Visual Effects of Biofeedback on Post-stroke Patients' Balance: A Literature Review

Hilman Muhammad Firdaus[1], Umi Budi Rahayu[2(✉)], and Rinna Ainul Maghfiroh[2]

[1] Faculty of Health Science, University Muhammadiyah Surakarta, Surakarta, Indonesia
[2] Faculty of Health Sciences, University Muhammadiyah Surakarta, Surakarta, Indonesia
ubr155@ums.ac.id

Abstract. Visual biofeedback is a visual technology similar to video games. Some studies claim that visual biofeedback improves the balance of stroke patients, but others claim that traditional exercise physical therapy is superior to visual biofeedback. This study set out to investigate how biofeedback affected post-stroke patients' visual abilities. A review of the literature from an online database that was published between 2012 and 2022 was used as the basis for the study. The randomized control trial articles were found using the keywords "visual biofeedback" and "balance" and "stroke" in the MEDLINE, PubMed, Science Direct, and PEDro databases, with no language restrictions. This review included sample with stroke lasting longer than three months, had no visual problems and were being treated with visual biofeedback. The study was evaluated using PICO (Population, Intervention, Comparison, and Outcome), a framework developed and used throughout the literature selection process. A total of 8 articles were reviewed by PICO and met the PEDro score criteria with an average score of 8.0. Visual biofeedback is an additional intervention solution for improving balance by using measuring instruments, such as BBS (Berg Balance Scale), TUG (Timed Up and Go Test) measured between before and after treatment. The use of visual biofeedback in post-stroke patients has been shown to improve balance, walking, and quality of life. However, further research is needed to determine how this additional intervention will be used in the future to make it more optimal, innovative, and modern in the treatment of stroke patients for both acute, subacute, and chronic stroke.

Keywords: Balance · Visual Biofeedback · Stroke

1 Introduction

Stroke is a prevalent problem among general practitioners, and it includes emergency problems that must be treated immediately in hospitals [1] Balance problems are one of several risk factors for weakness in post-stroke patients. Balance disorders are the leading cause of injury, and activity limitations cause the individual to fall more easily, causing problems [2]. Balance is a system that involves the integration and coordination of sensory, motor, and biomechanical activities in order to improve the body's static and dynamic performance [3].

B. Ichsan et al. (Eds.): ICHWB 2022, AHSR 61, pp. 366–379, 2023.
https://doi.org/10.2991/978-94-6463-184-5_33

Balance issues are a common dysfunction in post-stroke patients, causing difficulty recovering, standing as well as walking, and an increased risk of falling.[4] Researchers who specialize in neurological rehabilitation patients are discussing how to improve function balance in stroke patients [5]. Physiotherapists have used a variety of therapeutic methods, one of which is visual biofeedback, to improve balance, muscle strength, and quality of life [6].

Visual biofeedback is a visual output technology from a system such as a video game that allows users to move their limbs for the better with a system that has been designed, by providing information through video games that the patient will play to move the decreased limb and weakness in the sides/limbs, and can gradually increase the range of motion of the joints [4].

Improve knee mobility and life quality in stroke patients by combining visual biofeedback with other interventions like balance training and pro-kin systems [7]. Sit-to-Stand workout When used in conjunction with real-time visual biofeedback, it has been shown to improve lower limb muscle strength, stability, stride length, and life quality are all affected. [8]. Exercise with a Smartphone-based visual feedback trunk control training (SPVFTCT) system improves trunk control abilities and results in a shorter spatiotemporal gait in stroke patients. However, in improving walking ability, independence of daily living, muscle strength, thrust control, and balance in stroke patients, visual biofeedback exercises combined with cycling.

functional electrical stimulation (FES) was less effective than conventional interventions stretching, workouts for postural control, standing, biking, taking a walk, and upper extremity regeneration of the same intensity [9]. The purpose of this study is to see how visual biofeedback affects the balance of post-stroke patients.

2 Methods

Search in 3 databases PubMed, Pedro, and ScienceDirect for articles with the keywords "Balance" and "Stroke" and "Visual Biofeedback" published between 2012 and 2022. The screening system is applied to titles and abstracts, followed by a full reading of all submitted articles found in randomized controlled trials articles.

