2.0 contact hrs
NCPD Nursing Continuing Professional Development

Using Mirror Therapy to Optimize the Efficacy of Balance Programs for Older Adults With Poststroke Balance Impairment

Mohammad Reza Armat[1], PhD, Hamed Mortazavi[1], PhD, Hadi Akbari[2], PhD, Amir Emami Zeydi[3], PhD & Arezoo Sarani[4]

Abstract

Purpose: Poststroke rehabilitation is an inevitable element of the treatment for stroke survivors. This study aimed to investigate the effect of balance training with mirror therapy in older adults with poststroke balance impairment.

Design/Methods: The study adopted a two-arm randomized clinical trial and included 38 older adults with poststroke balance impairment. The intervention group received balance exercises with mirror therapy, whereas the control group received the same balance exercises without mirror therapy (a nonreflective plate was used instead). The patient outcome, the balance score, was measured using the Berg Balance Scale. Analysis of covariance was used for statistical analysis.

Results: Results showed that balance exercises combined with mirror therapy were significantly more effective than balance exercises without mirror therapy in improving balance in the stroke survivors ($p < .001$).

Conclusion: Mirror therapy combined with regular balance exercises is an effective and practical method for enhancing balance in older adults suffering from balance impairment.

Clinical Relevance: Balance training combined with mirror therapy may be included in the rehabilitation programs of older adults with poststroke balance impairment.

Keywords: Stroke; rehabilitation; mirror therapy; aged; neurological rehabilitation.

Introduction

Stroke is the second leading cause of disability and death worldwide (Krishnamurthi et al., 2020). On average, every 40 seconds, a person suffers a stroke (Benjamin et al., 2017). One of the common complications of stroke is balance impairment (Khan & Chevidikunnan 2021; Vincent-Onabajo et al., 2018; Weerdesteijn et al., 2008), which limits the mobility of stroke survivors. For normal daily activities, the brain needs to regulate motor function, muscle tone, joint movement, and balance (Arene & Hidler, 2009); hence, malfunctions in any level of the mobility process can interfere with the ability of the stroke survivor to walk and move independently. In addition, balance impairment may increase the risk of falls and hip fracture (Cortés-Pérez et al., 2020; Pouwels et al., 2009) and negatively affect balance confidence (Schinkel-Ivy et al., 2017; Yiu et al., 2012).

Specific therapies such as standing practice, walking activities, strengthening training (Lubetzky-Vilnai & Kartin, 2010), whole-body vibration (Sade et al., 2019), virtual reality (Corbetta et al., 2015), and training in water (Mehrholz et al., 2011) have been shown to be effective in enhancing balance in stroke survivors. Several studies have investigated the effectiveness of other techniques (e.g., sliding board, trunk exercises on a physioball, shoe wedge, gait training, motor imagery, yoga, and tai chi) in improving balance in stroke survivors, but none has been shown to be more effective than others (Winstein et al., 2016).

In a study of systematic reviews, the effectiveness of physical therapy, virtual reality, electromechanical devices, tai chi, whole-body vibration, circuit training intervention,

Correspondence: *Hadi Akbari, Addiction and Behavioral Sciences Research Center, North Khorasan University of Medical Sciences, Bojnurd, Iran. E-mail: hadi.ha@gmail.com*

1 Geriatric Care Research Center, Department of Medical-Surgical Nursing, School of Nursing, North Khorasan University of Medical Sciences, Bojnurd, Iran.

2 Addiction and Behavioral Sciences Research Center, North Khorasan University of Medical Sciences, Bojnurd, Iran.

3 Department of Medical-Surgical Nursing, Nasibeh School of Nursing and Midwifery, Mazandaran University of Medical Sciences, Sari, Iran.

4 Student Research Committee, School of Nursing, North Khorasan University of Medical Sciences, Bojnurd, Iran.

Cite this article as:
Armat, M. R., Mortazavi, H., Akbari, H., Emami Zeydi, A., & Sarani, A (2022). Using mirror therapy to optimize the efficacy of balance programs for older adults with poststroke balance impairment. *Rehabilitation Nursing, 47*(6), 202–209. doi: 10.1097/RNJ.0000000000000389

and cognitive rehabilitation in improving balance was reviewed (Arienti et al., 2019). It was shown that most of the systematic reviews suffered from poor methodology, making it difficult to determine the efficacy of a particular balance-restoring technique. Regardless of the efficacy of these techniques, most require special devices or training. In addition, the cost of many balance therapies is usually high, which is a challenge for many older adults dealing with healthcare issues and their costs. This is particularly challenging for those living in countries with limited medical care insurance like Iran.

