MAJALAH ILMIAH FISIOTERAPI INDONESIA

ORIGINAL ARTICLE

Volume 13, Number 1 (2025), Page 12-16
P-ISSN 2303-1921, E-ISSN 2722-0443

Effectiveness of Ankle Proprioceptive Control on Walking Balance in Post-Stroke Patients: A Pre-Experimental Study

Dori Budi Siswanto[1*], Agung Hadi Endaryanto[2], Fransisca Xaveria[3], Sartoyo[4]

[1,2,3,4]Bachelor's Program in Physiotherapy, Faculty of Health Sciences, dr. Soepraoen Hospital Science and Health Institute, Kesdam V/Brawijaya, Malang City, East Java
*Koresponden: dori.budi01@gmail.com

Submitted: 26 Oktober 2024 | Accepted: 07 November 2024 | Published: 15 January 2024
DOI: https://doi.org/10.24843/mifi.2025.v13.i01.p03

Abstract

Introduction: Good walking balance is crucial for improving the functional abilities of stroke patients. Balance impairments in stroke patients increase the risk of falls and hinder daily activities. Ankle proprioceptive control exercises have proven to enhance walking balance in post-stroke patients.
Methods: This pre-experimental study employed a one-group pretest-posttest design with 30 participants selected based on inclusion and exclusion criteria. Subjects were subacute and chronic stroke patients aged 45–60 years. Ankle proprioceptive control exercises were administered thrice weekly at the Wijaya Clinic in South Jakarta for three months. Statistical analysis included the Shapiro-Wilk test and paired t-test.
Results: There was a significant improvement in Ten-Metre Walking Test (10mWT) scores, with p=0.000, indicating the effectiveness of the exercise.
Conclusion: Ankle proprioceptive control exercises effectively improve walking balance in post-stroke patients, as the increased 10mWT scores demonstrate.

Keywords: walking balance, proprioceptive control, rehabilitation, stroke

Introduction

Stroke is a condition characterized by the blockage or rupture of blood vessels in the brain. It is one of the leading causes of mortality worldwide, accounting for approximately 17.9 million deaths each year. In Indonesia, the prevalence of stroke increased from 7‰ of the population in 2013 to 10.9‰ in 2018.[2]

Stroke patients often experience various issues, such as sensory disturbances and impaired balance. Good balance is closely related to enhanced functional abilities, including gait function. Balance impairments in stroke patients make daily activities challenging and increase the risk of falls. Optimal balance relies on integrating visual, vestibular, and proprioceptive information. The proprioceptive system, particularly in the ankle area, plays a crucial role in balance control by providing information on body position and movement.[3,4]

Post-stroke proprioceptive and tactile somatosensory disturbances are more prevalent in the legs than in the arms, affecting balance and gait. Somatosensory information comes from the joints (proprioception) and skin (tactile sensation) and is linked to verticality perception, which is associated with the balancing process. This information is vital in providing feedback about limb weight-bearing, as the ankle area is the only part of the body in contact with the ground. Ankle proprioception includes essential information that adjusts ankle position and upper body movement, enabling stroke patients to perform balance tasks successfully.[5]

The inability to perform ankle dorsiflexion is a shared walking issue in stroke patients. Increased muscle tension in the triceps surae prevents stroke patients from actively controlling dorsiflexion, leading to a tendency for the foot to drop (drop foot).[6] Consequently, this condition can lead to reduced postural stability during weight shifting and diminished balance ability, contributing to gait balance disturbances. Declines in balance and gait performance significantly impact the ability to perform various daily activities.[7] Therefore, walking balance becomes one of the primary goals of interventions carried out by physiotherapists.[8]

A measurement that can be used is the Ten-Metre Walking Test (10mWT). This test assesses walking ability in meters per second over a short distance. It is commonly used in neurological disorders related to functional mobility, gait, and vestibular function.[9]