The PEDro scale of 11 items was used to assess the methodology's quality. The following classification is used to rate studies: 9–10 is considered very good, 6–8 is considered good, a score of 4–5 is regarded as fair, and one of just under 4 is regarded as poor. The author assessed the quality of the articles in the study independently.

This review included articles that used randomized controlled trials, post-stroke patients over the age of 18 with a time since stroke the of more than 3–6 months, no visual problems, and used visual biofeedback as a treatment. Visual biofeedback, balance training, and conventional exercise were the interventions used in this study.

Outcomes in the study showed the results of measuring balance or the ability to walk. In the research data sources, the measuring instruments used can be (FMA) Fugl-Meyer assessment, Berg Balance Scale (BBS), Functional Index Measure (FIM), Time Up and Go Test (TUGT), 10 min Walking Test (10 MWT), velocity, (ABC) activity-specific balance confidence, (FAC) Functional Ambulation Classification, (LRT) lateral reach test, (6 MWT) 6-min walking test, (SCP) Scale for contraversive pushing.

3 Result

The purpose of this research was to see how visual biofeedback improved balance in post-stroke patients.

3.1 Article Search Result

The search through the search engine above resulted in 615 articles from 4 databases using the same combination of keywords balance, visual biofeedback, stroke and article deletion. After screening the titles and abstracts, 15 fully read texts of papers with the potential to be taken. Seven journals have been dismissed because they failed to meet the criteria for inclusion, leaving eight papers for review. Figure 1.

Articles were reviewed using the PICO method as a framework in the review process. There are 4 points in the PICO standard, namely (Population, Intervention, Comparison, and Outcome). The population consists of all research subjects. The treatment given to the patient is referred to as intervention. In the article, a comparison or comparison

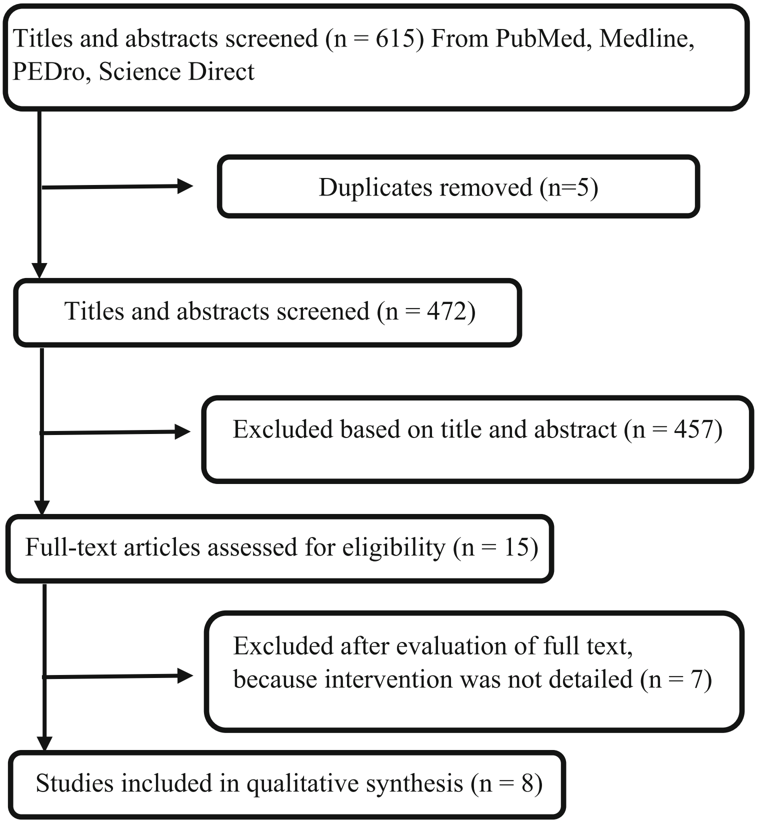

Fig. 1. Search Strategy Flow

Table 1. Study Characteristics

No	Author and Year	Journal	Location	Design
1	Ambrosini *et al.* (2020)	European Journal of Physical and Rehabilitation Medicine	Italy	Experimental
2	Barcala *et al.* (2013)	Journal of Physical Therapy Science	Brazil	Experimental
3	H.-J. NOH H.-J. *et al.* (2019)	Journal of Stroke and Cerebrovascular Diseases	Korea	Experimental
4	Hyun *et al.*(2021)	International Journal of Environmental Research and Public Health	Korea	Experimental
5	Pak and Lee (2019)	International Journal of Rehabilitation Research	Korea	Experimental
6	Shin (2019)	Department of Physical Therapy, College of Health Sciences	Korea	Experimental
7	Yang *et al.* (2014)	Kaohsiung Journal of Medical Sciences	Taiwan	Experimental
8	Zhang *et al.* (2020)	Medicine Observational Study	China	Experimental

