (Backward Walking Training, BWT) and Group B (Standing Balance Training, SBT), with comparable demographic characteristics. The mean age of participants in Group A was 35.70 ± 9.6 years, while Group B had a mean age of 35.10 ± 8.7 years. A majority of participants (58.3%) were male, and 60% had left-sided strokes. Ischemic strokes were predominant in both groups, occurring in 66.7% of participants. The body mass index (BMI) distribution showed 20% of participants in Group A and 30% in Group B classified as obese, with Group A having a mean BMI of 24.52 ± 5.038 and Group B at 25.84 ± 5.53.

In the 6-Minute Walk Test (6-MWT), Group A showed significant improvement from a baseline mean of 0.24 ± 0.03 to 0.31 ± 0.06 at the fourth week. In contrast, Group B exhibited a more modest increase, with a baseline mean of 0.22 ± 0.04 progressing to 0.25 ± 0.06 at week four. The 3-Meter Backward Walk Test (3-MBWT) in Group A improved from 0.15 ± 0.01 at baseline to 0.21 ± 0.03, while Group B progressed from 0.15 ± 0.02 to 0.18 ± 0.03. Statistically significant differences were observed between groups in both 6-MWT and 3-MBWT outcomes at the fourth week ($p < 0.05$).

The Berg Balance Scale (BBS) scores at baseline were similar between groups, with Group A scoring 28.43 ± 4.34 and Group B at 27.32 ± 4.00. By the fourth week, Group A achieved a mean score of 42.03 ± 4.22, showing a marked improvement, whereas Group B improved to a mean score of 30.84 ± 3.77. While both groups improved, Group A demonstrated greater gains in balance and walking metrics. Missing details about long-term follow-up or specific subgroup outcomes may limit the comprehensive understanding of these interventions.

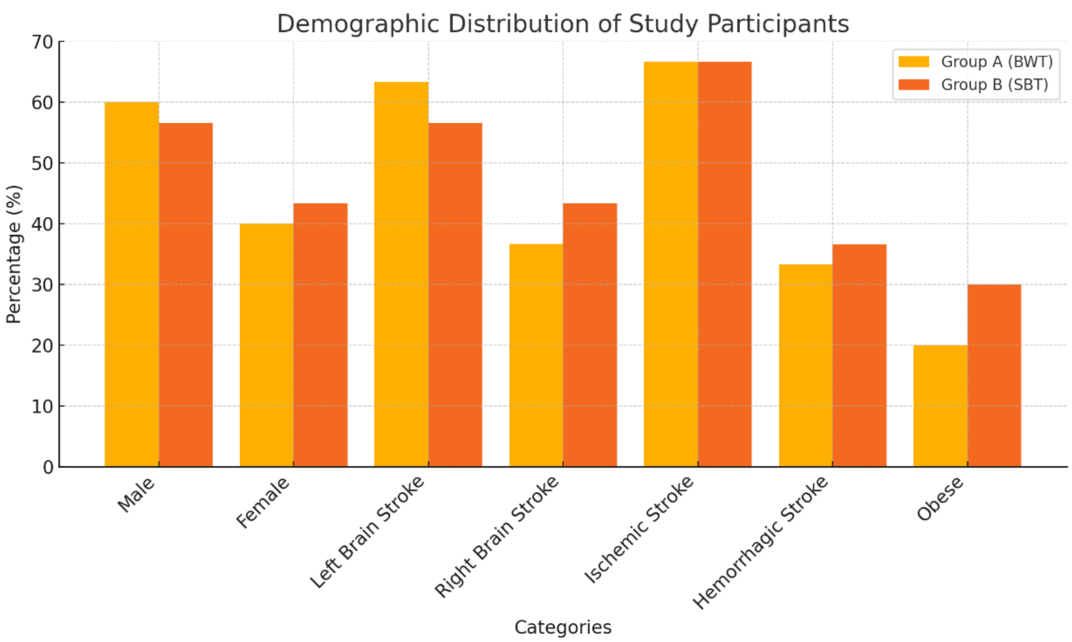

Figure 3 Demographic Distribution Of Study Participants

The demographic distribution of the study participants revealed balanced characteristics between Group A (Backward Walking Training, BWT) and Group B (Standing Balance Training, SBT). Group A comprised 60% males and 40% females, while Group B included 56.6% males and 43.3% females. Left-sided strokes were more common in both groups, with 63.3% in Group A and 56.6% in Group B. Similarly, ischemic strokes predominated, accounting for 66.7% of cases in both groups. The BMI distribution showed that 20% of Group A participants and 30% of Group B participants were classified as obese, while healthy weight proportions were 53.3% and 40% for Groups A and B, respectively. These balanced demographic variables ensured comparability between groups for the intervention outcomes.

