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Original Paper

The Effect of Mirror Therapy on the Walking Ability of Patients After Stroke

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ABSTRACT

Introduction: Stroke is the most prevalent debilitating neurological disease in adults, which damages the motor system. Therefore, rehabilitation programs are essential to improve the condition of these patients. One of the novel rehabilitation methods is Mirror Therapy (MT).

Objective: This study aimed to evaluate the effect of MT on the walking ability of patients after stroke.

Materials and Methods: In this clinical trial, 93 patients with stroke were studied in one of the physiotherapy centers in Rasht City, Iran, in 2016. They were assigned into three groups using block randomization technique. In the MT and nonreflective groups, the rehabilitation exercises besides routine rehab program were administered in twenty 15-min sessions every other day in front of the mirror (reflective plane for the MT group) and wood (nonreflective plane for the nonreflective group). The control group received only routine physiotherapy program. The walking ability of the samples was evaluated by the Functional Ambulation Category (FAC) test before and after the intervention. For analyzing the collected data, we used the Chi-squared test, ANOVA Kruskal-Wallis test, Friedman test, Mann-Whitney U test, and Generalized Estimating Equation (GEE) model.

Results: There were no significant differences between the three groups before the intervention in terms of FAC test score and confounding variables. But all three groups showed a significant difference compared to their pretest scores (P<0.05). Also, the MT group showed more significant improvement in walking ability compared to the other two groups.

Conclusion: Mirror therapy, as a simple and client-centered treatment, combined with the routine rehabilitation programs, can improve patients' ability to walk after a stroke.

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Highlights

- Stroke is the most common debilitating motor disorder in adults.
- Severe motor disorder in the limbs results in rehabilitation failure and the patient's disability.
- In most cases, rehabilitation plays the most critical part in ensuring the recovery of post-stroke patients.
- Mirror therapy is a simple and client-centered treatment for improving motor ability after a stroke.
- Mirror therapy, combined with conventional rehabilitation exercises, can improve the walking ability of post-stroke patients.

Plain Language Summary

Stroke is one of the most common debilitating diseases of the nervous system. It is a significant cause of disability that requires home care. It is also the most important cause of long-term disability in the world. Motor disabilities, including unilateral paresis, are the most common and worst complications of a stroke. Severe motor disorder in the limbs leads to failure in rehabilitation therapy and patient's disability. Conventional methods for treatment include paralyzed limbs exercises, functional electrical stimulation, and motor therapy. Recent studies reported different outcomes to these treatments, and have not yet been able to identify the most effective method for unilateral paresis. Mirror therapy is one of the new therapies that has recently shown positive results in patients with motor disabilities. In this study, 93 hemiplegic stroke patients were studied in three groups. The mirror and non-reflective groups received twenty 15min rehabilitation therapy every other day in front of reflective and wood (non-reflective side) in addition to routine physiotherapy. The control group received only the routine physiotherapy program. According to the results, there was no significant difference in the walking ability of groups before the intervention. But after the intervention, all groups showed substantial improvement, and the mirror group showed more significant improvement compared to the other two groups.

Introduction

Stroke is the most common debilitating neurological disease in adults that damages sensory, motor, perceptual, visual, and cognitive systems, and thus cripples these patients in doing daily routine activities [1-4]. According to the World Health Organization, the stroke incidence rate is between 2.7-4.7 per 1000 people and is one of the three leading causes of death in advanced countries after heart disease and cancer [5, 6]. One-third of the patients with stroke develop permanent disabilities. Of these patients, only (13%) can return to their previous jobs, of which (25%) aged <65 years [5-7].

Severe motion impairment in the limb after a stroke leads to a failure in rehabilitation therapy and limitation in the individual's movement. About (30-40%) of those who survive stroke experience severe motor disabilities such as hemiplegia and hemiparesis [1, 2, 8]. More than (85%) of these patients develop sustained motor disabilities, and only up to (83%) of them can regain their ability to walk [9-11].