affects the intervention group. Outcomes are accomplishments or outcomes in studies related to the treatment of research subjects.

The population this article's subject population is stroke patients, and the interventions are visual biofeedback, conventional exercise, and balance training. Visual biofeedback and conventional exercise intervention are compared in stroke patiens. Outcomes are determined by examing the progress of functional improvement or decline, particularly the patient's balance.

3.2 Inclusion Characteristics Included in the Study

Eight articles involving 208 participants who met the inclusion criteria in all articles were selected to assess the effect of visual biofeedback to improve balance in post-stroke patients. Table 1 contains further information.

3.3 Rating of Quality

The PEDro scale, which included 11 assessment items, was used to evaluate the study's quality. Each item receives the information "Yes" for 1 point if it meets the criteria and "No" for 0 points if it does not meet the criteria.

The average PEDro score from the study results is 8.0. All articles used randomized group participants, in terms of the most crucial prognostic indicators at baseline, allocation was concealed, and the groups were similar, For at least one key outcome, the study provides both direct measurement and measures of variability, and the outcomes of statistical comparisons between groups are found for at least one key outcome. All examiners who measured at least one important outcome were blind folded.

Except for [7], all subjects were randomly assigned to groups in all articles, and all subjects were blinded in all articles except [10, 11]. The article claims that there was no blinding in the physiotherapy study and that more than 85% of the subjects who were initially assigned to groups had measurements of at least one important outcome. Except for one article, all reported that all subjects for whom outcome measures were available received the treatment. [12] (Table 2).

3.4 Participants

The study participants' ages ranged from 18 to 90 years old, with the origins of 1 acute stroke article [7], 3 subacute stroke articles [8–10], and 4 chronic stroke articles [11–14] more than three and six months, first stroke stroke, and no visual problems (Table 3).

3.5 Interventions

Intervention to improve balance in the experimental group. The visual biofeedback method investigated is shown below.

3.5.1 Visual Biofeedback Balance Training Wii Fit

This equipment consists of the Wii Balance Board, a platform with weight sensors and a center of gravity. Wii Fit comes with 40 different kinds of balance exercises. However, only three were chosen for this study: plata formas, deep sea fishing, and floja cuerda. The difficulty level will be adjusted based on the patient's ability and condition. Each exercise lasts 10 min, with rest intervals varying according to the patient's condition. The wireless Nintendo Wii balance board is connected to an exercise, the program wireless network to a personal computer program, and the intervension interactive visual feedback training consists of a training program with visual feedback that is available online. [12, 13].

Table 2. PEDro Scale

Trial	Amborsini et al. (2019)	Barcala et al. (2013)	Hyun et al. (2021)	NOH H-J et al. (2019)	Pak and Lee (2019)	Shin (2019)	Yang et al. (2014)	Zhang et al. (2020)
Eligibility criteria were specified	Y	Y	Y	Y	Y	Y	Y	Y
Random allocation	Y	Y	Y	Y	Y	Y	Y	N
Concealed allocation	Y	Y	Y	Y	Y	Y	Y	Y
Groups similar at baseline	Y	Y	Y	Y	Y	Y	Y	Y
Participant blinding	N	N	N	Y	N	Y	N	N
Therapist blinding	N	N	N	N	N	N	N	N
Assesor blinding	Y	Y	Y	Y	Y	Y	Y	Y
$<15\%$ droupouts to follow-up	N	N	N	N	N	N	N	N
Intetion-to-treat analyses	Y	N	Y	Y	Y	Y	Y	Y
Between-group difference reported	Y	Y	Y	Y	Y	Y	Y	Y
Point estimate and variability reported	Y	Y	Y	Y	Y	Y	Y	Y
Total (0–10)	8/11	7/11	8/11	9/11	8/11	9/11	8/11	7/11

Note: Y = Yes; N = No

3.5.2 Three-Dimensional Balance Training Using Visual Feedback

The exercise program includes three areas of movement: sagittal, frontal, and transverse. Frontal plane exercises involving play that induces left and right movement. In the sagittal plane, we play games that cause up and down movements. Transverse plane exercises are performed in a 3D environment using games that induce random motion. Each exercise program has a difficulty level ranging from 1 to 10. When the patient can perform more than 75% of the exercises, the level of difficulty rises [10].