Recent studies have focused on balance training as a critical approach to improving mobility recovery in post-stroke patients, particularly ankle control. Various techniques have been used, including calf muscle stretching, muscle strength training, functional electrical stimulation, balance training, weight-bearing training, ankle mobilization with movement, etc. These methods aim to enhance muscle strength or range-of-motion exercises focusing more on joint flexibility.[8,10] However, proprioceptive training has shown more targeted and practical benefits in improving joint position awareness and body balance during walking. Another study concluded a significant improvement in balance in chronic stroke patients using ankle control training with Neuromuscular Electrical Stimulation (NMES) as an intervention.[11]

Another study concluded that ankle proprioceptive control exercises led to balance and walking ability changes in stroke patients. These changes occurred due to the increased strength of the dorsiflexor muscles of the ankle, which help prevent foot drop.[12]

Another study on ankle stability concluded that ankle stability exercises significantly improved balance and functional mobility compared to conventional therapy, as indicated by significant improvements in the Berg Balance Scale and 2-Minute Walk Test. These changes were due to the adaptation of balance training through proprioceptive senses and neuromuscular control.[13] Winter found that a proprioceptive approach can enhance sensorimotor performance, helping post-stroke patients address motor dysfunction more effectively.[14] Another study by Chiaramonte emphasized that proprioceptive exercises, particularly when combined with dual-task training, significantly improve balance, body movement control, and walking speed in post-stroke patients.[15] This is supported by a study by Xu et al., which found that using vibratory proprioceptive exercises specifically improved ankle stability, making this method relevant for adequate recovery.[16] Researchers have yet to find a study specifically discussing the application of ankle proprioceptive control exercises to improve balance in stroke patients. Therefore, the uniqueness of this study lies in its novel approach of providing ankle proprioceptive control exercises to enhance walking balance and minimize the risk of falls in stroke patients.

Based on the explanation above, the researcher is interested in conducting a study to assess changes in walking balance in stroke patients accurately. Based on observations made at the Wijaya Clinic, most patients are stroke survivors who face walking difficulties, particularly related to ankle stability.

This study examines changes in walking balance in post-stroke patients before and after ankle proprioceptive control exercises, hypothesizing that these exercises positively affect walking balance. Additionally, the study seeks to evaluate the impact of ankle proprioceptive control exercises on walking balance in post-stroke patients, addressing the gap in research specifically focusing on this method for balance improvement.

This study is expected to be a reference for physiotherapists and academics in enhancing rehabilitation approaches for balance in post-stroke patients through ankle proprioceptive control exercises. Moreover, this research opens opportunities to develop further methods to improve walking balance in post-stroke patients based on scientifically sound and accurate methods.

Method

This study was conducted at the Wijaya Clinic, Melawai Village, Kebayoran Baru District, South Jakarta. The research method used was a pre-experimental design with a one-group pretest-posttest framework. Samples were selected using purposive sampling based on predetermined inclusion and exclusion criteria. The inclusion criteria were stroke patients of either gender, aged 45-60 years, with stable vital signs, diagnosed with hemiparetic stroke (weakness on one side of the body) in the sub-acute to chronic phase, capable of walking independently for at least 10 meters without assistive devices, with a Mini-Mental State Examination (MMSE) score of over 24/30, and willing to participate in the study. The exclusion criteria included visual or auditory impairments, cognitive disorders, history of fractures, inflammation, and deformities in the lower extremities, as well as diagnoses such as Parkinson’s disease or stroke ataxia (coordination disorders).

The sample size for this study was determined using Lemeshow's formula, resulting in 30 participants who met the inclusion criteria and provided informed consent. These participants underwent a pre-test that included measurements of blood pressure, pulse, and the Ten-Metre Walking Test (10mWT). For the 10mWT, participants were instructed to walk 10 meters at their usual pace. The therapist started timing with a stopwatch when the participant's foot crossed the second-meter mark and stopped when the foot struck the eighth-meter mark. The test was repeated three times to obtain an average score.

Following the pre-test, participants underwent ankle proprioceptive control training, which consisted of a warm-up and core exercises, carried out over 12 sessions over 4 weeks. The warm-up included stretching the gastrocnemius and soleus muscles, performed in 2 sets of 30 seconds each. Core exercises involved standing in various positions and weight shifting for 1 minute per set, with 15-second rest intervals.

