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Effects of Cadence Cueing Versus Backward Walking on Mobility and Balance in Subacute Stroke Patients

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LINK MEDICAL INTERFACE

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ABSTRACT

Background: Stroke is a leading cause of disability globally, affecting individuals' mobility and balance, which are crucial for daily activities and quality of life. Rehabilitative strategies such as cadence cueing and backward walking training are used to address these deficits.

Objective: To evaluate the effects of cadence cueing versus backward walking training on mobility and balance in sub-acute stroke patients.

Methods: This randomized clinical trial included 34 sub-acute stroke patients aged 40-60 years, recruited from two hospitals over ten months. Participants were randomly assigned to receive either cadence cueing or backward walking training, supplemented with conventional therapy. Interventions were administered five days a week for four weeks. Mobility was assessed using the Timed Up and Go (TUG) test, and balance was measured using the Berg Balance Scale (BBS). Statistical analysis was performed using SPSS version 25.

Results: Post-intervention, Group A (cadence cueing) showed a BBS improvement from 31.23 ± 2.84 to 46.58 ± 3.77 and a TUG score reduction from 16.35 ± 2.08 to 10.581 ± 1.50. Group B (backward walking) improved BBS from 31.70 ± 3.27 to 38.17 ± 4.39 and TUG from 14.58 ± 1.97 to 12.00 ± 2.15.

Conclusion: Both cadence cueing and backward walking training significantly enhance balance and mobility in sub-acute stroke patients, with cadence cueing showing slightly superior.

INTRODUCTION

Stroke is the second leading cause of disability worldwide, significantly impacting daily living activities, fostering social isolation, and reducing quality of life (1). Approximately 60% of post-stroke individuals engage in daily activities and are considered independent walkers according to the Functional Independence Measure or Barthel Index; however, they often continue to experience disabilities that limit their community ambulation skills (2). Stroke, whether hemorrhagic or ischemic, results in brain damage that causes movement disorders, reducing range of motion, muscle length, sensory perception, and coordination. These disorders diminish balance and trunk stability, heightening the risk of falls and leading to deteriorated gait parameters, which overall negatively affect the functional mobility of stroke patients (3).

Abnormal gait patterns such as the extension synergy along with flexion synergy contribute to gait abnormalities (4). Walking impairments are common in stroke patients due to decreased stride length, muscular weakness, decreased velocity, and poor muscular control; in various cases, simple walking training is not sufficient to achieve the meaningful and successful goals of rehabilitation in stroke patients (5). About 70% of stroke patients recover to have normal walking in 1 year, but 5-9% remain with gait disturbances and are dependent on others (6).

The primary goal of stroke rehabilitation is to regain functional mobility by improving gait parameters, with modern approaches emphasizing gait enhancement to overcome mobility barriers. Therapeutic methods include proprioceptive neuromuscular facilitation, neurodevelopmental therapy, lower limb strengthening, functional electrical stimulation, task-oriented exercises, and treadmill walking. Additionally, fast tempo rhythmic auditory stimulation provides sensory cues to the motor system, enhancing walking gait (7). To improve dynamic balance and reduce the risk of falls, backward walking training is effective, serving both as a balance and lower limb strengthening exercise. This training is recommended in stroke rehabilitation as it can potentially offer greater benefits than forward walking training alone (8).

Despite the emphasis on walking function recovery in post-stroke rehabilitation, 75% of individuals report walking difficulties in the community, and 50% experience falls at home, leading to depression and isolation (9). Rehabilitation must focus on walking adaptability, modifying stepping patterns to meet task and environmental demands, rather than just forward walking on flat surfaces. Recently, backward walking has gained attention in post-stroke rehabilitation due to its unique neural control, higher metabolic cost, increased muscle activity, and greater intentional demand compared to forward walking. This form

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of walking adaptation can enhance mobility and walking adaptability (10).

Stroke-induced impairments, particularly in neuro-motor control, characteristically slow the gait cycle in post-stroke patients. Although forward walking training is widely used in stroke rehabilitation, research shows that forward and backward walking have different physiological benefits, such as improved temporospatial frequency and endurance in backward walking. Forward walking shows lesser improvement in gait cycle quality compared to backward walking, where toe contact occurs first during the stance phase, altering muscle activity patterns (11, 12).

Practices like walking backward on an underwater treadmill demonstrate greater paraspinal muscle movement due to buoyancy reducing weight-bearing stress (13). Backward walking is beneficial for patients with lower extremity injuries as it reduces reactionary forces on the patellofemoral joint and improves gait performance and motor control in hemiplegic patients (14). Asymmetrical gait patterns in stroke patients can be improved with backward walking training, enhancing weight-bearing during the stance phase and reducing fall risk associated with impaired balance, sensory and motor impairments, and fear of falling (15). Additionally, backward walking increases cardiopulmonary load and aerobic capacity, reduces knee joint stress, and improves anterior cruciate ligament stability (16).