Table 3. Subject Characteristics

No	Author and Year	Number of Subject	Subject Characteristics
1	Amborsini et al. (2019)	Twentyfour with stroke sub-acute	Before being enrolled, patients had to have experienced their first stroke within the previous six months, have hemiparesis, be between the ages of 18 and 90, have a range of motion in their lower limbs that allows them to pedal, have reduced spasticity in their leg muscles used modified Ashworth scale 2, and be able to sit for thirty minutes.
2	Barcala et al. (2013)	Twenty with stroke chronic	per week visits to the facility for physical therapy, the capacity to maintain orthostatic balance without help, the absence of osteoarticular deformities and recognizing visual biofeedback People with accompanying illnesses unidentified to the pathophysiology of stroke were not included in the research.
3	H.-J. NOH et al. (2019)	Twentyfour with stroke sub-acute	The inclusion criteria included all patients with range 56.42 $\pm$ 5.85 years old, who had their initial stroke, during the six months prior.
4	Hyun et al. (2021)	Fourty with stroke subacute	Those who could follow instructions, understand what needed to be done, and follow directions by Mini-Mental State Examination-Korean and those who had hemiparesis as a result of a stroke that was diagnosed between three and six months after the onset (MMSE-K) score of more than 21 points. Those who were able to stand up without assistance while seated for more than a minute, those who were unable to perform the standing motion, those who had no body parts fractures, chronic pain, joint motion restrictions (instability), and had no vestibular dysfunction, hemianopsia, amblyopia, or vertigo.
5	Pak and Lee (2019)	Twentyfour with stroke chronic	An individual who can walk 10 m without assistance, is free of musculoskeletal or cardiopulmonary diseases, has a minimum score of 24 on the Korean version of the Mini-Mental Status Examination, and has not been identified as having cerebellar or basal nuclei damage.
6	Shin., (2019)	Twentyfour with stroke chronic	the capacity to walk for 10 m both with and without the aid of an assistive device, hemiparesis caused by a single stroke for more than six months, capacity to comprehend and adhere to straightforward directions verbal with MMSE-K $>$ 24, and there is no significant heart disease or unmanaged hypertension.

(*continued*)

Table 3. (*continued*)

No	Author and Year	Number of Subject	Subject Characteristics
7	Yang et al. (2014)	Tweleve with stroke chronic	The ability to follow simple verbal instructions, a diagnosis of unilateral hemiparesis brought on by a cerebral hemorrhage confirmed by MRI, and more than 0 points in every category on the level for pushing that is unruly (sitting plus standing), as described by Baccini et al..
8	Zhang et al. (2020)	Fourty with stroke acute	They all ranged in age from 50 to 80, had a Mini-Mental State Examination score of 22, and had no history of knee injury problems or other conditions linked to stability deficits (MMSE). If a participant could stand unaided for one minute and needed stability training, as determined by the senior physiotherapist, they were considered a participant.

3.5.3 Smartphone-Based Visual Feedback

The balance board is linked to the monitor and speaker on the smartphone. A wireless Nintendo Wii balance board connected to an exercise The PC interactive visual feedback training is a program with a personalized, accessible online sensor based training program. [11].

3.5.4 Visual Feedback Training and Visual Targets on Muscle Activation, Balancing, and Walking Ability

They are shoulder-width apart, standing up straight, with their leg parallel, was required of the participants. After aiming a laser at their sternum's xiphoid process with a full-body looking glass mirror that is one meter ahead of them, the patient draws a vertical center line on the mirror. In tandem, participants weight was shifted to the paralyzed side, and tape or other markers were used to indicate the patient's ability. [14].