Mirror therapy is a potentially convenient and cost-effective method to enhance balance in stroke survivors and has recently been gaining popularity (Deconinck et al., 2015). Mirror therapy was first introduced to reduce phantom pain by showing the reflected image of the healthy limb in the mirror to the patient (Ramachandran & Rogers-Ramachandran, 1996). The visual illusion of movement of the affected limb (mainly the amputated limb) stimulates positive feedback to the motor cortex that may stop the pain cycle (Cacchio et al., 2009). When a mirror is placed between two limbs of a patient (arms or legs), seeing the movement of the healthy limb in the mirror creates the illusion of movement of the affected limb (Arya, 2016; Stevens & Stoykov, 2003; Wang et al., 2021). It has been hypothesized that such an illusion could reduce imaginary pain or phantom pain (Cacchio et al., 2009). It is believed that the mirror therapy effect is associated with motor imagery, which functions as visual feedback to the brain for the successful performance of movements in the affected limb.

Deconinck et al. (2015) reviewed neuroimaging studies of mirror visual feedback and concluded that mirror visual feedback strongly influences the motor network through increased cognitive penetration in action control rather than activation of motor neurons. Regardless of the theoretical explanation, studies have shown the benefits of using mirror therapy in the motor function recovery of upper and lower limbs in stroke survivors (Arya & Pandian, 2013; Broderick et al., 2018; Li et al., 2018; Louie et al., 2019; Wang et al., 2021).

Although the theoretical background and previous empirical studies (In et al., 2016; Kim et al., 2016; Mohan et al., 2013) show signs of efficacy of mirror therapy in improving balance in stroke survivors, it is still not possible to reach a proper consensus (Li et al., 2018; Louie et al., 2019). Some empirical studies have shown that mirror therapy helps restore balance in stroke survivors (Cha & Kim, 2015; Galeazzi et al., 2006; Kim et al., 2016; D. Lee et al., 2016; Mohan et al., 2013; Shahidi et al., 2020). However, systematic reviews have not suggested concluding evidence for the use (Li et al., 2018; Louie et al., 2019) and efficacy of mirror therapy.

Given the cost-effectiveness of mirror therapy and its applicability for home use, further studies are required to explore its benefits in enhancing balance in stroke survivors. This study aimed to examine the effect of balance exercise combined with mirror therapy on the balance of stroke survivors in Iran.

Methods

This study was a two-arm randomized clinical trial. The outcome of the study was the balance status of the stroke survivors. The intervention was balance exercises combined with mirror therapy. This clinical trial was approved by the Committee of Ethics in North Khorasan University of Medical Sciences (code: 1396.72 ir.nkums.RES) and registered in the Iranian Registry of Clinical Trials (code: IRCT20180526039851N1).

Participants

The participants were older adults with a history of hemorrhagic or ischemic stroke within the last 6 months. All suffered from stroke balance impairment. Participants were oriented and could perform the study protocols independently or with the assistance of a caregiver. All the participants signed the informed consent form before participating in the study.

Sampling and Sample Size Calculation

Initially, medical records of all stroke patients (n = 443) within the last 6 months in two hospitals in Bojnurd (a city in northeast Iran) between January and August 2019 were assessed. Based on inclusion criteria and sample size calculation, 40 stroke survivors were included in the study. Inclusion criteria were patients suffering from balance impairment because of movement problems in one leg within the last 6 months, being oriented and able to communicate, having a caregiver to assist with the balance exercises and mirror therapy, and not suffering from any injuries or diseases making balance exercises and mirror therapy hazardous. The exclusion criteria were any evidence suggesting incomplete training (not answering reminder phone calls, inconsistency in reporting about the trainings, etc.) and any unexpected events (falls, illness, dizziness, influenza, etc.) that could disturb balance training.

The sample size was estimated according to the effect size of mirror therapy (1.0009) from previous studies. Using G*Power 3.1 software, the minimum sample size was estimated to be 34 (n = 17 for each group). The sample size was increased to 40 (n = 20 in each group) after considering an attrition rate of 15%. A post hoc power analysis for the final sample size showed a power of .982, ensuring the adequacy of the study sample. Finally,

the participants were randomly assigned to intervention (n = 20) and control (n = 20) groups using permuted block randomization. We used an online tool for this purpose, with the inputs 2, 2, and 50, for the number of groups, block size, and list length, respectively (Sealed Envelope Ltd., 2021).