Data were analyzed using descriptive statistics for sample characteristics and hypothesis testing using paired sample t-tests to determine significant differences between pre-test and post-test walking balance scores. This study received ethical clearance from the RS dr. Soepraoen Health and Science Institute with approval number KEPK-EC/122/VII/2024, ensuring the research adhered to ethical principles.

Results

The flowchart shows that this study began with a population of 99 stroke patients. According to Lemeshow, 49 participants were required based on the sample size calculation. Of these, 19 participants were excluded based on exclusion criteria, leaving 30 eligible participants for the study. No participants were lost to follow-up, so all 30 participants were included in the analysis. This can be seen in Figure 1. Research Flowchart.

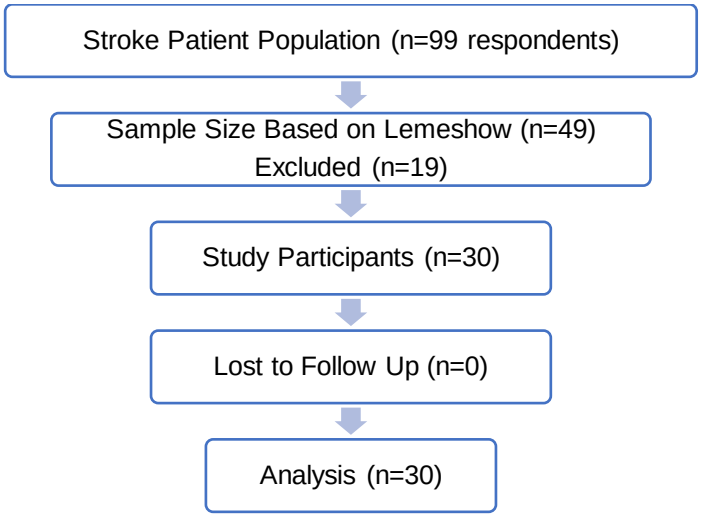

Figure 1. Research Flowchart.

The following are the characteristics of the subjects based on gender, age, and the Ten-Metre Walking Test (pretest and posttest), presented in Table 1. This table provides a comprehensive overview of the study participants' profiles.

Table 1. Distribution of Gender, Age, and Ten-Metre Walking Test Characteristics

Variable	Frequency (n)	Percentage (%)	Min/Max	Mean
Gender				
Male	20	66.7%		
Female	10	33.3%		
Age				
45-50 Years	7	23.3%		
51-55 Years	12	40.0%		
56-60 Years	11	36.7%		
Ten-metre walking test (pre-test)			0.10 / 1.28 (meters/second)	0.489 meters/second
Ten-metre walking test (post-test)			0.17 / 1.53 (meters/second)	0.695 meters/second

Table 1 shows the characteristics of the study participants based on gender, age, and the results of the Ten-Metre Walking Test (pretest and posttest), as presented in Table 1. Most participants were male (66.7%), and most were between 51 and 55 (40%).

Regarding walking balance, as measured by the Ten-Metre Walking Test, the pre-test walking speed ranged from the lowest value of 0.10 meters/second to the highest value of 1.28 meters/second, with an average of 0.489 meters/second. After the ankle proprioceptive control exercises, walking speed increased, ranging from 0.17 to 1.53 meters/second, with the average increasing to 0.695 meters/second. The analysis of walking balance before and after the ankle proprioceptive control training is detailed in Table 2.

Table 2. Paired Sample T-Test Results for the Ten-Metre Walking Test

Walking Balance with Ankle Proprioceptive Control	Mean	Standard Deviation	95% Confidence Interval	Probability
Before Exercise	0.489 m/s	0.12665	-0.25296 – (-0.15838)	0.000
Sesudah Latihan	0,695 meter/detik			

In Table 2, the results of the paired sample t-test show a significant increase in the average Ten-Metre Walking Test score, from 0.489 meters/second (pre-test) to 0.695 meters/second (post-test). The 95% confidence interval ranged from -0.25296 to -0.15838 with p=0.000, indicating a significant difference between the pre-test and post-test values.

With p=0.000, which is less than the significance level of 0.05, these results suggest that ankle proprioceptive control training significantly improves walking speed in post-stroke patients. Throughout the study, no side effects or injuries were reported due to the ankle proprioceptive control exercises, indicating that the intervention was safe and well-tolerated by the study participants.

