International Journal of Current Pharmaceutical Research

ISSN- 0975-7066 Vol 16, Issue 5, 2024

Original Article

QUANTITATIVE ANALYSIS OF METRONOME AND CORE STRENGTHENING EXERCISES ON GAIT AND DYNAMIC BALANCE IN STROKE PATIENTS

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Received: 20 Jun 2024, Revised and Accepted: 05 Aug 2024

ABSTRACT

Objective: Stroke remains a leading cause of adult disability worldwide, significantly impacting gait and dynamic balance. This study evaluates the effectiveness of metronome training combined with core strengthening exercises on improving these parameters in stroke patients.

Methods: A randomized controlled trial was conducted with 40 participants aged 45-60, six months post-stroke, and experiencing walking disabilities. Participants were randomly assigned to two groups: Group A (metronome training with core strengthening and general balance exercises) and Group B (core strengthening and general balance exercises only). Data were collected at four intervals over eight weeks using the Tinetti test and Timed Up and Go test.

Results: Group A showed significant improvements in the Tinetti scores (mean difference: 3.95, $p<0.001$) compared to Group B. Similarly, the Timed Up and Go test results favored group a (mean difference: 0.95, $p<0.001$), indicating better gait and dynamic balance outcomes with the combined intervention.

Conclusion: Incorporating metronome training with core strengthening exercises significantly enhances gait and dynamic balance in stroke patients, suggesting a valuable addition to rehabilitation protocols.

Keywords: Stroke rehabilitation, Gait, Dynamic balance, Metronome training, Core strengthening exercises, Randomized controlled trial

DOI: https://dx.doi.org/10.22159/ijcpr.2024v16i5.5065 Journal homepage: https://innovareacademics.in/journals/index.php/ijcpr

INTRODUCTION

Stroke, as defined by the World Health Organization, is characterized by rapidly developing clinical signs of focal or global disturbance of cerebral function, lasting 24 h or longer, or leading to death, with no apparent cause other than vascular origin. This definition encompasses subarachnoid hemorrhage but excludes subdural hemorrhage, transient ischemic attacks (TIAs), or hemorrhage or infarction caused by tumors or infections [1]. Silent cerebral infarcts are also not included. Stroke remains the leading cause of adult disability and the third leading cause of death in the Western Hemisphere, with significant long-term disabilities affecting approximately 50% of survivors [2].

The sudden onset of a stroke results in the rapid loss of brain function due to an interruption in blood supply, which can be caused by either ischemia or hemorrhage. This leads to a wide range of impairments, including motor, sensory, perceptual, and cognitive deficits [3]. These impairments can severely limit the rehabilitative potential of individuals, creating numerous challenges in daily functioning and overall quality of life. Stroke survivors often struggle with asymmetrical posture, abnormal body balance, and difficulties in weight transfer, making it challenging to maintain balance and postural control while standing upright [4].

Impaired trunk control is particularly problematic as it affects steady walking and increases the risk of falls. Stroke survivors often exhibit asymmetric movement patterns, which disrupt midline orientation, spatial awareness, and proper vertebral alignment [5]. This impacts trunk rotation, trunk-to-extremity movement, anterior-posterior pelvic tilt, and essential protective and equilibrium reactions. Effective rehabilitation strategies are critical to address these issues and enhance the quality of life for stroke survivors [6].

One promising approach in stroke rehabilitation is the use of metronome and core strengthening exercises. The integration of rhythm and movement through auditory cues like metronomes can significantly enhance motor function. Recent studies have highlighted the neurobiological connections between music, rhythm, and the human brain [7]. The auditory system's rapid and precise processing of temporal information allows it to serve as an effective stimulus for motor performance. Rhythmic auditory stimulation (RAS) has shown substantial benefits in improving gait and upper extremity function in stroke patients by synchronizing motor responses with rhythmic auditory cues [8].

Furthermore, core strengthening exercises play a crucial role in improving balance and gait in stroke patients [9]. The core, comprising muscles of the back, abdomen, diaphragm, pelvic floor, and hip girdle, acts as the body's stabilizing center. Strong core muscles facilitate proper posture, movement, and the efficient transfer of forces through the body. Weakness in these muscles, common in stroke survivors, can lead to thoracic bending and a posterior shift in the center of gravity, exacerbating balance and gait issues [10].

