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The visual feedback training effect of the walking abilities to improve quality of life of stroke patients: a systematic review

Jerry Maratis[1]*, Mira Asmirajanti[2]

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[1]Physiotherapy Study Program, Faculty of Physiotherapy, Universitas Esa Unggul, Indonesia

[2]Nursing Study Program, Faculty of Health Science, Universitas Esa Unggul, Indonesia

***Correspondence:**
jerry.maratis@esaunggul.ac.id

Abstract

Purpose: Stroke can cause problems with balance and gait ability. This research was conducted to describe the effectiveness of visual feedback training as an exercise method for stroke patients in training balance and gait abilities. **Methods:** A systematic review was conducted on articles published between 2019 and 2023 examining visual cue training for stroke patients. **Results:** Six relevant studies reviewed the benefits of visual feedback training on balance and gait ability, including benefits on recumbent stepping and improving the quality of post-stroke patients. **Conclusion:** Exercise is needed to improve post-stroke patients' balance and gait. The development of training techniques for post-stroke patients, one of which is visual feedback training, still needs to be carried out.

Keywords: stroke patients; training; visual feedback; walking abilities

INTRODUCTION

Stroke is the second-leading cause of death in the world [1,2]. Disability rates after stroke are also increasing more rapidly in middle- and low-income developing countries than in high-income countries. Stroke rates are also growing globally in young and middle-aged people (aged <55 years). The death rate from stroke continues to increase by 50%—by 6·6 million in 2020, to 9.7 million in 2050—and disability-adjusted life-years (DALYs) by 144.8 million in 2020, to 189.3 million in 2050 [2]. Post-stroke patients can experience hemiplegia in brain lesions on the contralateral body, which is characterized by asymmetrical postural control due to weight-bearing control and loss of balance on the affected side. Asymmetrical posture affects the gait cycle, resulting in difficulty achieving balance when sitting or standing [3,4]. Chronic stroke disrupts sitting balance and trunk function [5,6]. Balance requires precise postural control of the center of gravity and movement and complex motor and sensory input processing. Post-stroke patients require trunk stabilization exercises [7].

The main focus of the rehabilitation program is improving mobility and balance for daily activities, namely functional abilities. Visual feedback is mostly used in physiotherapy interventions to improve mastery of sitting or standing postures and train load transfer abilities by moving the whole body or trunk [8]. Visual feedback is one of the most widely used external stimuli to improve abilities. Balance training is a common approach to treating disorders and improving the patient's overall function and quality of life. Visual feedback is essential for stroke patients because it can improve balance and postural control [3,9].

Stroke often disrupts the sensory-motor system [10,11], interfering with the patient's ability to maintain balance [12]. They improved motor learning. Visual feedback helps stroke physiotherapy patients enhance balance in the short-term and long-term intervention. By integrating visual feedback into physiotherapy, stroke patients can obtain functional training to improve postural control [3]. Gait deficits after stroke are considered to be a major factor contributing to functional disability in patients affected by stroke.

Compared with healthy individuals, stroke patients show gait deficits characterized by reduced walking speed and residual left-right spatiotemporal asymmetry [13]. Gait improvement is an important element of functional training after stroke and a major therapeutic goal. Research is needed to evaluate whether visual feedback plays an important role in stroke recovery and may be a valuable approach. Therefore, a systematic review of various studies related to visual feedback is needed to determine its effect on balance and gait ability. The review also aims to provide information about effective training methods for stroke patients.

Previous research discusses visual feedback training in certain cases, and not much has been researched about visual feedback training. Meanwhile, the state of the art in this article discusses previous research from several articles related to visual feedback training to provide an overview of visual feedback training and its benefits in post-stroke patients.

METHODS

Search Strategy. For this systematic review, searches used three databases (Science Direct, Proquest, and Scopus). This research was conducted on articles published in English between 2019 and 2023 with the keywords "visual feedback training" combined with "gait" and "stroke patients.". The articles were then filtered by excluding paid articles not in English, articles with incomplete text, and articles with irrelevant titles and abstracts. From the search results of 3 databases, Science Direct, Proquest, and Scopus, 143 articles were obtained, published from 2020 to 2024. Furthermore, relevant titles and abstracts were filtered and tested for eligibility to obtain six full-text articles. Based on these six articles, this paper reviews visual feedback training for stroke patients.