Discussion

Sample Characteristics

The sample characteristics show that most subjects were male (66.7%) and aged 51-55 (40%). This is in line with data from the RISKESDAS 2018, which indicates that the prevalence of stroke is higher in males compared to females (11.0‰ vs. 10.9‰),[2] with risk factors such as hypertension, smoking, and cardiovascular diseases being more commonly observed in males. Males also tend to experience stroke at a younger age, partly due to the lack of the

protective effects of estrogen before menopause in females. Risky behaviors, such as higher rates of smoking and alcohol consumption in males, also contribute to this difference.[17,18]

Effect of Ankle Proprioceptive Control Training on Walking Balance

The results of the paired sample t-test showed a p-value of 0.000, indicating that ankle proprioceptive control training significantly improved walking balance in post-stroke patients. These findings are consistent with a study by Ali F, which also demonstrated a significant improvement ($p < 0.05$) in the balance of stroke patients after six weeks of ankle stability training. Another study by Lee SY supports these findings, where ankle control exercises based on NMES also showed improved balance. Ankle proprioceptive control training enhances proprioception and ankle muscle strength, improving walking balance.[11,13]

According to Mao, ankle-based robotic sensory training can enhance sensory input sensitivity by increasing the ankle joint's range of motion and strength. In this study, the 10mWT measurement was used to assess walking balance by observing the change in walking speed before and after the intervention. This indicates that the patient's confidence in walking safely has improved due to better postural stability control, standing and walking balance stability, and enhanced sensory input.[19]

In stroke patients, decreased proprioceptive control, particularly at the ankle, can lead to significant postural imbalance and impair walking ability. Proprioception is the body's ability to sense joint position and movement without visual input, which is crucial for balance and motor control. Research indicates that ankle proprioceptive control training can improve sensorimotor function, enhance postural strategies for maintaining balance, and reduce the risk of falls in stroke patients.[20]

Physiologically, proprioceptive training for the ankle enhances neural plasticity by stimulating the damaged sensorimotor cortex areas due to stroke. This exercise improves motor control by increasing afferent feedback from proprioceptive receptors in the ankle to the brain, helping patients more accurately perceive foot position and maintain balance while walking. Activation of the sensorimotor circuits—including the motor cortex, basal ganglia, and cerebellum—improves postural adaptation and neuromuscular control, enabling stroke patients to maintain dynamic balance more effectively while walking.[20,21]

This study has several limitations, including the absence of a control group, which could strengthen the validity of the results. Clinical environmental factors such as lighting, floor surface, and noise could also influence the subject's performance. Future research is recommended to use a design with a control group to provide a more precise comparison of the effectiveness of the intervention, as well as to consider environmental variables and patient characteristics to enhance the generalizability of the findings.

Conclusion

Ankle proprioceptive control exercises significantly improve walking balance in stroke patients. The findings indicate that providing ankle proprioceptive control exercises positively impacts ankle stability, helping patients more accurately perceive the position and movement of their feet, which contributes to better balance during walking.

Other Information

This study was conducted without any funding from external sources and was purely part of the final project. The Ethics Committee of the Institute of Science and Health Technology RS dr has approved the study design. Soepraoen with the approval number KEPK-EC/122/VII/2024.