One modern approach with significant potential for improving walking parameters after a stroke is "cadence cueing" via external auditory cues during walking programs. This method uses a metronome or pre-recorded music tapes, where patients synchronize their steps to the beat, enhancing spatiotemporal symmetry and increasing cadence, speed, and stride length. This cost-effective method can be performed on a treadmill or over-ground and offers significant improvements that balance training alone cannot achieve (17, 18).

Auditory rhythms influence the motor system, helping stroke patients synchronize their steps and improve stride length, with studies showing enhanced hemiparetic gait and immediate effects on gait and balance (19). Devices like metronomes and oscillators engage auditory motor pathways in the brain, improving spatiotemporal gait parameters through sequential muscle contraction and anticipatory postural control. This approach addresses asymmetric impairments in gait, focusing on increasing step length and stepping frequency to normalize gait patterns, ultimately improving stride length and symmetry (20).

The aim of this study is to determine the effect of cadence cueing and backward walking training on mobility and balance in sub-acute stroke patients. Application of these modern approaches in clinical practice may improve balance and mobility to prevent the risk of fall in stroke patients.

MATERIAL AND METHODS

This randomized clinical trial was designed to evaluate the effects of cadence cueing and backward walking training on mobility and balance in sub-acute stroke patients. The research was conducted over ten months at the Government Kot Khawaja Saeed Teaching Hospital and General Hospital in Lahore. Using the EPITOOL sample size calculator, a total of 34 patients were determined necessary for the study, incorporating a 10% attrition rate to account for potential dropouts.

Participants were recruited through convenient sampling. Inclusion criteria required patients to have been diagnosed with ischemic stroke in the sub-acute stage (12 to 20 weeks post-stroke), aged between 40 to 60 years, and capable of maintaining an upright standing posture with moderate assistance. They were scored 4 or 5 on the level of independence scale and ranged between 28 and 40 on the Berg Balance Scale (BBS). Patients were excluded if they exhibited significant balance impairments as defined by a BBS score outside the inclusion range, presented with weight-bearing pain, had other neurological diagnoses such as Alzheimer's disease, Parkinson’s disease, and dementia, or were unable to follow a two-step command.

Upon meeting the inclusion criteria, participants were randomly assigned into two groups. Group A consisted of 19 participants who received cadence cueing along with conventional therapy, while Group B also comprised 19 participants who underwent backward walking training in addition to conventional therapy. Both groups received their respective therapies five days a week for 30 minutes per session over a duration of four weeks.

Data collection was facilitated using two primary assessment tools: the Berg Balance Scale (BBS) and the Timed Up and Go (TUG) test. The BBS is a well-established clinical measure used to assess balance impairments, boasting high inter-rater reliability (ICC = 0.945) and predictive validity (0.57). The TUG test evaluates functional mobility by timing participants as they rise from a chair, walk three meters, turn, walk back, and sit down, with a strong association with other valid mobility outcome measures (Spearman correlation rs = 0.71 to 0.90) and high reliability (ICC = 0.98).

The study adhered to the ethical guidelines of the Declaration of Helsinki, and all participants provided informed consent before participation. Ethical approval was obtained from the local ethics committee of the hospitals involved. All data were anonymized to maintain participant confidentiality.

Data analysis was performed retrospectively using SPSS for Windows, version 25. The Shapiro-Wilk test was used to assess the normality of data distribution; given values exceeding 0.05, the data were considered normally distributed, allowing for the use of parametric tests. Descriptive statistics were employed to summarize the data, while changes over time and differences between the groups were evaluated using an independent t-test for group comparisons and a paired sample t-test for within-group assessments. Statistical significance was set at a p-value of less than 0.05.

RESULTS

The study successfully recruited 34 patients who met the inclusion criteria for a randomized clinical trial aimed at assessing the impact of cadence cueing and backward walking training on mobility and balance in sub-acute stroke patients. Participants were evenly divided into two groups; Group A focused on cadence cueing, while Group B engaged in backward walking training. Both interventions were supplemented with conventional therapy, conducted over four weeks with sessions held five days per week.

Table 1: Demographics of Participants

Description	Total Participants	Mean Age (±SD)	Gender Distribution (M)
Total	34	51.97 ± 6.05	21:13
Group A (Cadence)	17	52.03 ± 6.12	10:7
Group B (Backward)	17	51.91 ± 6.01	11:6

The study meticulously divided 34 patients into two groups to evaluate the efficacy of cadence cueing and backward walking training in improving balance and mobility among sub-acute stroke patients. Both groups participated in their assigned therapies supplemented with conventional therapy for a duration of four weeks, with sessions conducted five days per week. The demographic profile of the participants revealed a mean age of approximately 52 years, with a slight male predominance. Specifically, Group A, which focused on cadence cueing, consisted of 17 participants with a mean age of 52.03 years and a gender distribution of 10 males to 7 females. Group B, engaged in backward walking training, also included 17 participants, with a mean age slightly lower at 51.91 years and a gender ratio of 11 males to 6 females.