In most cases, rehabilitation plays the most significant role in the recovery of post-stroke patients [6, 12]. Therefore, it is critical to develop practical rehabilitation approaches concerning the therapeutic, social, and economic aspects for recovery after stroke. Conventional therapeutic methods for this condition include paralyzed limbs exercises, functional electrical stimulation, and motor therapy. Recent studies have shown different responses to treatment methods and have not yet been able to identify the most effective treatment for hemiparesis [6-4].

Mirror Therapy (MT) is one of the new therapeutic methods that has recently shown positive results in patients with Phantom pain and Complex Regional Pain syndrome. This method may also be useful for patients with hemiparesis due to stroke [4, 6, 13]. In mirror therapy, the patient places his or her affected limb inside the mirror box and then moves the unaffected limb in front

of the mirror. The patient must focus his or her eyes on the mirror. In this way, the brain is cheated and takes the reflected movement of the unaffected limb in the mirror as the movement of the paralyzed limb [14-16]. It is a relatively new, inexpensive, and client-centered approach focused on healthy organs. This method has recently drawn the attention of many scholars because of its usefulness for patients with motor disorders [17-19]. It may also be useful as a complementary technique along with the routine rehabilitation program in the early stages of therapy. If the caregiver receives adequate training, it will be even possible to use it for a longer time and even at home after discharge [20, 21].

In Iran, this method is still not used as supplemental rehab technique for patients after stroke. Results of Yavuzer et al. study indicate that MT improves motor recovery and self-care scores in the stroke patients [10]. Sütbeyaz et al. study results also suggest that MT improves patients' motor recovery and motor functionality but not spasticity and walking ability [20]. In Iran, one study supports the effect of mirror therapy on motor recovery and walking ability [3].

Despite the effectiveness of MT in improving motor functioning and walking ability, few studies have been conducted on it. After extensive research on different databases, we found a few studies on the effect of MT on the walking ability of stroke patients. Even these studies had some limitations, such as small sample size and investigating a few indexes. Thus, this study was conducted to examine the effect of MT on the walking ability of patients after stroke.

Materials and Methods

This study is a clinical trial. The study population consisted of all stroke outpatients referring to the Physiotherapy Center of Rasht City Disabled and Elderly Hospice, Rasht City, Iran. They were already discharged from the hospital and sent to this center for performing physiotherapy and had the following inclusion criteria. The study samples had a stroke diagnosed by a neurologist and confirmed by CT scan or MRI results. They should not have a history of receiving rehabilitation. They must be 30-65 years old and at least one month should have passed since their stroke and were currently under a regular rehabilitation program. Also, the samples should have obtained Brunnstrom stages (the index of functional recovery) score of one to three. They should not have a verbal impairment, severe cognitive problem, previous dementia, global aphasia, and any visual impairment based on examination of a neurologist. They must have experienced a stroke for the first time. Besides, they should not have any underlying condition that could cause motor impairment (according to the patient and his or her companions' report) or cognitive impairment (based on mini-mental state examination test score >24).

On the other hand, the exclusion criteria were the absence of more than four alternate sessions or two consecutive sessions from the rehabilitation program, patient's or his/her family's unwillingness to continue the study, and patient's death.

The sample size was determined as 93, by comparing the mean and standard deviation of Functional Ambulation Category (FAC) test scores reported in the study of Mazlom et al., considering (99%) confidence interval, and (95%) test power [3]. The samples then were assigned to three groups of MT (n=31), nonreflective (n=31), and control (n=31). Random sampling was done by random blocks (block size of 6) using a computer program. To determine the order of the six blocks, the first and second (MT and control) groups were selected by drawing from the first block, and the next block was used for choosing the nonreflective group. Sampling lasted for five months (July to November 2016). In this way, 93 hemiplegic stroke patients (out of 263 stroke patients referred to the center) entered into the study based on the inclusion criteria. The written consent form was taken from the samples or their relatives (if the patients were illiterate) before the study. The patients were re-evaluated by statistical tests for homogeneity between three groups (Figure 1).