Table: 1 Demographic Data of Participants

	Category	Group A (BWT) (N=30)	Group B (SBT) (N=30)
Gender	Male	18(60%)	17(56.6%)
	Female	12(40%)	13(43.3%)
Involved side	Left Brain Stroke	19(63.3%)	17(56.6%)
	Right Brain Stroke	11(36.7%)	13(43.3%)
Type of Stroke	Ischemic Stroke	20(66.7%)	20(66.7%)

	Category	Group A (BWT) (N=30)	Group B (SBT) (N=30)
	Hemorrhagic Stroke	10(33.33%)	11(36.6%)
Body Mass Index	Underweight	2(6.7%)	2(6.7%)
	Healthy weight	16(53.3%)	12(40.%)
	Overweight	6(20.0%)	8(26.6%)
	Obese	6(20.0%)	9(30.%)

The mean age of group A participant was found to be 35.70 ± 9.6 years and group B was 35.10 ± 8.7 years. The mean age of group A and B participants were 35.70 ± 9.6 and 35.10 ± 8.7 year. In current study 35(58.3%) male and females 25(41.66%). 36(60%) were having left sided stroke 40(66.66%) were having Ischemic stroke and 14(23.3%) in overweight and 15(25%) in Obese category of BMI. The BMI of group A participants was 24.52 ± 5.038 and group B was 25.84 ± 5.53. (Table .No 1)

Table 2 Intra- Group Comparison

Outcomes			Group A (BWT Group)		Group B (SBT Group)		P Value
6MWT		N	Mean	SD	Mean	SD	.00
	Baseline	30	.24	.03	.22	.04	
	After 2nd week	30	.27	.04	.24	.04	
	After 4th week	30	.31	.06	.25	.05	
3-MBWT	Baseline	30	.15	.01	.15	.02	.00
	After 2nd week	30	.18	.02	.17	.02	
	After 4th week	30	.21	.03	.18	.03	
BBS	Baseline	30	28.43	4.33	27.32	4.00	00
	After 2nd week	30	35.87	4.11	29.29	3.89	
	After 4th week	30	42.03	4.22	30.84	3.76	

The results of 6-MWT at baseline in group A was 0.24 ± 0.03 and at 4th week, it was 0.31 ± 0.06 , while in group B 6-MWT at baseline was 0.22 ± 0.04 and at 4th week, it was 0.25 ± 0.06. The results of 3-MBWT baseline was 0.15 ± 0.01, after at 4th week, it was 0.21 ± 0.03. While in group B , 3-MBWT the mean score baseline was 0.15 ± 0.02 and at 4th week, it was 0.18 ± 0.03. The results of BBS at baseline in group A was 28.43 ± 4.34 and at 4th week, it was 42.03 ± 4.22 While in Group B , BBS baseline 27.32 ± 4.00 and 4th week, it was 30.84 ± 3.77. (Table .No 2)

Table: 3 Inter Group Comparison A and B

		t-test for Equality of Means						
		t	Df.	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
6-MWT Baseline	Equal variances assumed	1.75	59	.08	.01	.00	-.00	.03
	Equal variances not assumed	1.75	58.89	.08	.01	.00	-.00	.03
6-MWT 4th week	Equal variances assumed	4.02	59	.00	.06	.01	.03	.09
	Equal variances not assumed	4.01	58.29	.00	.06	.01	.03	.09
3-	Equal variances	-1.08	59	.28	-.00	.0	-.01	.00
MBWT Baseline	assumed							
	Equal variances not assumed	-1.08	58.99	.28	-.00	.0	-.01	.00
3- MBWT 4th WEEK	Equal variances assumed	3.30	59	.00	.02	.0	.01	.04
	Equal variances not assumed	3.29	57.32	.00	.02	.0	.011	.04
BBS at baseline	Equal variances assumed	1.04	59	.30	1.11	1.06	-1.0	3.24
	Equal variances not assumed	1.03	58.2	.30	1.11	1.06	-1.0	3.25
BBS after 4th week	Equal variances assumed	10.93	59	.00	11.19	1.02	9.14	13.24
	Equal variances not assumed	10.91	57.7	.00	11.19	1.02	9.14	13.24