References

1. WHO. Cardiovascular Diseases [Internet]. World Health Organization. 2022. Available from: https://www.who.int/health-topics/cardiovascular-diseases/#tab=tab_1
2. Kemenkes RI. Laporan Riskesdas 2018 Nasional. Lembaga Penerbit Balitbangkes. 2018. p. hal 156.
3. Borode AO, Awotidebe TO, Ademoyegun AB, Borode AO, Falokun IG, Omisore OB, et al. Interrelationship Among Fear of Falling, Gait Characteristics and Dynamic Balance in Stroke Survivors – A Case-control Study. Turk Noroloji Dergisi. 2023;29(4):241–8.
4. Kim KH, Kim DH. Effects of ankle joint proprioceptive training and thermal approach on stroke patients' trunk, balance stability and gait parameter. J Back Musculoskelet Rehabil. 2022;35:1237–46.
5. Chia FSF, Kuys S, Low Choy N. Sensory retraining of the leg after stroke: systematic review and meta-analysis. Clin Rehabil. 2019;33(6):964–79.
6. Park D, Bae Y. Proprioceptive neuromuscular facilitation kinesio taping improves range of motion of ankle dorsiflexion and balance ability in chronic stroke patients. Healthcare (Switzerland). 2021;9(11).
7. Alamer A, Melese H, Getie K, Deme S, Tsega M, Ayhualem S, et al. Effect of Ankle Joint Mobilization with Movement on Range of Motion, Balance and Gait Function in Chronic Stroke Survivors: Systematic Review of Randomized Controlled Trials. Degener Neurol Neuromuscul Dis. 2021;Volume 11:51–60.
8. Gillen G. Stroke Rehabilitation: A Function-Based Approach. Fourth. New York, USA: Mosby Elsevier; 2015.
9. Andersen CW, Kristensen MT. Performance Stability and Interrater Reliability of Culturally Adapted 10-Meter Walking Test for Danes with Neurological Disorders. Journal of Stroke and Cerebrovascular Diseases. 2019;28(9):2459–67.
10. Park D, Cynn HS, Yi C, Choi WJ, Shim JH, Oh DW. Four-week training involving self-ankle mobilization with movement versus calf muscle stretching in patients with chronic stroke: a randomized controlled study. Top Stroke Rehabil. 2020;27(4):296–304.

11. Lee SY, Park HJ, Choi YS. Effects of Ankle Control Training Using Neuromuscular Electrical Stimulation on Leg Muscle Activation and Balance in Patients with Stroke. The Journal of Korean Physical Therapy. 2023;35(5):145–50.
12. T S, Kunduru S. Proprioceptive Training versus Progressive Adaptive Physical Activity on Balance in Subjects with Sub-Acute Stroke. Int J Health Sci Res. 2022;12(1):7–12.
13. Ali F, Baig MO. Effects of Ankle Stability Exercises on Balance in Stroke Patients. Pak J Med Res. 2020;59(01):28–31.
14. Winter L, Huang Q, Sertic JVL, Konczak J. The Effectiveness of Proprioceptive Training for Improving Motor Performance and Motor Dysfunction: A Systematic Review. Frontiers in Rehabilitation Sciences. 2022;3(April).
15. Chiaramonte R, Bonfiglio M, Leonforte P, Coltraro GL, Guerrera CS, Vecchio M. Proprioceptive and Dual-Task Training: The Key of Stroke Rehabilitation, A Systematic Review. J Funct Morphol Kinesiol. 2022;7(3).
16. Xu P, Song J, Fan W, Zhang Y, Guan Y, Ni C, et al. Impact of whole-body vibration training on ankle joint proprioception and balance in stroke patients: a prospective cohort study. BMC Musculoskelet Disord [Internet]. 2024;25(1):768. Available from: https://doi.org/10.1186/s12891-024-07906-z
17. Blum B, Wormack L, Holtel M, Penwell A, Lari S, Walker B, et al. Gender and thrombolysis therapy in stroke patients with incidence of dyslipidemia. BMC Womens Health. 2019;19(1):1–10.
18. Ospel J, Singh N, Ganesh A, Goyal M. Sex and Gender Differences in Stroke and Their Practical Implications in Acute Care. J Stroke. 2023;25(1):16–25.
19. Mao Y, Gao Z, Yang H, Song C. Influence of proprioceptive training based on ankle-foot robot on improving lower limbs function in patients after a stroke. Front Neurorobot. 2022;16.
20. Cho JE, Kim H. Ankle Proprioception Deficit Is the Strongest Factor Predicting Balance Impairment in Patients With Chronic Stroke. Arch Rehabil Res Clin Transl. 2021;3(4):100165.
21. Chiaramonte R, Bonfiglio M, Leonforte P, Coltraro GL, Guerrera CS, Vecchio M. Proprioceptive and Dual-Task Training: The Key of Stroke Rehabilitation, A Systematic Review. J Funct Morphol Kinesiol. 2022;7(3).

This work is licensed under Creative Commons Attribution 4.0 International License.