The obtained data showed that the samples were homogeneous in terms of sociodemographic and disease-related factors in all three groups. Two patients from the MT group (due to absence in physiotherapy sessions and irregular visit) and one from the control group (due to death) left the study. They were replaced with three other samples. All groups received a routine physiotherapy rehabilitation that involved neuromuscular electrical stimulation and motor recovery for one hour. The patients were assigned to three study groups by our sampler colleague. The rehabilitation exercises were taught to one of our nurse practitioners during three one hour sessions. At the end of the training, the trained nurse could explain and do the rehab exercises correctly for three study groups. The motor exercises were taught only by our sampler colleague. The researcher evaluated the patients before the intervention and at the end of the 5th, 10th, 15th, and 20th session. All groups did the routine rehab exercises of the physiotherapy center, but

the MT and nonreflective groups performed the lower-extremity motor recovery for an additional 15 min in front of the reflective and nonreflective planes of the mirror. The patients in the control group left the center after their 1h routine physiotherapy.

For performing mirror therapy, the subject was in a semi-sitting position on a bed, while the affected leg was put inside the mirror box (70×40cm). The subject was asked to move his or her ankle and knee joints of the normal leg in front of the mirror while watching it in the mirror (Figure 2). The patient received no verbal feedback during the MT section. The nonreflective group did the same movements in front of a nonreflective (wooden) plane with the same dimensions as the mirror box (Figure 3). They also looked at the nonreflective plane during the task performing. The control group received only routine physiotherapy for one hour every other day. All three groups were evaluated before and at the end of sessions five, ten, 15, and 20.

The researcher-made questionnaire, which included the demographic and disease-related information, was prepared by reviewing new and prestigious books and articles in this field. For measuring walking ability, we used FAC test that has also been employed in other studies [5, 20]. This tool categorizes patients according to basic motor skills for walking ability from one to six.

In level one, the patient cannot walk at all or walk between two rails with the assistance or supervision of more than two persons. In level two, the patient can walk on a flat surface with the manual help of one person. In level three, the patient can walk and maintain balance with continual manual assistance of another person. In level four, the patient can walk on a flat surface without manual contact but needs continuous support and supervision only because of judgmental reasons, an unstable heart condition, or the need for verbal guidance. The patient in level five can walk independently on a flat surface but need assistance for climbing stairs or walking on sloped or rough surfaces. In level six, the patient walks independently on a flat, rough, or sloped surface and stairs. The validity of the personal information questionnaire and FAC was evaluated by content validity. The validity of the demographic questionnaire and FAC were confirmed by 13 faculty members of Guilan University of Medical Sciences.

The obtained data were analyzed in SPSS V. 22. To investigate the homogeneity of sociodemographic and disease-related variables in the study groups, the Chi-squared test and ANOVA were used. For assessing the normality of quantitative data distribution, the Shapiro-Wilkis test was carried out. Kruskal-Wallis test was used for comparing the Mini-Mental State Examination (MMSE) scores as well as FAC test scores in each session for three groups before and after the intervention. Friedman test was used to test the difference in walking ability between groups, and Mann-Whitney U test for their pairwise comparison. Furthermore, the Generalized Estimating Equation (GEE) approach was used to determine the effect of MT by controlling the impact of sociodemographic and disease-related factors (confounding variables).

Results

Based on the results, the study groups were not significantly different from one another in terms of sociodemographic factors of gender, age, body mass index, level of education, monthly income, occupation, and marital status. Also, they were similar concerning disease-related factors of post-stroke duration, type of stroke, the damaged side of the brain, dominant hemisphere, lower and upper limb muscle strength, and MMSE score (Table 1).

Changes in FAC test scores was significant in all groups (P=0.0001). This significance decreased until the 5th session in the nonreflective group (based on mean rank) but increased in the MT group. By comparing FAC scores based on measurement time points, no significant difference was reported in the walking ability of participants between three groups, except at the end of the 20th session (P=0.002) (Table 2).

Concerning the pairwise comparison of FAC scores, the results of the 20th session showed a significant difference between the nonreflective and MT groups (P=0.004). However, no significant difference was seen between the nonreflective and control groups (P=0.541). There was also a statistically significant difference between the MT and control groups based on comparative results of the 20th session (P=0.002) (Table 3).