RESULTS

Figure 1 presents prisma diagram of the study. A total of 143 articles were obtained from three databases: PubMed, Scopus, Cochrane, and other databases. Then, six articles were obtained in the full-text screening in English from 2019 to 2023. This paper reviews the effectiveness of visual feedback training methods to improve balance and walking ability. **Table 1** study summarizes six research articles included in the study that investigated the impact of visual feedback training on stroke patients' balance, gait, and muscle activation.

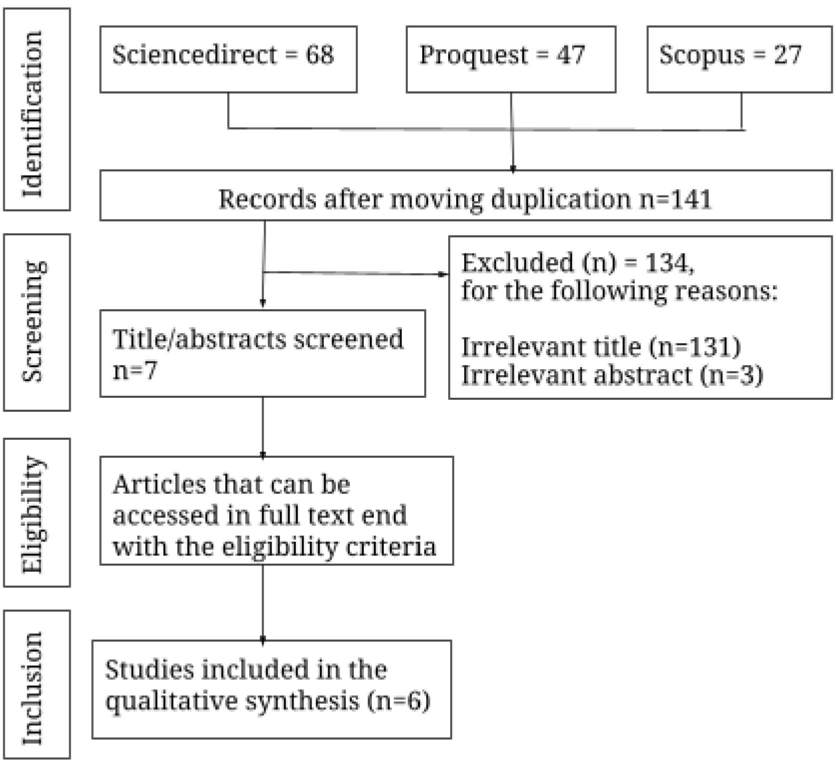

Figure 1. PRISMA Diagram

Table 1. Summary of articles included in the study

Title	Researcher (Year)	Country	Main topic	Study design	Sample size
Effect of balance training in sitting position using visual feedback on balance and gait ability in chronic stroke patients	Yeo et al. (2023) [3]	Korea	Balance and gait ability	Experimental	39
Effects of robot-assisted gait training with active motion visual feedback induced by guidance force on walking speed in patients with chronic stroke: a pilot study	Yoon & Oh (2020) [17]	Korea	Walking speed	Experimental	3
Use of real-time visual feedback during overground walking training on gait symmetry and velocity in patients with post-stroke hemiparesis: randomized controlled, single-blind study	Kim & Oh (2020) [15]	Korea	Gait symmetry and velocity	Experimental	24
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	Pak & Lee (2020) [18]	Korea	Muscle activation, balancing, and walking ability	Experimental	21
Effect of treadmill training with visual biofeedback on selected gait parameters in subacute hemiparetic stroke patients	Kaźmierczak et al. (2022) [19]	Poland	Gait Parameters	Experimental	92
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 randomised controlled trial	Hyun et al. (2021) [20]	Korea	Strength, balance, gait ability, and quality of life in patients	Experimental	30

The studies were conducted in Korea and Poland and included various experimental designs. The sample sizes ranged from 3 to 92 stroke patients who were at least six months post-stroke and capable of independent walking. The interventions included visual feedback combined with balance training, robot-assisted gait training, and treadmill training.