Incorporating core strengthening exercises into rehabilitation programs has been shown to enhance trunk control, stability, and overall functional mobility. This approach not only targets the physical impairments caused by stroke but also addresses secondary issues such as respiratory function and overall muscle coordination [11]. By combining metronome-based rhythmic auditory stimulation with targeted core strengthening exercises, rehabilitation programs can offer a comprehensive and effective strategy for improving gait and dynamic balance in stroke patients [12].

This article aims to explore the quantitative impact of these interventions on gait and dynamic balance, providing evidence for their efficacy and offering insights into optimizing stroke rehabilitation strategies [13]. Through a detailed analysis of the physiological and functional outcomes associated with these exercises, this study contributes to the growing body of research focused on enhancing the recovery and quality of life for stroke survivors.

MATERIALS AND METHODS

Study design: This study is a randomized controlled trial.

Source of data: Data will be collected from eligible community dwellers.

Sample: A total of 40 participants, both male and female, were included.

Sampling technique: Participants were selected using a simple random sampling method.

Sample size: Forty participants were chosen.

Selection criteria

Inclusion criteria

- Age: 45-60 y old
- Right hemiplegic, six months post-stroke
- Walking disability but able to stand and transfer
- Spasticity grade 2 (modified Ashworth scale)
- Extension synergy type

Exclusion criteria

- Cognitive or hearing impairments
- Cardiovascular or cardiopulmonary issues
- Orthopedic conditions
- Use of walking aids

Data collection tools

- Client information and assessment sheets
- Consent form
- General instruction sheet
- Timed Up and Go test
- Tinetti test
- Data collection sheet

Materials used

- Metronome

Methodology

Participants were randomly assigned to two groups:

Group A

- Metronome training combined with core strengthening and general balance and gait exercises.

Group B

- Core strengthening and general balance and gait exercises only.

Data will be collected over eight weeks on days 1, 30, 60, and 90. Outcome measures include the Tinetti gait and balance score and the Timed Up and Go test.

Procedure

Core strengthening exercises (Both groups)

- Bridging
- Knee Rolling
- Single Leg Drop-Outs
- Single Leg Bridging
- Four-Point Kneeling

General dynamic balance and gait training exercises (Both groups)

- Heel Raises (Holding On)
- Side Stepping (Holding On)
- Single Leg Standing
- Backwards Walking
- Parallel Bar Walking

Group a specific

- Incorporates metronome training into the above exercises.

Assessment

- **Timed Up and Go test:** Measures the time taken to stand, walk three meters, turn, return, and sit down.
- **Tinetti test:** Assesses balance and gait through various tasks.

RESULTS

The statistical analyses conducted on the different interventions aimed at improving balance and mobility metrics provided clear insights. Two main groups were compared: Tinetti A, which involved metronome training with core strengthening, and Tinetti B, which solely focused on core strengthening.

Table 1 analysis

The mean scores of the Tinetti performance in Group A were significantly higher (M = 22.30, SD = 1.04) compared to Group B (M = 18.35, SD = 1.43). This demonstrates a notable enhancement in balance when metronome training was integrated with core strengthening exercises.

Table 2 analysis

Similar patterns were observed in the Timed Up and Go (TUG) test results. Group A, which combined metronome training with core strengthening, displayed better mobility with a lower mean time (M = 11.45, SD = 0.81) compared to Group B, which only engaged in core strengthening (M = 12.40, SD = 0.69).

Paired differences and T-tests for tinetti

The paired differences for the Tinetti test between the groups highlighted a significant improvement, with a mean difference of 3.95 (95% CI, 3.15 to 4.75; $t(38) = 9.993$, $p<0.001$). This result was consistent, regardless of whether variances were assumed equal or not, indicating robustness in the observed effect of the combined intervention over core strengthening alone.

Paired differences and T-tests for TUG test

For the TUG test, the mean difference was also significant at 0.95 seconds (95% CI, 0.47 to 1.43; $t(38) = 3.987$, $p = 0.00015$). This finding reaffirms that the inclusion of metronome training significantly enhances mobility along with core strengthening.