The inter-group comparison demonstrated statistically significant differences in outcomes between Group A (BWT) and Group B (SBT). For the 6-Minute Walk Test (6-MWT) at the fourth week, Group A exhibited a significantly greater improvement with a mean difference of 0.06 ($p = 0.00$), whereas baseline scores showed no significant difference ($p = 0.08$). Similarly, the 3-Meter Backward Walk Test (3-MBWT) at the fourth week showed a significant mean difference of 0.02 ($p = 0.00$), though baseline scores were comparable ($p = 0.28$). For the Berg Balance Scale (BBS), significant improvements were noted at the fourth week, with Group A achieving an 11.19-point higher mean score than Group B (p = 0.00). However, baseline BBS scores showed no significant difference between groups (p = 0.30). These results highlight the superior efficacy of BWT over SBT in improving gait speed, backward walking, and balance in sub-acute stroke patients.

DISCUSSION

The findings of this study highlight the comparative effectiveness of backward walking training (BWT) versus standing balance training (SBT) in enhancing walking speed and balance in sub-acute stroke patients (13). Both techniques demonstrated efficacy, but BWT showed statistically significant superiority in improving gait speed and postural control. These improvements can be attributed to the dynamic and static postural demands of BWT, which may have facilitated enhanced sensory input and neuromuscular activation. The increased muscular engagement, particularly in hip extensors critical for gait efficiency, underscores the potential of BWT in addressing functional impairments post-stroke (14, 15).

The study's results align with previous research suggesting that backward walking engages fundamental neuronal circuits shared with forward walking, enabling cross-functional improvements in gait-related tasks. This dual activation supports the concept of neuroplasticity, where rehabilitative efforts target injured neural circuits and enhance recovery outcomes (16). Participants in the BWT group achieved higher backward walking speeds, some exceeding 0.25 m/s, which has implications for reducing fall risk and improving mobility-related confidence, an essential component of post-stroke rehabilitation (17). These findings are consistent with evidence supporting the role of task-specific and progressive resistance training in improving mobility and balance in stroke survivors (18, 19).

While the study reinforces the benefits of BWT, it also highlights the complementary role of traditional approaches such as mirror therapy and progressive resistive exercises in enhancing limb function and overall rehabilitation outcomes (20). However, certain limitations warrant consideration (21). The absence of long-term follow-up restricts insights into the sustainability of these functional gains. Furthermore, interactions between routine physical therapy and group-specific techniques, such as BWT or SBT, may have influenced outcomes, underscoring the need for more controlled investigations to delineate these effects (22, 23).

Despite these constraints, the study's strengths lie in its structured methodology and robust comparative analysis, which provide evidence for the safety and efficacy of BWT as a rehabilitation strategy. Incorporating BWT into standard rehabilitation programs can yield superior improvements in walking capacity and balance, offering a viable and innovative approach for ambulatory hemiparetic patients. These findings contribute valuable knowledge to the growing body of evidence supporting task-oriented, neuroplasticity-driven interventions in post-stroke recovery.

CONCLUSION

Backward walking training demonstrated greater effectiveness than standing balance training in improving critical functional outcomes in sub-acute stroke patients. It not only enhanced backward walking speed and balance, essential factors for reducing fall risk, but also contributed to notable improvements in forward gait speed. These findings support the integration of backward walking training as a key component in rehabilitation programs, offering a dynamic and neuroplasticity-driven approach to optimize recovery and mobility in stroke survivors.

AUTHOR CONTRIBUTIONS

Author	Contribution
Muhammad Umer Shabbir	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Adiba Javed	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Zain Ali	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Rafia Ather	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Mehneel Saqib	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Zermeen Zerish	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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