



Effectiveness of Cueing of Cadence with Ambulation Training in Hemiplegic Stroke Patients

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Received: 19 Feb 2025

Accepted: 25 Aug 2025

Citation to this article

Monica G, Prathap Suganthirababu S, Anitha A. Effectiveness of Cueing of Cadence with Ambulation Training in Hemiplegic Stroke Patients. *J Iran Med Counc.* 2026;9(3):676-81.

Abstract

Background: Stroke remains a significant global health challenge, causing long-term impairments that substantially impact patients' quality of life and healthcare costs. Hemiplegia, characterized by paralysis or weakness on one side of the body, particularly challenges rehabilitation efforts, especially in restoring gait and mobility. This study investigates the effectiveness of cadence cueing in ambulation training for post-hemiplegic stroke patients.

Methods: The research employed an experimental design involving 30 hemiplegic stroke patients divided into two groups: a conventional gait training group (n=15) and an experimental cadence cueing group (n=15). Both groups underwent a 4-week intervention, with the experimental group receiving specialized rhythmic auditory and visual cueing during ambulation training. The Dynamic Gait Index (DGI) was used to assess gait, balance, and fall risk.

Results: The findings suggested that cadence cueing with ambulation training offers a promising approach to improving gait and balance in hemiplegic stroke patients. It demonstrated statistically significant improvements in both groups, with the experimental group exhibiting substantially greater enhancements. The post-test mean values were 19.8 for the conventional group and 21.06 for the experimental group, with p-values <0.5 indicating significant statistical differences.

Conclusion: This study contributed valuable insights into innovative rehabilitation strategies, highlighting the potential of cadence cueing as a supplementary technique in stroke rehabilitation protocols.

Keywords: Gait, Health care costs, Hemiplegia, Quality of life, Stroke, Stroke rehabilitation, Walking

Introduction

Stroke remains a major global cause of long-term disability, significantly affecting quality of life and healthcare costs (1). Among post-stroke impairments, hemiplegia, or paralysis on one side, poses significant rehabilitation challenges, particularly in gait recovery (2). Independent walking is essential for functional autonomy and community reintegration (3), making gait improvement a primary focus in stroke rehabilitation programs worldwide (4).

Recent research has emphasized innovative strategies to enhance walking ability in hemiplegic patients, with cadence cueing gaining attention (5). Cadence, defined as steps per *min*, critically influences walking speed and efficiency (6). By providing rhythmic auditory or visual cues, therapists aim to improve step timing and promote symmetrical gait patterns (7).

This method builds on established principles of neurological rehabilitation, notably Rhythmic Auditory Stimulation (RAS), previously used in Parkinson's disease and multiple sclerosis (8).

The effectiveness of cadence cueing stems from the brain's ability to synchronize motor responses to external rhythmic stimuli, compensating for impaired internal timing mechanisms (9). This process, termed auditory-motor synchronization, offers a framework for organizing movement and improving gait symmetry (10). Additionally, the approach aligns with motor learning principles, providing real-time feedback that accelerates adaptation and skill acquisition (11). Early-stage gait training particularly benefits from such external guidance, reinforcing new movement strategies (12). The RAS scale was used in the subacute stage of the patients (3-6 months) with hemiplegic stroke.

Several studies have demonstrated that cadence cueing can lead to significant improvements in walking speed, with one study showing increased stride length and better step symmetry in stroke patients who underwent rhythmic cueing interventions (13).

Another study found that the use of rhythmic auditory cues helped individuals achieve better temporal coordination, resulting in more stable and balanced walking patterns (14). A systematic review of cadence cueing methods concluded that rhythmic cueing significantly enhances gait parameters in stroke patients and can be a valuable addition to conventional

rehabilitation strategies (15). Muscle strength and the ability to perform isolated lower-limb movements were assessed during baseline evaluation to ensure participants could safely perform the required exercises. Thus, motor coordination was the primary target of training, not basic strength acquisition. Despite these promising results, challenges remain in determining the optimal frequency and intensity of cues. For instance, some research highlights the difficulty in identifying the most effective delivery method, whether auditory, visual, or haptic, as different patients respond variably to each type of cue (16). Another challenge is the long-term retention of gait improvements, with some patients struggling to maintain the benefits once external cues are removed (17). More studies are needed to explore how best to sustain these improvements over time (18).

Combining cadence cueing with advanced rehabilitation technologies presents exciting possibilities for enhancing stroke recovery.