According to the GEE model, after controlling the effects of sociodemographic and disease-related factors, MT had a significant effect on the walking ability of stroke patients compared to the control group (P=0.014). Also, the nonreflective plane had a significant effect compared to the control group (P=0.046). In addition to MT effect on the walking ability, factors of gender, education, dominant hemisphere, and lower limb muscle strength significantly affected the walking ability of the patients (P<0.05) (Table 4).

Table 1. Comparing disease-related variables between three study groups

Variables Related to Disease			Nonreflective	Mirror Therapy	Control	Sig.
Post-stroke duration (mon)	Mean±SD		5±5	4±5	5±6	0.649**
Mini-mental state examination score (0-30)	Mean±SD		25.87±1.26	26.61±1.65	26±1.24	0.157***
Type of stroke	Ischemic	N (%)	29(93.5)	27(87.1)	26(83.9)	0.486*
	Hemorrhagic		2(6.5)	4(12.9)	5(16.1)	
Damaged side of brain	Right	N (%)	7(22.6)	9(29)	10(32.3)	0.688*
	Left		24(77.4)	22(71)	21(67.6)	
Dominant hemisphere	Right	N (%)	2(6.5)	1(3.2)	5(16.1)	0.169*
	Left		29(93.5)	30(96.8)	26(83.9)	
Muscular strength score of lower limbs (0-5)	1	N (%)	0	0	5(16.1)	0.133*
	2		10(32.3)	9(29)	10(32.3)	
	3		18(58.1)	17(54.8)	13(41.9)	
	4		3(9.7)	5(16.1)	3(9.7)	

*The Chi-squared test; **ANOVA test; ***Kruscal Valis test

Discussion

The study results indicated that difference in walking ability in all study groups was statistically significant, where MT produced more significant changes in the walking ability compared to two other groups. Consistent with our study results, Mazlom et al. study also report that MT influences the walking ability of stroke patients [3]. Wang et al. found out that MT could rehabilitate lower limb motor function in patients with stroke hemiplegia [22]. Bhoraniya et al. reported that MT could improve the walking of chronic stroke patients compared to conventional methods [23].

Contrary to our results, Sütbeyaz et al. concluded that MT had no effect on the walking ability of post-stroke patients [20]. Walking is a complicated action, and normal walking needs muscle strength, coordination, balance, and so on. As motor learning is successful when it is presented based on a pattern close to the normal state, the discrepancy in results can be because of difference in the applied pattern and short duration of the intervention [3].

The results in our study indicated that the difference between the MT and the control group in walking ability was significant before and after the intervention. Regarding the effect of MT after controlling sociodemographic and disease-related factors, the results support the effect of MT performing in front of the reflective side of the mirror box on the walking ability of the MT group patients compared to controls. It should be mentioned that the effect of the nonreflective group was also significant compared to the control group. In this regard, it can be said that both MT and nonreflective groups had an additional 15 min motor recovery in each session compared to the control group.

The results revealed that MT had less effect on the walking ability of the patients with education level lower than an academic degree. In this regard, it can be said that the person with a higher level of literacy, has fewer problems in the acquisition of information. It may be because an educated person has many ways to acquire knowledge compared to an illiterate person. This education helps them learn more information about the disease and frequently evaluate their conditions that eventually result in a better understanding of the problem [24]. Moreover, it may be added that the motivation of educated people is higher for following the treatment plan because of their awareness of their condition. Our results also indicate that the patients with right hemisphere brain damage respond better to the intervention compared to the patients with the left hemisphere brain damage. Damage to the dominant hemisphere (usually the left one) causes problems in

Table 2. Comparing FAC scores before and after the intervention between three study groups