Table 1: Descriptive statistics of mean, std deviation for treatment of tinetti

Group	N	Mean	Std. deviation	Std. error mean
Tinetti A (metronome training with core strengthening)	20	22.3000	1.04378	0.23340
Tinetti B (core strengthening)	20	18.3500	1.42672	0.31902

Table 2: Descriptive statistics of mean, std deviation for treatment of tug test

Group	N	Mean	Std. deviation	Std. error mean
TUG test B (core strengthening)	20	12.3963	0.68807	0.15386
TUG test A (metronome training with core strengthening)	20	11.4462	0.81379	0.18197

Table 3: Descriptive statistics of paired differences, T-test, DF and P value of tinetti

Equality of variances	Levene's test for equality of variances F	Levene's test for equality of variances Sig.	t-test for equality of means T	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference lower	95% confidence interval of the difference upper
Tinetti Equal variances assumed	1.863	0.180	9.993	38	0.000	3.95000	0.39528	3.14979	4.75021
Tinetti Equal variances not assumed	1.863	0.180	9.993	35	0.000	3.95000	0.39528	3.14737	4.75263

Table 4: Descriptive statistics of paired differences, T-Test, DF and P value of TUG test

Equality of variances	Levene's Test for equality of variances F	Levene's test for equality of variances Sig.	t-test for equality of means T	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% Confidence interval of the difference lower	95% Confidence interval of the difference upper
TUG TEST Equal variances assumed	0.744	0.394	3.987	38	0.00015	0.95000	0.23830	0.46760	1.43240
TUG TEST Equal variances not assumed	0.744	0.394	3.987	37	0.00015	0.95000	0.23830	0.46716	1.43284

DISCUSSION

This study aimed to investigate the effects of combining metronome training with core strengthening exercises on gait and dynamic balance in stroke patients. The results indicate that incorporating rhythmic auditory stimulation (RAS) with traditional core exercises significantly enhances rehabilitation outcomes [14].

The integration of metronome training leverages the brain's auditory-motor synchronization capabilities. Previous studies have demonstrated that rhythmic cues can facilitate motor performance by engaging neural circuits responsible for timing and coordination. Our findings align with these studies, showing that participants in Group A, who received metronome training, exhibited notable improvements in both Tinetti and Timed Up and Go test scores compared to those in Group B [15].

The core strengthening component addressed the crucial need for trunk stability in stroke patients. Strong core muscles are essential for maintaining posture, facilitating movement, and preventing falls. The exercises used in this study, such as bridging and single-leg bridging, effectively targeted these muscles, contributing to improved balance and gait stability [16].

The significant improvements observed in Group A can be attributed to the synergistic effects of RAS and core strengthening. Rhythmic auditory cues likely enhanced the participants' ability to perform core exercises more effectively, leading to better overall outcomes. This combination not only improved physical parameters but also potentially boosted participants' confidence in their mobility, further aiding their rehabilitation [17].

These results suggest that incorporating metronome training into stroke rehabilitation programs could provide substantial benefits. The metronome's rhythmic cues likely helped participants achieve more consistent and stable movements, which are critical for gait improvement. Moreover, the enhanced trunk control from core exercises provided a stable foundation for these movements [18].

It is important to note some limitations of this study. The sample size was relatively small, and the study duration was limited to eight weeks. Future research with larger sample sizes and longer follow-up periods would help to validate and expand upon these findings. Additionally, exploring the impact of different frequencies and durations of metronome training could provide further insights into optimizing this intervention.

Overall, the combination of metronome training with core strengthening exercises offers a promising approach to improving gait and dynamic balance in stroke patients. This study contributes to the growing body of evidence supporting the use of rhythmic auditory stimulation in rehabilitation and underscores the importance of targeted core exercises. Implementing these findings in clinical practice could enhance the effectiveness of rehabilitation programs, ultimately improving the quality of life for stroke survivors.

CONCLUSION

This study demonstrates that combining metronome training with core strengthening exercises significantly improves gait and dynamic balance in stroke patients. These findings highlight the potential of rhythmic auditory stimulation as a valuable addition to stroke rehabilitation protocols, offering a comprehensive strategy to enhance recovery outcomes.

FUNDING

Nil

AUTHORS CONTRIBUTIONS

All the authors have contributed equally

CONFLICTS OF INTERESTS

Declared none

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