The integration of cadence cueing with body-weight-supported treadmill training has shown promising results, as it allows severely affected patients to practice walking in a controlled environment while receiving rhythmic guidance (19). Similarly, robotic gait training systems that incorporate cadence cueing have been found to optimize rehabilitation outcomes by providing consistent and adaptive cueing during walking sessions (20).

With the advancement of technology, cadence cueing is becoming more accessible for home-based rehabilitation. The development of wearable devices and smartphone applications capable of delivering rhythmic cues enables patients to continue their gait training independently, extending rehabilitation beyond clinical settings (21). Such technologies hold the potential to increase training intensity and encourage long-term engagement in gait rehabilitation exercises (22).

However, implementing cadence cueing effectively requires careful consideration of patient variability. Some individuals may become overly reliant on external cues, which could hinder their ability to develop independent gait control (23). Strategies for gradually reducing cue dependence and fostering the internalization of learned gait patterns are crucial for maximizing the long-term benefits of cadence

cueing interventions (24). Future research should focus on personalizing cueing strategies to meet the specific needs of different patients, ensuring optimal rehabilitation outcomes (25).

Materials and Methods

Materials required

Music devices, metronome, The study employed an experimental design with 30 post-hemiplegic stroke patients. All the patients had experienced stroke 3–6 months prior to the study, which corresponds to the subacute stage of motor recovery when rhythmic auditory stimulation is considered most effective, randomly divided into conventional (n=15) and experimental (n=15) groups. The participants of both genders aged between 30–60 yrs. with hemiplegic gait dysfunctions were included, while those with cognitive impairments, hearing issues, or uncontrolled medical conditions were excluded. The study compared two rehabilitation approaches for hemiplegic stroke patients, both conducted for 30 mins, four times weekly over four weeks. All the participants in the experimental group were capable of performing these exercises from the beginning of the intervention.

The conventional group performed structured physical exercises targeting gait and balance, including:

Heel rises: The patient was made to stand with their feet hip-width apart, holding onto a stable surface for support. They were then instructed to perform heel rises by slowly lifting their heels off the ground, rising onto their toes as high as possible. After holding the position for a second, they were guided to lower their heels back down in a controlled manner. This movement was repeated for 10 repetitions to strengthen the calf muscles and improve stability.

Tandem stance: The patient was positioned in tandem stance, with one foot placed directly in front of the other, heel to toe, as if standing on a tightrope. They were asked to maintain this position for 30 sec while keeping their posture upright and arms relaxed at their sides or slightly extended for balance. A support surface was available if needed.

Standing marches: The patient was made to stand tall with their feet hip-width apart. They were then guided to lift one knee up toward hip level, hold briefly, and slowly lower it before repeating with the other leg in a controlled marching motion. This

exercise was performed for 10 repetitions on each side to enhance lower-body strength and coordination.

Supported leg balance: The patient was positioned for supported leg balance by standing with both feet together while holding onto a stable support. They were instructed to shift their weight onto one leg and lift the opposite foot slightly off the ground, maintaining balance for 10 sec. If stable, they were encouraged to attempt the exercise without holding onto support.

Parallel bar walking: The patient was placed between two parallel bars and instructed to grip them lightly for support. They were guided to take slow, controlled steps forward, focusing on even weight distribution and an upright posture. After reaching the end of the bars, they turned around and repeated the process to reinforce proper gait and balance.

Partial squats: The patient was positioned with their feet shoulder-width apart to perform partial squats. They were instructed to bend their knees and lower themselves halfway down while keeping their weight in their heels, ensuring their knees did not extend past their toes. After holding for a second, they were guided to push through their heels to return to a standing position. This movement was repeated for 10 repetitions to strengthen the lower body while maintaining joint safety.

These exercises focused on improving strength, balance, and motor control through graduated, supported movements designed to challenge the patients progressively.

In contrast, the experimental group received a more advanced intervention utilizing cadence cueing with comprehensive auditory and visual stimulation techniques.

Auditory cues involved rhythmic stimulation using metronomes and music, where patients synchronized their steps with rhythmic beats, received verbal instructions timed with movements, and engaged in music therapy with adaptable tempo. Visual cues were equally sophisticated, such as:

Floor markings: Lines or patterns on the floor were used to guide step length and foot placement. Different colors can be used to indicate left and right steps.

Mirror therapy: Patients were made to walk in front of a mirror to provide visual feedback on their gait.