3.5.5 The Sit-To-Stand Training Program with Real-Time Visual Feedback

The sit-to-stand method is used in the visual feedback motor learning method [8].

3.5.6 Pro-kin System

Patients were instructed to move their CoP (Center of Pressure) across a designated area in random directions, including upwards, back, sideways, and in a rotational movement, using visual feedback. Furthermore, the clients chose two gameplay from three possibilities: ping pong, a laser show, and a sky sport simulator. [7].

3.5.7 Multimodal Training with Visual Biofeedback

The use of 20 min of cycling training and 20 min of exercise with visual feedback, as well as conventional exercise physical therapy [9].

3.6 Outcome Measurements

The measuring instruments used in the various articles collected varied. Various outcome measures were used to assess static balance, dynamic balance, walking balance, and walking speed before and after the intervention. There are 6 articles using the Berg Balance Scale (BBS) [7–10, 12, 13], 3 articles using the Time Up and Go Test (TUGT) [7, 8, 12], 2 articles using the Functional Index Measure (FIM) [9, 12] and 10 min Walking Test (10 MWT) [8, 14], the remainder using activity-specific balance confidence. (ABC) score [10], Functional Ambulatory Classification (FAC) [7], Barthel Index (BI) [7], Scale for Contraversive Pushing (SCP) [13], Fugl-Meyer assessment (FMA) [13], Trunk Impairment Scale (TIS score) [11], Lateral Reach Test (LRT) [14], Velocity [14], Stroke-Specific Quality of Life (SS-QOL) [8], MI Leg [9] as a support for article outcome variations (Table 1).

3.7 Study Results

The findings of research on the advantages of visual biofeedback to enhance balance in post-stroke patients are presented in Table 4.

4 Discussion

One of the major factors in carrying out daily activities in post-stroke patients is impaired balance and body control. This study looked at the effects of biofeedback visual balance in post-stroke patients. There are quality results from the PEDro scale measurements that have been performed; there are those who get enough to very good scores to help rehabilitation in post-stroke balance training. In stroke patients, visual biofeedback can help improve static and dynamic balance. [13].

Four of the eight articles used chronic stroke patients as respondents, three used sub-acute stroke patients as respondents, and one used acute stroke patients as respondents. Only one of the eight articles found argued that visual biofeedback did not aid stroke survivors' functional recovery or ability to balance [9], while another argued that visual biofeedback was better and more effective in improving balance, functional, mental health, and walking in stroke patients rather than using conventional interventions.

Two high-quality articles address the restoration of balance and walking after stroke in both the acute and chronic phases. Both studies found that there was a significant improvement in balance and walking between groups. The same measuring instrument was used in both studies to assess balance ability using the Berg Balance Scale (BBS) with experimental group results in acute stroke 15.70 - 38.55 and chronic stroke patient group 39.6 - 41.9 and to assess walking quality using the Time Up and Go test (TUG test) with experimental group results in acute stroke 26.30 - 21.60 and chronic stroke patient group 27.9 - 24.3.

Table 4. Study Result

No	Author and Year	Study Results
1	Amborsini et al. (2019)	1. T3-T1 changes in spatiotemporal gait parameters, the experimental group's trend in outcome measures was greater. 2. At T3, there was a significant association (P = 0.048) between the intervention and an increase in walking speed, only 46% of the control group increased their walking speed clinically significantly, while 73% of the experimental group did. 3. Running endurance based on 6MWT results was 77% in the experimental group and 46% in the control group, with a P value of 0.023. 4. Walking, functional recovery, and balance ability are all promoted. In addition to usual care, at the same intensity, multimodal biofeedback exercise that incorporates Functional electrical stimulation riding and stability training performs better than standard care..
2	Barcala et al. (2013)	1. Following the intervention, both groups (control and experimental) showed a decrease in COP mediolateral oscillations. 2. After treatment, both groups had lower COP anteroposterior oscillations. 3. The between-group analysis revealed no statistically significant differences ($p > 0.05$).
3	H.-J. NOH et al. (2019)	1. Balance training with visual feedback resulted in significant improvements in BBS, gait parameters, and ABC over time when compared to the control group. 2. These findings support the notion that 3D balance training with visual feedback improves balance, gait, and balance.
4	Hyun et al. (2021)	1. The hip flexor, hip abductor, and knee extensor muscle groups there was an increase in strength, in the experimental group 2. The use of measuring instruments with outcome measure used COP, BBS, TUG, 10MWT, SS-QOL, and 10MWT resulted in significant changes. 3. These findings suggest that the experimental group is more effective in improving post-stroke patients' balance and quality of life.
5	Pak and Lee (2019)	1. EMG measurements revealed that the experimental group had significant changes in the rectus femoris (RF), gluteus medius (GM), and tensor fascia lata (TFL) before and after intervention ($P < 0.05$). 2. In the control group, only muscle RF and TFL showed significant changes ($P < 0.05$). 3. With the weight-bearing measurement on the affected side, the experimental and control groups significantly differed from one another ($P < 0.05$). 4. Significant variations existed in the experimental group for measuring the distance between positional movements before and after the intervention.