Instrumentation

Berg Balance Scale

The balance scores at baseline and after the intervention were measured at the patients' homes using the Berg Balance Scale (BBS). A colleague (a geriatric nurse skilled in balance training and assessment) who was blinded to the grouping of the participants measured the balance scores of the intervention and control groups before and after the intervention. The BBS was developed by Berg et al. (1992) and has been used in previous studies as a valid and reliable measure of nonvestibular balance function (Wirz et al., 2010). In the current study, the Persian version of the scale was used. The interrater reliability of the Persian version was estimated to be .99 using the Pearson correlation coefficient. The BBS measures the status of dynamic and static functional balance and takes approximately 15–20 minutes to complete. It includes 14 items composed of three components: sitting balance, standing balance, and dynamic balance. Each item has a score between 0 and 4 (a higher score indicates better balance). The BBS total score ranges between a minimum of 0 and a maximum of 56. A score equal to or less than 20 indicates a high risk of falling, a score of 20–40 indicates a moderate risk of falling, and a score above 40 indicates a low risk of falling (Berg et al., 1992).

Intervention

The protocol for the intervention group included balance exercises and mirror therapy. The same protocol was administered to the control group, except that a nonreflective plate was used instead of a mirror. The protocol consisted of two parts. The first part included regular balance exercises (the same for the control and experimental group), and the second part included mirror therapy for the experimental group and sham treatment with a non-reflective plate for the control group. Both parts of the protocol were explained at the home of the stroke survivor by the same instructor (a geriatric nurse) for 1 week. During the instructions, the instructor observed the patients and their caregivers performing the balance exercises and the mirror therapy to make sure they could implement the protocol appropriately and independently. To ensure the patients and caregivers performed the protocol routinely for the remaining 3 weeks, the instructor made repeated phone calls 5 days a week to remind them of the exercises and instructions.

In the first part of the protocol, participants practiced sitting on a chair, standing up, and standing back and forth while keeping their feet parallel. The participants in both groups implemented the leg movements barefoot while they were sitting in a semisitting position on a chair. The leg movements included (1) hip-knee-ankle flexion, (2) knee extension with ankle dorsiflexion, and (3) knee flexion beyond 90 degrees. The caregivers were taught by a geriatric nurse, one of the research team, to assist the patients with the balance exercises. Caregivers were instructed to assist the patients by checking the chair for any broken or defective parts, holding patients' hands to avoid falls, monitoring the sequence of the exercises, mimicking the exercises for the patients, and checking the patients' performance. In addition, caregivers were instructed to use a checklist to make sure exercises were done routinely for half an hour, 5 days a week, for 4 weeks. If patients were feeling any pain or discomfort, exercises were stopped and a report was given to the instructor. A manual containing the guide for the exercises and a phone number for any questions and reports was also given to the caregivers. This part of the protocol was the same in the intervention and control groups.

In the second part of the protocol, a 50 $\times$ 100 cm mirror was used in the intervention group, and a same-sized nonreflective plate was used for sham treatment in the control group. The mirrors were prepared with the help of the instructor and other research team members and included a rubber edge trim to protect the patients and caregivers against the sharp edge of the mirrors. The participants were in a sitting position in both groups while the mirror or nonreflective plate was placed between the participants' affected and healthy legs. The caregivers were instructed to hold the mirror between the patient's legs in a vertical position while the side of the mirror with the 50-cm length was on the floor. The participants in the intervention group moved their healthy leg while watching their reflection in the mirror in place of the affected leg. The participants in the control group performed the same exercise, but they could not see the reflection of their healthy leg because the plate was nonreflective.

Statistical Analysis

The collected data included demographic (participants' gender, age, height, weight, income, marital status, education level, and caregivers' age) and clinical information (history of chronic conditions, type of stroke, and balance scores before and after the intervention). For the interval variables (participants' age, height, weight, income, and caregivers' age), mean, standard deviation, independent-samples t test, and categorical variables (marital status, gender,