Video recording and analysis: Patients were

Table 1. Pre-test and post-test values of conventional gait training group and experimental group using paired t-test

Group	Time period	Mean	SD	p-value
Conventional group	Pre-test	16.8	1.36	<0.001
	Post-test	19.8	1.32	
Experimental group	Pre-test	17.33	1.45	<0.001
	Post-test	21.06	0.88	

Table 2. Post-test comparison between the conventional group and experimental group using independent t-test

Group	Time period	Mean	SD	p-value
Conventional group	Post-test	19.8	1.32	<0.001
Experimental group	Post-test	21.6	0.88	<0.001

made to walk in front of a mirror and record to provide visual feedback on their gait.

Physical step targets and treadmill training:

Physical objects (*e.g.*, foam blocks) were placed as step targets to encourage proper stride length.

Treadmill training with visual feedback:

Treadmills with screens displaying real-time gait information or virtual environments were used with dynamic visual information.

The core objective of the experimental approach was to enhance gait symmetry, walking speed, and balance by providing multi-sensory external cues that could help patients overcome neurological movement constraints. By introducing rhythmic, synchronized stimuli across auditory and visual channels, the intervention aimed to retrain neural pathways, improve motor coordination, and facilitate more natural, efficient walking patterns in stroke patients with hemiplegic gait impairments.

These exercises focused on improving strength, balance, and motor control through graduated, supported movements designed to challenge the patients progressively.

Both groups were assessed using DGI, a comprehensive 8-item assessment scoring gait and balance from 0-3, with a maximum score of 24 and fall risk indicated by scores below 19.

Statistical analysis

The statistical analysis was performed using SPSS software version 20. As the study included

continuous variables and had a moderate sample size, parametric tests were used under the assumption of normality. Paired t-test was utilized to compare pre- and post-test scores within each group, and an independent t-test was used for comparison between the groups. Results were reported as mean±standard deviation (SD), and a p-value of less than 0.05 was considered statistically significant.

Results

Paired t-tests were used to examine significant changes between the pre-test and post-test measurements (Table 1).

The post-test mean values of conventional and experimental group was 19.8 and 21.06. p-value of conventional and experimental group was <0.001 (Table 2). Since the p-values are <0.001 the given values are statistically significant. This indicates that comparing the two groups both the groups showed a positive effect on gait and balance. Experimental group showed a better statistical post mean value compared to the conventional training group.

Discussion

The study's findings provide compelling evidence for the effectiveness of cadence cueing in stroke rehabilitation. The experimental group demonstrated significantly superior improvements in gait parameters compared to the conventional training group, with post-test mean values of 21.06 vs. 19.8 on DGI.

The neurological mechanisms underlying these improvements are multifaceted. Cadence cueing appears to facilitate neural reorganization by providing external rhythmic stimuli that help synchronize motor outputs. This process potentially bypasses damaged neural pathways, creating alternative motor control strategies for hemiplegic patients.

The intervention's success can be attributed to several key factors. First, the rhythmic auditory and visual cues provide a consistent temporal framework that helps patients overcome internal timing irregularities. Second, the multisensory approach (auditory, visual, proprioceptive) engages multiple neural networks, potentially enhancing neuroplastic reorganization.

Notably, the study reveals that cadence cueing is more than a mere compensatory technique. It actively engages the patient's motor learning capabilities, providing immediate feedback and encouraging more symmetrical movement patterns. This approach aligns with contemporary rehabilitation principles that emphasize active, task-specific learning.

Limitations of the study include the relatively small sample size and short intervention period. Future research should explore long-term effects, optimal cueing parameters, and potential variations across different stroke severity levels. Additionally, investigating the neurophysiological changes accompanying cadence cueing could provide deeper insights into its therapeutic mechanisms.

The clinical implications are significant. Cadence cueing offers a non-invasive, potentially cost-effective approach to improving gait in hemiplegic stroke patients. Its simplicity and adaptability make it a promising addition to existing rehabilitation protocols.

Conclusion

In conclusion, the evidence strongly suggests that incorporating cadence cueing into ambulation training can lead to superior outcomes compared to conventional gait training alone for individuals with hemiplegia following stroke. From improvements in specific gait parameters to enhanced functional mobility and potentially greater neuroplastic changes, cadence cueing appears to offer a range of benefits. However, it is important to note that individual responses may vary, and the optimal application of cadence cueing (*e.g.*, frequency, duration, type of cues) may differ among the patients. Subsequent investigations ought to concentrate on identifying the attributes of patients who are most anticipated to gain advantages from this methodology and on optimizing cueing protocols for different subgroups of stroke survivors.

Ethical approval

This study was approved by the institutional scientific review board (02/006/2023/ISRB/SR/SCPT), and all the participants provided written informed consent.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgement

The authors would like to thank all the participants for volunteering their time for this study.

Conflict of Interest

There was no conflict of interest in this manuscript.

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