(*continued*)

Table 4. (*continued*)

No	Author and Year	Study Results
6	Shin., (2019)	1. TIS increased significantly in the SPVFTCT group after the 4-week intervention (P < 0.05). 2. There was a significant increase in spatial gait parameters, including stride length and stride length, in the SPVFTCT group. 3. When Temporal gait parameters, including speed and cadence, were measured in the SPVFTCT group, they were significantly higher than in the control group.
7	Yang et al. (2014)	1. According to the BBS and the scales for aggressive driving, interactive feedback training and computer-generated visual mirrors were associated with a significant reduction in the severity of Pusher's syndrome and an increase in post-training balance ability compared to pre-training. 2. The experimental group improved their balance more than the control group, as measured by the aggressive drive scale and the post-training Berg balance scale. 3. Lower extremity motor function improved significantly in both groups following training. 4. In both groups, there was no significant change in upper extremity motor function after training compared to before training.
8	Zhang et al. (2020)	1. After the intervention, the experimental group showed significant results in outcome measure used and Pro-kin compared to the control group (P < .05). Before intervention, BBS and TUG scores were significantly correlated with outcome measure used (FAC, BBS, TUG, and BI).

Two high-quality articles on walking recovery after stroke in the subacute and chronic phases are available. Both studies found that there was a significant improvement in balance and walking between groups. The experimental group of subacute stroke 28.94 - 34.77 and the group of chronic stroke patients 38.50 - 43.41 used the same measuring instrument to assess their ability to walk in both studies.

Four high-quality articles address the restoration of balance and walking after stroke in both the acute and chronic phases. Three studies found significant differences in balance and walking ability between groups, while one study found visual biofeedback to be less effective in improving functional recovery and balance ability. Three of the four studies used the BBS (berg balance scale) to assess balance ability, with the results, the experimental group on subacute strokes 24 - 38 - 44 - 43; and the other 37.20 - 51.27; a group of chronic stroke patients 13.6 - 28.3.

BBS showed the visual impact of biofeedback on enhancing balance in stroke patients results in the experimental group 37.20 - 51.27 and the control group 41.60 - 47.73, as well as quality of life in post-stroke patients using the SS-QOL in the experimental group 149.93 - 116.60 and the control group 164.87 - 144.07 [8]. A record of visual biofeedback as an additional intervention must be supervised and not blinded by the physiotherapist and the patient, and the physiotherapist must also understand the purpose and function of the visual biofeedback given to match the recovery target that has been established.

Several factors make the balance results in the experimental group insignificant, including visual biofeedback combined with cycling training, which can increase Maximum Oxygen Volume (VO2max) in stroke patients [15], patients were blinded to the given intervention (in the study, four patients who had been tested for inclusion dropped out of the study), one patient refused to take measurements, reducing the data obtained in the study, and there was an argument in the conclusion that subjects with severe gait disturbances appear to benefit more from this intervention [9]. The disadvantages of this article include the amount of different data collected from each article, such as the varying number of sessions, different durations ranging from 20 min to 1 h, differences in patient criteria, and measuring instruments used. As a result, it is difficult to separate influence of post-stroke patients' achieved balance. There are two articles claiming that the journal is methodologically biased due to blindness and that there is missing data. The study's external validity may also be harmed by its small sample size. The intensity of the intervention dose varied greatly between studies, and no justification was provided in any of the studies. Therefore, the results of the included studies may contain errors.