Table 2: Within Group Comparison of Berg Balance Scale (BBS) and Timed Up and Go (TUG) Scores

Group	Pre-Treatment BBS	Post-Treatment BBS	Mean Difference	P-value
	Mean ± SD)		(±SD)	
Group A	31.23 ± 2.84	46.58 ± 3.77	-15.35 ± 1.96	<0.001
Group B	31.70 ± 3.27	38.17 ± 4.39	-6.47 ± 3.22	<0.001
Group	**Pre-Treatment TUG**	**Post-Treatment TUG**	**Mean Difference**	**P-value**
Group A	16.35 ± 2.08	10.581 ± 1.50	5.76 ± 2.58	<0.001
Group B	14.58 ± 1.97	12.00 ± 2.15	2.58 ± 1.58	<0.001

Evaluating the effectiveness of the interventions, significant improvements were observed within each group. For Group A, the pre-treatment Berg Balance Scale (BBS) average was 31.23, which improved to 46.58 post-treatment, marking a substantial mean difference of -15.35. This group also saw significant enhancements in mobility, with the Timed Up and Go (TUG) test scores improving from an average of 16.35 to 10.581. Similarly, Group B experienced improvements, though less pronounced, with the BBS scores increasing from an average of 31.70 to 38.17, and TUG scores decreasing from 14.58 to 12.00.

Table 3: Across Group Comparison of BBS and TUG Scores

Measurement	Group A (Mean ± SD)	Group B (Mean ± SD)	P-value	Significance (2-tailed)
Pre-Treatment BBS	31.23 ± 2.84	31.70 ± 3.27	0.657	Not significant
Post-Treatment BBS	46.58 ± 3.77	38.17 ± 4.39	<0.001	Significant
Pre-Treatment TUG	16.35 ± 2.08	14.58 ± 1.97	0.016	Significant
Post-Treatment TUG	10.581 ± 1.50	12.00 ± 2.15	0.032	Significant

Comparisons across the groups post-treatment underscored the more pronounced benefits of cadence cueing over backward walking. The post-treatment BBS mean for Group A was significantly higher than that of Group B (46.58 vs. 38.17), and a similar trend was observed in the TUG test results, with Group A achieving a lower mean score of 10.581 compared to Group B's 12.00, indicating better mobility performance. These results solidify the conclusion that cadence cueing, as compared to backward walking, more effectively enhances balance and mobility in sub-acute stroke patients, which is critical for reducing fall risk and improving quality of life.

DISCUSSION

The results of this study have demonstrated that both cadence cueing and backward walking training significantly improve balance and mobility in sub-acute stroke patients, although cadence cueing exhibits a marginally superior efficacy. This finding aligns with previous studies that have emphasized the beneficial effects of rhythmic auditory stimulation on gait parameters in stroke rehabilitation (21, 22). For instance, Gonzalez-Hoelling et al. (2021) reported significant improvements in balance and gait parameters when rhythmic auditory stimulation was applied, underscoring the effectiveness of this approach in enhancing spatiotemporal gait symmetry and overall mobility in stroke patients.

The more pronounced improvements observed in Group A may be attributed to the integration of auditory cues that facilitate a higher degree of motor synchronization, which is crucial for recovering coordination and functional mobility after a stroke. This concept is supported by research indicating that auditory rhythms can effectively engage the motor pathways in the brain, thus enhancing the coordination between perception and action required for walking (18, 19).

Comparatively, backward walking training also yielded significant improvements, particularly in enhancing balance by requiring patients to engage different muscle groups and apply distinct motor control strategies than those used in forward walking. This form of training is beneficial for its higher metabolic demands and the involvement of additional sensory inputs, which are critical for improving postural control and reducing fall risk in stroke patients (13, 15). However, the unique benefits of cadence cueing in providing rhythmic auditory stimuli appear to offer superior enhancements in terms of stride length and gait symmetry, which are essential for safe and independent ambulation.

While the study presents robust evidence supporting the efficacy of these rehabilitation techniques, it is not without limitations. The sample size, though adequate for statistical power, is relatively small, which may limit the generalizability of the findings. Additionally, the study was conducted within a controlled clinical environment, which may not fully replicate the everyday challenges faced by stroke survivors in their home or community settings. Future research could benefit from larger, multicenter trials that explore the long-term effects of these interventions in more diverse populations. Moreover, incorporating a follow-up phase could provide insights into the sustainability of improvements over time.

The study's strengths include its randomized control design and the use of validated outcome measures to assess improvements in balance and mobility. These factors contribute to the reliability of the findings. Nevertheless, future studies should consider exploring additional variables that could influence rehabilitation outcomes, such as the severity of stroke, age-related differences in response to therapy, and individual variations in learning and adapting to new gait patterns.

CONCLUSION

In conclusion, this study adds valuable evidence to the field of stroke rehabilitation, highlighting the potential of cadence cueing and backward walking training as effective interventions for improving balance and mobility in sub-acute stroke patients. The findings advocate for the incorporation of these techniques into clinical practices, emphasizing the need for tailored therapeutic approaches that address the specific functional impairments and recovery goals of stroke patients.

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