Stage		N (%)			Sig.*
		Nonreflective	Mirror Therapy	Control	
Before the intervention	1	4(12.9)	0	3(9.7)	0.322
	2	16(51.6)	17(54.8)	17(54.8)	
	3	11(35.5)	13(41.9)	11(35.5)	
	4	0	1(3.2)	0	
	Mean rank	43.9	52.27	44.82	
Session 5	2	6(19.4)	1(3.2)	8(25.8)	0.123
	3	17(54.8)	18(58.1)	14(45.2)	
	4	8(25.8)	11(35.5)	9(29)	
	5	0	1(3.2)	0	
	Mean rank	43.74	54.34	42.92	
Session 10	2	2(6.5)	0	2(6.5)	0.124
	3	10(32.3)	6(19.4)	12(38.7)	
	4	13(41.9)	16(51.6)	10(32.3)	
	5	6(19.4)	8(25.8)	7(22.6)	
	6	0	1(3.2)	0	
	Mean rank	43.81	54.58	42.61	
Session 15	2	0	0	1(3.2)	0.211
	3	3(9.7)	0	5(16.1)	
	4	13(41.9)	10(32.3)	10(32.3)	
	5	10(32.3)	17(54.8)	11(35.5)	
	6	5(16.1)	4(12.9)	4(12.9)	
	Mean rank	45.31	53.34	42.35	
Session 20	2	0	0	1(3.2)	0.002
	3	1(3.2)	0	3(9.7)	
	4	10(32.3)	3(9.7)	9(29)	
	5	14(45.2)	13(41.9)	12(38.7)	
	6	6(19.4)	15(48.4)	6(19.4)	
	Mean rank	42.15	60.02	38.84	
	Sig.**	0.0001	0.0001	0.0001	

*Kruskal-Wallis test; **Friedman test

Table 3. Pairwise comparison of FAC scores between study groups

Sessions		N (%)			The Significance Level of Study *	The Significance Between Non-Reflective and MT**	The Significance Between nore-flective and Control**	The Significance Between MT and Control**
		Nonreflective	Mirror Therapy	Control				
Session 20	2	0	0	1(3.2)	0.002	0.004	0.541	0.002
	3	1(3.2)	0	3(9.7)				
	4	10(32.3)	3(9.7)	9(29)				
	5	14(45.2)	13(41.9)	12(38.7)				
	6	6(19.4)	15(48.4)	6(19.4)				

*Kruskal-Wallis test; **Mann-Whitney U test

speech, language, comprehension and analysis, while damage to non-dominant hemisphere (usually the right one) causes spatial problems. Therefore, this problem can affect the outcome of rehabilitation [1].

Our results indicate that lower limb muscle strength also affects the MT on the walking ability. Since this variable is very dependent on the power of the lower limbs, this result was expected. The present study also showed that the effect of MT on walking ability was higher in women. This result can be explained by the fact that men are providing for their families. When they get sick, their jobs are also affected. This situation can affect their confidence and mood. Since the effect of rehabilitation process has a very close relationship with the patient's contribution and mood, this low confidence can affect the outcome of MT.

The findings of this study suggest that the MT can partly increase the walking ability of the patients after stroke. MT is a simple, affordable, and client-centered approach, which can be performed by the patient at

Table 4. The related factors to walking ability using GEE model in the mirror therapy group

Groups & Variables	Regression Coefficient	Standard Error	95%CI		Sig.
			Lower	Upper	
Nonreflective group	0.174	0.0871	0.003	0.344	0.046
Mirror therapy group	0.586	0.2385	0.119	1.054	0.014
Control group			Ref.		
Junior high school education	-0.777	0.1858	-1.141	-0.412	0.01
High school education	-0.0668	0.1845	-1.030	-0.306	0.01
Academic education			Ref.		
Inadequate income	-0.307	0.1710	-0.643	0.028	0.072
Adequate income			Ref.		
Dominant right hemisphere	0.741	0.3337	0.087	1.395	0.026
Dominant left hemisphere			Ref.		
Lower limb muscle strength	0.534	0.1660	0.209	0.860	0.001
Female gender	0.591	0.2119	0.176	1.006	0.005
Male gender			Ref.		