5 Conclusion

In conclusion, the use of visual biofeedback in post-stroke patients can improve balance, walking, and quality of life. There is no article that mentions visual biofeedback as the main intervention, but as an additional intervention combined with conventional exercise physical therapy. Further research is needed to determine the progress and effectiveness of using this additional intervention in the future, so that it can be more optimal, innovative, and modern in the treatment of stroke patients, both acute, subacute, and chronic.

Acknowledgments. This research was conducted by the first author as part of his undergraduate study in Physiotherapy at the Muhammadiyah University of Surakarta, Indonesia.

Authors' Contributions. Universitas Muhammadiyah Surakarta HMF helped with the article's preparation, writing, data gathering, and processing. UBR took part in the article's creation and review while also offering advice, suggestions, and input. RAM provided input and suggestions while helping to write the article.

References

1. A. Ghofir, *Tatalaksana Stroke dan Penyakit Vaskuler Lainnya*. Yogyakarta, 2021
2. I. N. Fikriyah, A. F. Naufal, and W. Wijianto, "Hubungan Keseimbangan Dinamis dengan Activity of Daily Living pada Lansia Muda," *FISIO MU Physiother. Evidences*, vol. 2, no. 2, pp. 59–64, Jul. 2021, doi: https://doi.org/10.23917/fisiomu.v2i2.10060.

3. H. Alhasan, V. Hood, and F. Mainwaring, "The effect of visual biofeedback on balance in elderly population: a systematic review," *Clin. Interv. Aging*, vol. Volume 12, pp. 487–497, Mar. 2017, doi: https://doi.org/10.2147/CIA.S127023.
4. K. Yasuda, K. Saichi, N. Kaibuki, H. Harashima, and H. Iwata, "Haptic-based perception-empathy biofeedback system for balance rehabilitation in patients with chronic stroke: Concepts and initial feasibility study," *Gait Posture*, vol. 62, pp. 484–489, May 2018, doi: https://doi.org/10.1016/j.gaitpost.2018.04.013.
5. I. Karyn, M. Dara, N. Handayani, O. Darmawan, F. Kedokteran, and I. Kesehatan, "HUBUNGAN FUNGSI KOGNITIF DENGAN KESEIMBANGAN PADA LANSIA DI JAKARTA ASSOCIATION BETWEEN COGNITIVE FUNCTION AND BALANCE AMONG THE ELDERLY IN JAKARTA," 2021
6. N. Byl, W. Zhang, S. Coo, and M. Tomizuka, "Clinical impact of gait training enhanced with visual kinematic biofeedback: Patients with Parkinson's disease and patients stable post stroke," *Neuropsychologia*, vol. 79, pp. 332–343, Dec. 2015, doi: https://doi.org/10.1016/j.neuropsychologia.2015.04.020.
7. M. Zhang *et al.*, "Effects of visual feedback balance training with the Pro-kin system on walking and self-care abilities in stroke patients," *Medicine (Baltimore).*, vol. 99, no. 39, p. e22425, Sep. 2020, doi: https://doi.org/10.1097/MD.0000000000022425.
8. S.-J. Hyun, J. Lee, and B.-H. Lee, "The Effects of Sit-to-Stand Training Combined with Real-Time Visual Feedback on Strength, Balance, Gait Ability, and Quality of Life in Patients with Stroke: A Randomized Controlled Trial," *Int. J. Environ. Res. Public Health*, vol. 18, no. 22, p. 12229, Nov. 2021, doi: https://doi.org/10.3390/ijerph182212229.
9. E. Ambrosini *et al.*, "A multimodal training with visual biofeedback in subacute stroke survivors: a randomized controlled trial," *Eur. J. Phys. Rehabil. Med.*, vol. 56, no. 1, Feb. 2020, doi: https://doi.org/10.23736/S1973-9087.19.05847-7
10. H.-J. Noh, S.-H. Lee, and D.-H. Bang, "Three-Dimensional Balance Training Using Visual Feedback on Balance and Walking Ability in Subacute Stroke Patients: A Single-Blinded Randomized Controlled Pilot Trial," *J. Stroke Cerebrovasc. Dis.*, vol. 28, no. 4, pp. 994–1000, Apr. 2019, doi: https://doi.org/10.1016/j.jstrokecerebrovasdis.2018.12.016.
11. D.-C. Shin, "Smartphone-based visual feedback trunk control training for gait ability in stroke patients: A single-blind randomized controlled trial," *Technol. Heal. Care*, vol. 28, no. 1, pp. 45–55, Jan. 2020, doi: https://doi.org/10.3233/THC-191647.
12. L. Barcala, L. A. C. Grecco, F. Colella, P. R. G. Lucareli, A. S. I. Salgado, and C. S. Oliveira, "Visual Biofeedback Balance Training Using Wii Fit after Stroke: A Randomized Controlled Trial," *J. Phys. Ther. Sci.*, vol. 25, no. 8, pp. 1027–1032, 2013, doi: https://doi.org/10.1589/jpts.25.1027.
13. H.-C. Yang *et al.*, "Effect of biofeedback cycling training on functional recovery and walking ability of lower extremity in patients with stroke," *Kaohsiung J. Med. Sci.*, vol. 30, no. 1, pp. 35–42, Jan. 2014, doi: https://doi.org/10.1016/j.kjms.2013.07.006.
14. N.-W. Pak and J.-H. Lee, "Effects of visual feedback training and visual targets on muscle activation, balancing, and walking ability in adults after hemiplegic stroke: a preliminary, randomized, controlled study," *Int. J. Rehabil. Res.*, vol. 43, no. 1, pp. 76–81, Mar. 2020, doi: https://doi.org/10.1097/MRR.0000000000000376.
15. I. H. and U. B. R. Arjun Gholpa Ashadi, "PENGARUH LATIHAN STATIC CYCLE TERHADAP PENINGKATAN VOLUME OKSIGEN MAKSIMAL (VO2MAX) PADA PASIEN PASCA STROKE," University Muhammadiyah surakarta, Surakarta
16. C. Timmermans, M. Roerdink, C. G. M. Meskers, P. J. Beek, and T. W. J. Janssen, "Walking-adaptability therapy after stroke: results of a randomized controlled trial," *Trials*, vol. 22, no. 1, pp. 1–13, 2021, doi: https://doi.org/10.1186/s13063-021-05742-3.