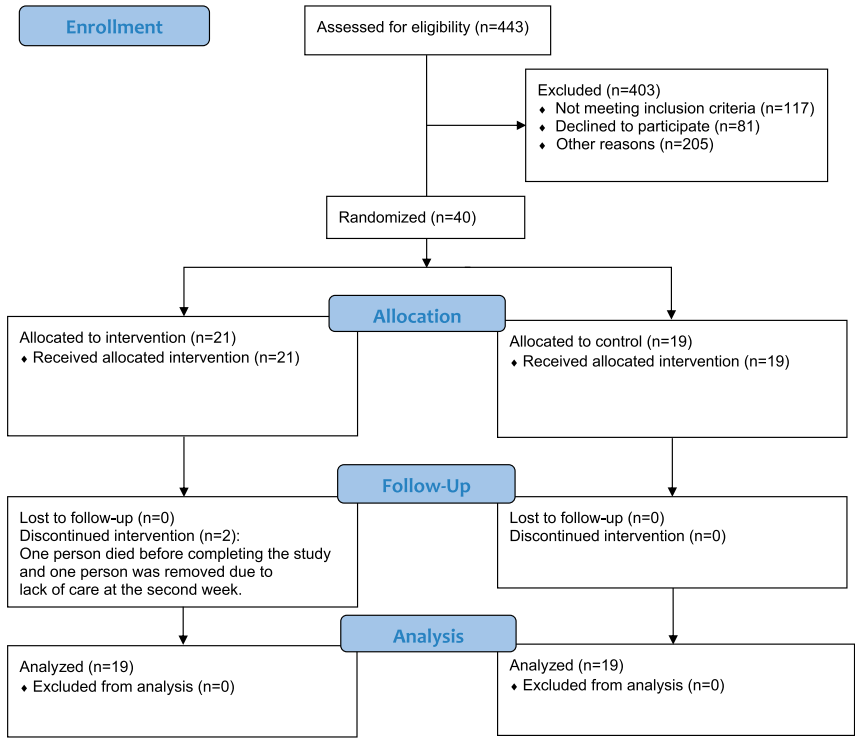

Figure 1. Flowchart of the study.

education level, history of chronic conditions, and stroke type), frequency counts, percentages, and the chi-square test were used to describe and compare the groups.

The independent variable (the intervention) was balance training combined with mirror therapy, and the dependent variable (outcome) was balance status. Descriptive statistics (mean and standard deviation) were used to profile the participants' balance status, and an analysis of covariance (ANCOVA) was used to examine the effect of balance exercises combined with mirror therapy on the balance of the stroke survivors. It should be noted that baseline balance scores served as the covariate. Before performing the ANCOVA, the necessary assumptions including normality of the data distribution, homogeneity of variance, and regression slopes were examined.

Gain score analysis and independent-samples *t* test (the difference between post-intervention and baseline balance scores) were also performed to consolidate the ANCOVA findings. The significance level was set at .05, and all the statistical analyses were done using SPSS 22.

Results

A total of 40 older adults with stroke were included in the sample. Ultimately, 19 participants in each study group successfully completed the study protocol (see Figure 1). Tables 1 and 2 show the characteristics of the participants and their caregivers in terms of weight, age, height, income, gender, marital status, chronic conditions, affected side, type of stroke, and education level.

As shown in Tables 1 and 2, preliminary analyses using independent-samples *t* tests and chi-square tests indicated that the study groups were homogeneous in terms of weight, age, height, income, gender, marital status, chronic condition, paralyzed side, type of stroke, and education level ($p > .05$).

The ANCOVA demonstrated a significant difference in the balance scores of the participants in the intervention group as compared to the control group, $F(1, 33) = 26{,}717$, $p < .001$, $\eta_p^2 = .447$, power $\geq .98$ (see Table 3). Adjusted R^2 was .920 meaning that more than 92% of variations in post-intervention balance scores could be attributed to the intervention (balance exercises

Table 1 Demographic Characteristics of the Groups

	Intervention ($n = 19$)	Control ($n = 19$)	*t* Test
Variable	Mean (*SD*)	Mean (*SD*)	*p*
Age (years)	67.2 (7.53)	68.6 (10.756)	.848
Height (cm)	168.89 (8.83)	166.35 (9.000)	.855
Weight (kg)	75.06 (12.26)	72.59 (5.350)	.973
Income (rials)	2.320 (9184159.77)	2.447 (45919927.11)	.259
Caregivers' age (years)	42 (14.23)	39 (12.60)	.442

Table 2 Baseline Comparison of the Groups: Categorical Variables

Variable		Study Groups			
		Intervention *n*	Control *n*	Total *n*	χ^2
Gender of stroke survivor	Female	9	8	17	0.775
	Male	10	11	21	
Marital status	Married	14	13	27	0.49
	Widow	5	6	11	
History of chronic disease	Yes	10	13	23	0.519
	No	9	6	15	
Affected side	Right	9	12	21	0.067
	Left	10	7	17	
Type of stroke	Hemorrhagic	3	4	7	0.83
	Ischemic	16	15	31	
Education level of stroke survivor	Illiterate	15	12	27	0.793
	Reading/writing	2	4	6	
	Primary school	1	1	2	
	Intermediate school	0	0	0	
	Diploma	1	2	3	
	College/university	0	0	0	
Caregivers' education level	Illiterate	6	5	11	0.49
	Reading/writing	0	1	1	
	Primary school	3	0	3	
	Intermediate school	4	7	11	
	Diploma	6	5	11	
	College/university	0	1	1	
Caregivers' gender	Female	11	14	25	0.748
	Male	8	5	13	

combined with mirror therapy). This, along with the value of η_p^2, reflects the intervention's appreciable effect size.