Table 2 in the document presents a summary of studies examining the effectiveness of visual feedback training for stroke patients, focusing on balance and gait abilities. The studies, mostly experimental, involved various interventions such as combining visual feedback with balance training on unstable surfaces, robot-assisted gait training, and treadmill exercises with biofeedback. These interventions consistently showed improvements in balance, walking speed, muscle activation, and gait parameters such as step length and symmetry. Visual feedback training often outperformed conventional therapy methods in enhancing functional recovery in stroke patients, indicating its potential as a valuable therapeutic approach for post-stroke rehabilitation.

Study 1 (Yeo et al., 2023) [3] and Study 3 (Kim & Oh, 2020) [15] demonstrate significant improvements in gait and balance in stroke patients using visual feedback combined with different training methods. Yeo et al. showed that combining visual feedback with balance training on an unstable surface led to a 25% improvement in stride length and an 18% improvement in hip/knee flexion angle. Similarly, Kim & Oh found that real-time visual feedback during overground walking significantly enhanced gait parameters such as step length and stride length compared to control groups.

Study 2 (Yoon & Oh, 2020) [17] and Study 4 (Pak & Lee, 2020) [18] highlight the effectiveness of visual feedback in boosting walking speed and muscle activation. Yoon & Oh observed that robot-assisted gait training with visual feedback led to walking speed improvements of up to 43.71%. Pak & Lee found that visual feedback targeting gradual weight shifting significantly increased muscle activation, particularly in the gluteus medius, which is crucial for walking stability and strength in stroke patients.

DISCUSSION

Effect of visual feedback on balance. A visual feedback training group increases The Trunk Impairment Scale (TIS) [3] and the Berg Balance Scale (BBS) [3,17]. Body balance assessed by the Romberg test rises [16], and the Center of Pressure test (COP) [17]. Balance is the process of maintaining the position of the body's center of gravity vertically based on support and relying on fast, continuous good feedback from visual, vestibular, and somatosensory so that coordinated neuromuscular activity occurs [18].

Visual feedback training uses vision stimulated by vision, vestibular sensation, and somatosensory sensation or self-generated causal information; correct errors in the performance of tasks and encourage learning of correct movements. Therefore, during sit-to-stand training, body asymmetry is continuously corrected through visual cues that align the body midline via real-time visual feedback. With visual feedback, correct errors in weight transfer to the paralyzed side and repeat the movement for accurate load transfer. Watching the balance and movement directly from the paralyzed lower limbs makes them less sway and gives real-time visual feedback that can control balance. This improves the biofeedback and bio-feedforward control mechanisms by making combining movements and senses easier, leading to better balance [17]. Good body balance determines walking efficiency, progressive movement flow, and safety when changing direction. Visual feedback improves body balance and gait efficiency [16].

Effect of visual feedback on gait ability. A visual feedback balance training reduction in Timed Up and Go (TUG) values [3,13,17]. There was an increase in the 10mWalking Test (10MWT) measurement [17]. In the gait parameters, there was an increase in the gait velocity [3,14,16] and stride length increased [3,13], Step length [16], Stride length, Single support time, Gait velocity, Step length ratio, Stride length ratio, Single support time ratio [13]. The standard walking speed of healthy people ranges from 0.82–1.62 m/s. For women aged 50–64, the required walking speed is 0.91–1.63 m/s; for men of this age, the walking speed is slightly higher (0.96–1.68 m/s). The factor that influences increasing walking speed is balance [19]. The exercises used are strengthening the muscles of the lower extremities, exercises for motor control of lower extremity paresis, and postural, static, and dynamic balance training, which undoubtedly improves walking speed for people after stroke [16].

Effect of visual feedback on muscle activation. Electromyography (EMG) tests on patients who received visual feedback showed significant differences in the rectus femoris (RF), gluteus medius (GM), and tensor fascia lata (TFL) before and after the intervention. Similarly, the Lateral Reach Test (LRT) measurement results showed significant differences before and after intervention [15].