17. D. K. Rose *et al.*, "Locomotor training and strength and balance exercises for walking recovery after stroke: Response to number of training sessions," *Physical Therapy*, vol. 97, no. 11. pp. 1066–1074, 2017. doi: https://doi.org/10.1093/ptj/pzx079.
18. A. Srivastava, A. B. Taly, A. Gupta, S. Kumar, and T. Murali, "Bodyweight-supported treadmill training for retraining gait among chronic stroke survivors: A randomized controlled study," *Ann. Phys. Rehabil. Med.*, vol. 59, no. 4, pp. 235–241, 2016, doi: https://doi.org/10.1016/j.rehab.2016.01.014.
19. A. Middleton *et al.*, "Body weight-supported treadmill training is no better than overground training for individuals with chronic stroke: a randomized controlled trial," *Top. Stroke Rehabil.*, vol. 21, no. 6, pp. 462–476, Jan. 2014, doi: https://doi.org/10.1310/TSR2106-462.
20. T. Ribeiro, H. Britto, D. Oliveira, E. Silva, E. Galvão, and A. Lindquist, "Effects of treadmill training with partial body weight support and the proprioceptive neuromuscular facilitation method on hemiparetic gait: A randomized controlled study," *Eur. J. Phys. Rehabil. Med.*, vol. 49, no. 4, pp. 451–461, 2013.
21. G. D. Baer, L. G. Salisbury, M. T. Smith, J. Pitman, and M. Dennis, "Treadmill training to improve mobility for people with sub-acute stroke: a phase II feasibility randomized controlled trial," *Clin. Rehabil.*, vol. 32, no. 2, pp. 201–212, 2018, doi: https://doi.org/10.1177/0269215517720486.
22. Y. R. Mao *et al.*, "The Effect of Body Weight Support Treadmill Training on Gait Recovery, Proximal Lower Limb Motor Pattern, and Balance in Patients with Subacute Stroke," *Biomed Res. Int.*, vol. 2015, 2015, doi: https://doi.org/10.1155/2015/175719