As mentioned earlier, a gain score analysis was done to further examine the effect of balance exercises combined with mirror therapy. Table 4 depicts a comparison of the groups in terms of gain scores. The *t* test showed a significant difference between the groups' gain scores ($t = 4.73$, $df = 21.91$, $p < .001$), suggesting that balance exercises combined with mirror therapy are more effective than balance exercises without mirror therapy in enhancing balance in stroke survivors.

Discussion

The study showed improved balance scores in the stroke survivors with a combination of mirror therapy with the balance exercises. Balance training without mirror therapy also improved balance in the stroke survivors; however, the improvement was less than what resulted from the balance training combined with mirror therapy. Some neurological and similar empirical studies on mirror therapy support these findings (Arya, 2016; Carvalho et al., 2013; Filimon et al., 2007; Galeazzi et al., 2006; Kim et al., 2016; H. J. Lee et al., 2017; Mazlom et al., 2013). It is hypothesized that motor neurons in the ventral and inferior areas of the brain's motor cortex are activated when the patient "observes" the movements of the healthy limb in the mirror (Arya, 2016; Filimon et al., 2007). It may be that watching the movements of the healthy limb in the mirror could deceive the brain into recruiting and activating the motor neurons, which facilitates the rehabilitation process of the affected limb (Fukumura et al., 2007). Fukumura

Table 3 Mean Balance Scores of the Groups at Baseline and After Intervention

Measurement Time	Study Groups	Mean (*SD*)	*t* Test	ANCOVA *F* Test[a]
Baseline	Control	34.76 (3.70)	$t = .43$, $df = 35$, $p = .671$	$F(1, 33) = 26{,}717$, $p < .001$
	Intervention	35.89 (3.90)		
After intervention	Control	35.06 (3.83)	$t = 2.4$, $df = 33$, $p = .022$	
	Intervention	37.89 (3.16)		

[a] $R^2 = .925$ (adjusted $R^2 = .920$).

Table 4 Difference Between the Gain Scores of the Groups

Study Groups	Measurement Time	Mean (*SD*)	Difference of Means (*SD*)	Independent *t* Test
Control	Baseline	34.76 (3.70)	0.30 (0.47)	$t = 4.73$, $df = 21.91$, $p < .001$
	After intervention	35.06 (3.83)		
Intervention	Baseline	35.89 (3.90)	2.00 (1.49)	
	After intervention	37.89 (3.16)		

Key Practice Points

- Mirror therapy is an easy-to-use, inexpensive, and safe rehabilitation technique in restoring balance in stroke survivors having a balance impairment.
- Mirror therapy can be easily taught to stroke survivors and their caregivers.
- Mirror therapy can be practiced at home.
- Rehabilitation nurses may include mirror therapy in balance training for more immediate balance recovery in stroke survivors.

et al. (2007) examined the neural mechanisms in the cortex using transcranial magnetic stimulation in healthy individuals and stated that the primary motor cortex is activated during mirror therapy. They concluded that watching the motions of a healthy hand in the mirror can contribute to the motor imagery in the affected hand.

Studies suggest that the interaction between vision, proprioception, and motor commands may facilitate the activation of motor neurons, leading to cortical reorganization and functional recovery of stroke survivors (Carvalho et al., 2013). However, a review study reported little evidence for the activation of motor neurons in mirror therapy but emphasized that mirror therapy mainly affects the motor network through increasing neural activity in areas involved with allocation of attention and cognitive control (Deconinck et al., 2015).

Regardless of the neural mechanism for the effect of mirror therapy, several empirical studies have shown the efficacy of mirror therapy in lower extremity motor function and balance of stroke survivors. It has been shown that combining motor neuron activation with a regular physiotherapy program can promote lower extremity motor recovery and motor functioning in stroke survivors (H. J. Lee et al., 2017). Kim et al. (2016) found that stroke survivors suffering from balance impairment gain significant improvement in their motor function and balance status after mirror therapy. Galeazzi et al. (2006) showed that watching one's own exercises in a mirror could improve the balance in stroke survivors. The study by Mazlom et al. (2013) on the effect of mirror therapy on the motor ability of stroke survivors demonstrated that patients had better motor recovery and ability to walk after mirror therapy. In a systematic review, six studies were focused on lower extremity impairment/function, gait, and balance. These studies reported an enhancement in "walking speed, single-limb stance, step, and stride lengths, static and dynamic balance, and mediolateral and anteroposterior sway in standing" after mirror therapy (Gandhi et al., 2020).