Effect of visual feedback on muscle strength test of lower extremities. There was an increase in lower extremity muscle strength after training on the strength of the hip flexor and knee extensor muscles. [17]. Training that performs more accurate movements through visual targets decreases compensation from other muscles, and motivation and concentration can increase [15]. Visual feedback exercises stabilize the posture of the hip joint in the stance phase, strength training is crucial, and the effect of increasing muscle strength is substantial in early stroke patients. Visual feedback training for stroke patients is a method to induce patient concentration and repetitive learning by increasing the load on the lower extremities using visual information. Through this method, body asymmetry is continuously corrected during sit-stand exercises, and accurate movements are performed while applying weight to the paralyzed lower limb to enable bilateral exercise training and increase the strength of the lower extremities [17].

Effect of visual feedback on analisis quality of life. Quality of life can be assessed with Stroke-Specific Quality of Life [20,21]. After a stroke, patients experience difficulty in carrying out daily independent activities, and their quality of life worsens due to life changes. Through visual feedback, therapists and patients can try various processes to plan exercise patterns to achieve goals and provide accurate knowledge about the patient's efforts to assist in rehabilitation. In stroke patients, multiple factors influence the quality of life, such as physical, psychological, social, and environmental aspects, especially the social and physical domains that affect the rehabilitation period [17,22,23]. Visual feedback training improve the quality of life of post-stroke patients [20].

Social impact. Visual feedback training has a significant social impact across multiple domains. It increases motivation to share knowledge, improves the quality of social interaction, aids motor recovery and balance, refines sound quality assessment, and reduces the risk of injury in physical activity. Visual feedback, particularly social comparisons focusing on achievable

Table 2. The effect visual feedback training on walking abilities stroke patients

Authors, location, study design	Intervention description	Outcome measure, control condition	Effectiveness
A1 [3] Korea Experimental	Randomly assigned to visual feedback combined with an unstable surface balance training group (VUSBG), an unstable surface balance training group (USBG), or a conventional physical therapy group (CG). This study used the Trunk Impairment Scale, the Bug Balance Scale, the Timed Get Up and Go Test, and the Gait Analysis.	Outcome: Balance and gait ability 39 samples, individuals with a confirmed neurologist diagnosis of stroke, at least six months post-diagnosis, the ability to stand and walk independently for at least 10 min over a distance of 6 m, no cognitive or visual impairments, ability to understand simple instructions (Mini-Mental State Examination, MMSE > 24), and ability to discriminate colors. Exclusion criteria included individuals with unstable medical conditions, severe joint deformities or contractures, and other neurological conditions that could affect gait or balance.	VUSBG and USBG improved function and gait (stride length and hip/knee flexion angle), but there was no significant difference in the CG group. Specific results showed that the stride length in the VUSBG improved by 25% ($p < 0.05$), and the hip/knee flexion angle improved by 18% ($p < 0.05$). The post-hoc analysis revealed that VUSBG had a greater impact on the hip/knee flexion angle relative to the other two groups, as well as gait velocity and stride length relative to CG. Visual feedback complex exercise based on the principle of proprioceptive neuromuscular facilitation could be an intervention strategy to improve gait speed, trunk stability, and mobility in chronic stroke patients
A2 [14] Korea Experimental	A single-subject reversal (A-B) design was applied. Overall, three patients with chronic stroke underwent robot-assisted gait training with visual feedback displaying active motion of the affected lower limb during the intervention phase. The walking function was measured using the 10-m walk test (10MWT) and peak knee flexion angle (PKFA) during walking.	Outcome :Walking speed Sample: 3 samples, (1) stroke onset > 6 months before; (2) independent walking with and without walking aids; (3) no orthopedic, cardiopulmonary, or neurologic diseases except stroke; (4) mild spasticity of the affected leg (£ G2 on the modified Ashworth scale); and (5) no cognitive impairment (> 24 points on the Korean version of the Mini-Mental State Examination) [14]. Patients with stroke-related symptoms that impeded training, such as serious sensory impairment, aphasia, or hemispatial neglect, were excluded from the study.	During the intervention phase, the 10MWT score of subjects 1, 2, and 3 improved by 23.95%, 30.95%, and 43.71%, respectively, and the PKFA improved by 8.41%, 15.92%, and 32.25%, respectively. The walking speed and PKFA in all subjects after the training showed improvement compared to the baseline phase ($p < 0.05$). Conclusions. Robot-assisted gait training with active motion visual feedback and guidance may be clinically helpful in improving walking recovery after stroke.
A3 [13] Korea Experimental	were randomly assigned to either the experimental or control groups. All subjects performed overground walking for 30 min, three times a week for six weeks, with real-time visual feedback (weight load to the affected	Outcome : Gait symmetry and velocity Sample: 24 samples, (1) chronic stroke (>6 months after stroke onset); (2) no unilateral neglect, hemianopia, or apraxia; (3) no cardiopulmonary or orthopedic complications; (4) ability to walk independently≥10 m without	Measures comprised the timed up-and-go test and gait parameters (step length, stride length, single and double support times, step and stride length ratios, and single support time ratio). In between-group comparison, the changes between pre-test and post-test scores