As witnessed in the current study, there are several benefits for mirror therapy when combined with routine balance exercises. First, this combination significantly improved the outcome of the balance rehabilitation process. Although the balance exercises (hip–knee–ankle flexion, knee extension with ankle dorsiflexion, and knee flexion beyond 90°) enhanced the balance of the stroke survivors to some extent, the addition of mirror therapy substantially boosted the desired outcome. Second, using a mirror while doing balance exercises is easy to perform, particularly when a caregiver is present to assist the patient. Finally, mirror therapy may not incur any adverse effects in stroke survivors suffering from balance impairment. This is an invaluable benefit, as little or no adverse effect is a key factor in selecting a therapeutic procedure. The low cost of mirror therapy is another benefit. Medical care costs have been reported as a barrier to successfully completing rehabilitation programs (Hwang et al., 2019). Because healthcare costs are a significant burden, mirror therapy as a nonpharmacological, noninvasive, and inexpensive treatment is practical. Based on these benefits, rehabilitation nurses may take a more creative and practical approach in restoring balance in stroke survivors. Rehabilitation nurses may seek ways to collaborate with the interdisciplinary team to provide such therapy.

The current study was not without limitations that need to be addressed in future studies. This study targeted the immediate effect of balance exercise combined with mirror therapy. Because a sustained outcome is preferable in clinical interventions, mirror therapy's long-term effects on stroke survivors' balance status are worthy of future study. In addition, visually impaired people with stroke balance impairment may not benefit from mirror therapy. Designing an alternative procedure to replace mirror therapy in patients who are visually impaired is suggested.

Conclusion

Many stroke survivors have some degree of balance impairment. The current study demonstrated that balance exercises combined with mirror therapy are significantly more effective than balance exercises alone in enhancing balance. Because mirror therapy is effective, cost-effective, and noninvasive for restoring balance in stroke survivors, it should be considered a part of a stroke survivor's balance rehabilitation program.

Conflict of Interest Statement

The authors declare no conflict of interest.

Funding

None.

References

Arene, N., & Hidler, J. (2009). Understanding motor impairment in the paretic lower limb after a stroke: A review of the literature. *Topics in Stroke Rehabilitation*, *16*(5), 346–356.

Arienti, C., Lazzarini, S. G., Pollock, A., & Negrini, S. (2019). Rehabilitation interventions for improving balance following stroke: An overview of systematic reviews. *PLOS ONE*, *14*(7), e0219781.

Arya, K. N. (2016). Underlying neural mechanisms of mirror therapy: Implications for motor rehabilitation in stroke. *Neurology India*, *64*(1), 38–44.

Arya, K. N., & Pandian, S. (2013). Effect of task-based mirror therapy on motor recovery of the upper extremity in chronic stroke patients: A pilot study. *Topics in Stroke Rehabilitation*, *20*(3), 210–217.

Benjamin, E. J., Blaha, M. J., Chiuve, S. E., Cushman, M., Das, S. R., Deo, R., De Ferranti, S. D., Floyd, J., Fornage, M., & Gillespie, C. (2017). Heart disease and stroke statistics—2017 Update: A report from the American Heart Association. *Circulation*, *135*(10), e146–e603.

Berg, K. O., Wood-Dauphinee, S. L., Williams, J. I., & Maki, B. (1992). Measuring balance in the elderly: Validation of an instrument. *Canadian Journal of Public Health*, *83*(Suppl. 2), S7–S11.

Broderick, P., Horgan, F., Blake, C., Ehrensberger, M., Simpson, D., & Monaghan, K. (2018). Mirror therapy for improving lower limb motor function and mobility after stroke: A systematic review and meta-analysis. *Gait & Posture*, *63*, 208–220. 10.1016/j.gaitpost.2018.05.017

Cacchio, A., De Blasis, E., De Blasis, V., Santilli, V., & Spacca, G. (2009). Mirror therapy in complex regional pain syndrome type 1 of the upper limb in stroke patients. *Neurorehabilitation and Neural Repair*, *23*(8), 792–799.

Carvalho, D., Teixeira, S., Lucas, M., Yuan, T. F., Chaves, F., Peressutti, C., Machado, S., Bittencourt, J., Menéndez-González, M., Nardi, A. E., Velasques, B., Cagy, M., Piedade, R., Ribeiro, P., & Arias-Carrión, O. (2013). The mirror neuron system in post-stroke rehabilitation. *International Archives of Medicine*, *6*(1), 41.

Cha, H. G., & Kim, M. K. (2015). Therapeutic efficacy of low frequency transcranial magnetic stimulation in conjunction with mirror therapy for sub-acute stroke patients. *Journal of Magnetics*, *20*(1), 52–56.

Corbetta, D., Imeri, F., & Gatti, R. (2015). Rehabilitation that incorporates virtual reality is more effective than standard rehabilitation for improving walking speed, balance and mobility after stroke: A systematic review. *Journal of Physiotherapy*, *61*(3), 117–124.

Cortés-Pérez, I., Nieto-Escamez, F. A., & Obrero-Gaitán, E. (2020). Immersive virtual reality in stroke patients as a new approach for reducing postural disabilities and falls risk: A case series. *Brain Sciences*, *10*(5), 296.

Deconinck, F. J., Smorenburg, A. R., Benham, A., Ledebt, A., Feltham, M. G., & Savelsbergh, G. J. (2015). Reflections on mirror therapy: A systematic review of the effect of mirror visual feedback on the brain. *Neurorehabilitation and Neural Repair*, *29*(4), 349–361.

Filimon, F., Nelson, J. D., Hagler, D. J., & Sereno, M. I. (2007). Human cortical representations for reaching: Mirror neurons for execution, observation, and imagery. *NeuroImage*, *37*(4), 1315–1328.

Fukumura, K., Sugawara, K., Tanabe, S., Ushiba, J., & Tomita, Y. (2007). Influence of mirror therapy on human motor cortex. *International Journal of Neuroscience*, *117*(7), 1039–1048.

Galeazzi, G. M., Monzani, D., Gherpelli, C., Covezzi, R., & Guaraldi, G. P. (2006). Posturographic stabilisation of healthy subjects exposed to full-length mirror image is inversely related to body-image preoccupations. *Neuroscience Letters*, *410*(1), 71–75.

Gandhi, D. B., Sterba, A., Khatter, H., & Pandian, J. D. (2020). Mirror therapy in stroke rehabilitation: Current perspectives. *Therapeutics and Clinical Risk Management*, *16*, 75–85.

Hwang, I., Song, R., Ahn, S., Lee, M. A., Wayne, P. M., & Sohn, M. K. (2019). Exploring the adaptability of tai chi to stroke rehabilitation. *Rehabilitation Nursing*, *44*(4), 221–229.

In, T., Lee, K., & Song, C. (2016). Virtual reality reflection therapy improves balance and gait in patients with chronic stroke: Randomized controlled trials. *Medical Science Monitor: International Medical Journal of Experimental and Clinical Research*, *22*, 4046–4053.

Khan, F., & Chevidikunnan, M. F. (2021). Prevalence of balance impairment and factors associated with balance among patients with stroke. A cross sectional retrospective case control study. *Healthcare (Basel)*, *9*(3), 320.

Kim, M.-K., Ji, S.-G., & Cha, H.-G. (2016). The effect of mirror therapy on balance ability of subacute stroke patients. *Hong Kong Physiotherapy Journal*, *34*, 27–32.

Krishnamurthi, R. V., Ikeda, T., & Feigin, V. L. (2020). Global, regional and country-specific burden of ischaemic stroke, intracerebral haemorrhage and subarachnoid haemorrhage: A systematic analysis of the global burden of disease study 2017. *Neuroepidemiology*, *54*(2), 171–179.

Lee, D., Lee, G., & Jeong, J. (2016). Mirror therapy with neuromuscular electrical stimulation for improving motor function of stroke survivors: A pilot randomized clinical study. *Technology and Health Care: Official Journal of the European Society for Engineering and Medicine*, *24*(4), 503–511.

Lee, H. J., Kim, Y. M., & Lee, D. K. (2017). The effects of action observation training and mirror therapy on gait and balance in stroke patients. *Journal of Physical Therapy Science*, *29*(3), 523–552.

Li, Y., Wei, Q., Gou, W., & He, C. (2018). Effects of mirror therapy on walking ability, balance and lower limb motor recovery after stroke: A systematic review and meta-analysis of randomized controlled trials. *Clinical Rehabilitation*, *32*(8), 1007–1021.

Louie, D. R., Lim, S. B., & Eng, J. J. (2019). The efficacy of lower extremity mirror therapy for improving balance, gait, and motor function poststroke: A systematic review and meta-analysis. *Journal of Stroke and Cerebrovascular Diseases*, *28*(1), 107–120.