	lower limb) provided during training for subjects in the experimental group.	a walking aid; and (5) no cognitive deficit [>25 points on the Korean version of the Mini-Mental Status Examination (MMSE-K)] (Folstein et al., 1975). Although they could walk independently, they mostly (experimental group: 10 and control group: 9) used walking aids and slower walking speeds to mitigate their fall risk.	in all parameters were significantly greater in the experimental group than in the control group ($P < 0.05$), except for double support time and step length ratio. Furthermore, values of all parameters were significantly more improved in the experimental group than in the control group ($P < 0.05$). Our findings suggest that real-time visual feedback may be an advantageous therapeutic adjunct to reinforce the effects of overground walking training in patients with post-stroke hemiparesis.
A4 [15] Korea Experimental	randomly assigned to two groups: an experimental group (visual feedback training with visual targets on gradual weight shifting) and a control group (visual feedback training on gradual weight shifting).	Outcome :Muscle activation, balancing, and walking ability Sample: 21 samples, individuals with a confirmed neurologist diagnosis of stroke, at least six months post-diagnosis, the ability to stand and walk independently for at least 10 min over a distance of 6 m	The experimental group made significantly larger gains than the control group due to gluteus medius muscle activation and the paretic side's weight-bearing ability.
A5 [16] Poland Experimental	A Biodex Gait Trainer 3 treadmill with biofeedback function was used to evaluate selected gait parameters (walking speed, step length, % limb loading, and traveled distance).	Outcome: Gait Parameters 62 samples, aged 63 ± 12 years, with ischemic stroke episode within six months after onset, ability to walk independently with or without orthopedic aid,	After four weeks of rehabilitation, step length, walking speed, traveled distance, and static balance were significantly improved for the study and control group ($p < 0.05$). Treadmill gait training yielded substantially better results than a conventional rehabilitation program. Only the study group observed a corrected walking base ($p < 0.001$)
A6 [17] Korea Experimental	were randomly divided into two groups. The RVF-STS group received sit-to-stand training combined with real-time visual feedback using a Wii Balance Board (n = 15), and the C-STS group received classic sit-to-stand training (n = 15).	Outcome: Strength, Balance, Gait Ability, and Quality of Life in Patients 30 sample, those diagnosed with hemiparesis due to a stroke between 3 and 6 months after onset, those who could communicate.	Lower extremity muscle strength, balance ability, walking ability, and quality of life of the RVF-STS group significantly improved in comparison to the pre- and post-differences ($p < 0.05$), and it also showed significant differences between groups ($p < 0.05$).

target goals, can influence willingness to contribute and maintain knowledge sharing. These findings underscore the potential of visual feedback as a powerful tool for improving social and functional outcomes in various settings.

CONCLUSION

Stroke is a disease that can cause problems with balance and walking ability. Exercise is needed to improve balance and the walking ability of post-stroke patients. The visual feedback training method is part of the training that can be given to post-stroke patients to improve balance and walking ability. The development of training techniques for post-stroke patients, one of which is visual feedback training, still needs to be done. The benefits of visual feedback training have been proven in several studies. Further research is required to further analyze the effectiveness of visual feedback compared to other training methods. The development of visual feedback training can be pursued and applied to the post-stroke human community as a visual feedback training home program.

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