Lubetzky-Vilnai, A., & Kartin, D. (2010). The effect of balance training on balance performance in individuals poststroke: A systematic review. *Journal of Neurologic Physical Therapy*, *34*(3), 127–137.

Mazlom, S., Hasanzadeh, F., & Ghandehari, K. (2013). The effect of mirror therapy on motor abilities of patients with stroke. *Evidence Based Care Journal*, *3*(3), 7–18.

Mehrholz, J., Kugler, J., & Pohl, M. (2011). Water-based exercises for improving activities of daily living after stroke. *Cochrane Database of Systematic Reviews*, *2011*(1), CD008186.

Mohan, U., Babu, S. K., Kumar, K. V., Suresh, B. V., Misri, Z. K., & Chakrapani, M. (2013). Effectiveness of mirror therapy on lower extremity motor recovery, balance and mobility in patients with acute stroke: A randomized sham-controlled pilot trial. *Annals of Indian Academy of Neurology*, *16*(4), 634–639.

Pouwels, S., Lalmohamed, A., Leufkens, B., de Boer, A., Cooper, C., van Staa, T., & de Vries, F. (2009). Risk of hip/femur fracture after stroke: A population-based case-control study. *Stroke*, *40*(10), 3281–3285.

Ramachandran, V. S., & Rogers-Ramachandran, D. (1996). Synaesthesia in phantom limbs induced with mirrors. *Proceedings. Biological Sciences*, *263*(1369), 377–386.

Sade, I., Çekmece, Ç., İnanir, M., SelÇuk, B., Dursun, N., & Dursun, E. (2019). The effect of whole body vibration treatment on balance and gait in patients with stroke. *Noro Psikiyatri Arsivi*, *57*(4), 308–311.

Schinkel-Ivy, A., Wong, J. S., & Mansfield, A. (2017). Balance confidence is related to features of balance and gait in individuals with

chronic stroke. *Journal of Stroke and Cerebrovascular Diseases: The Official Journal of the National Stroke Association*, *26*(2), 237–245.
Sealed Envelope Ltd. (2021). *Create a blocked randomization list*. https://www.sealedenvelope.com/simple-randomiser/v1/lists
Shahidi, S., Ghasemi, B., & Shafizadeh, A. (2020). The effect of mirror therapy on the gait of patients with subacute and chronic stroke. *Complementary Medicine Journal*, *10*(3), 218–229.
Stevens, J. A., & Stoykov, M. E. P. (2003). Using motor imagery in the rehabilitation of hemiparesis. *Archives of Physical Medicine and Rehabilitation*, *84*(7), 1090–1092.
Vincent-Onabajo, G., Musa, H. Y., & Joseph, E. (2018). Prevalence of balance impairment among stroke survivors undergoing neurorehabilitation in Nigeria. *Journal of Stroke and Cerebrovascular Diseases*, *27*(12), 3487–3492.
Wang, H., Fang, X.-Y., & Yao, J. (2021). Synergic effect of the combination of mirror therapy and electrical stimulation for lower extremity motor function recovery in stroke survivors: A meta-analysis of randomized controlled trials. *Topics in Stroke Rehabilitation*, 1–11. Advance online publication. 10.1080/10749357.2021.1970453
Weerdesteijn, V., Niet, M. D., Van Duijnhoven, H., & Geurts, A. C. (2008). Falls in individuals with stroke. *Journal of Rehabilitation Research and Development*, *45*(8), 1195–1213.
Winstein, C. J., Stein, J., Arena, R., Bates, B., Cherney, L. R., Cramer, S. C., Deruyter, F., Eng, J. J., Fisher, B., Harvey, R. L., Lang, C. E., MacKay-Lyons, M., Ottenbacher, K. J., Pugh, S., Reeves, M. J., Richards, L. G., Stiers, W., Zorowitz, R. D., & American Heart Association Stroke Council, Council on Cardiovascular and Stroke Nursing, Council on Clinical Cardiology, and Council on Quality of Care and Outcomes Research (2016). Guidelines for adult stroke rehabilitation and recovery: A guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*, *47*(6), e98–e169.
Wirz, M., Müller, R., & Bastiaenen, C. (2010). Falls in persons with spinal cord injury: Validity and reliability of the Berg Balance Scale. *Neurorehabilitation and Neural Repair*, *24*(1), 70–77.
Yiu, J., Miller, W. C., Eng, J. J., & Liu, Y. (2012). Longitudinal analysis of balance confidence in individuals with stroke using a multilevel model for change. *Neurorehabilitation and Neural Repair*, *26*(8), 999–1006.