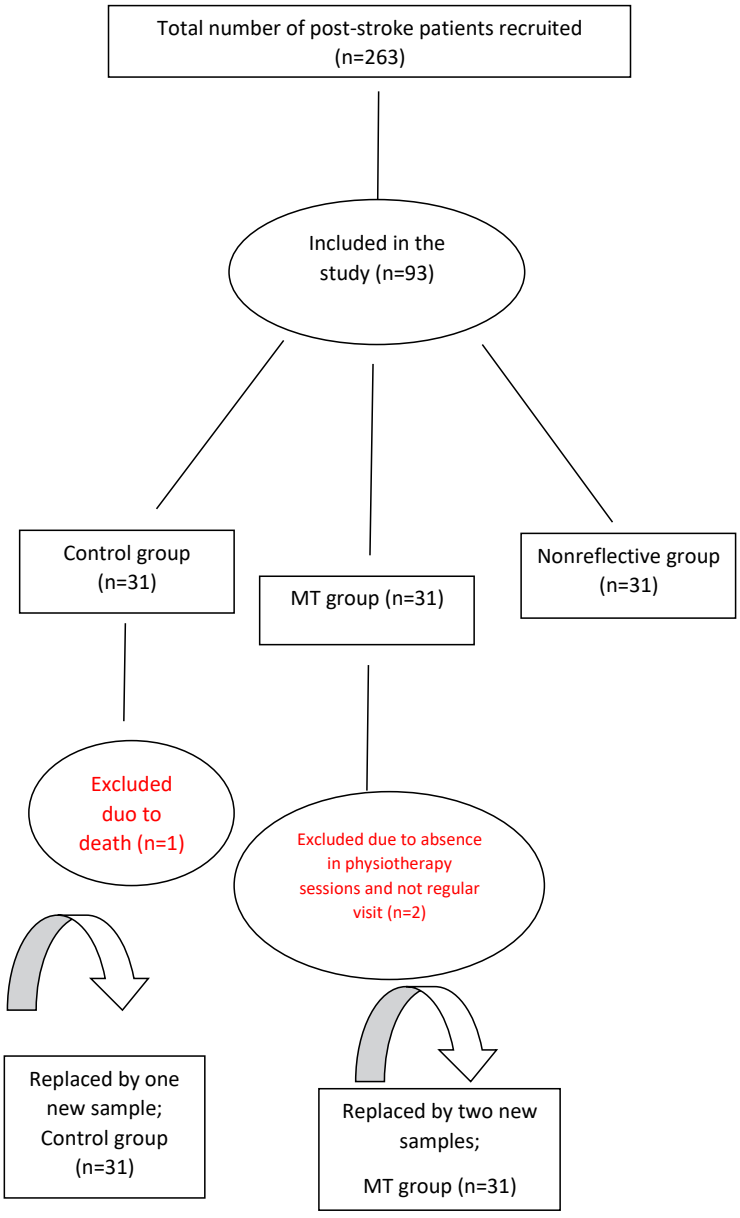

Figure 1. Flow diagram for randomized subject assignment

Figure 2. Mirror therapy in front of the reflective plane

Figure 3. Mirror therapy in front of the nonreflective wooden plane

home, and according to studies, has no side effects. So it can be used by the patient's relatives at home. By adding this therapy to the routine rehabilitation programs, it is possible to improve the patient's recovery process and prevent the immobility and the likelihood of recurrence of stroke in patients.

Although our patients did not have cognitive impairments, some patients had a high concentration and other low focus on watching the unaffected leg in the mirror. This situation could also affect the study results. Further research is recommended on studying the long-term effect of MT and adding a follow-up stage to determine the effect of MT on the walking ability of patients with stroke and also as a home-based treatment.

Ethical Considerations

Compliance with ethical guidelines

The present study was conducted after taking the ethical code (IR.GUMS.REC.1394.11) and registered by the Iranian Registry of Clinical Trials (Code: IRCT201504224787N5). The study objectives and procedure were explained for every sample separately, and their written informed consent was taken.

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Authors contributions

All authors contributed preparing this article.

Conflict of interest

Thr authors declared no conflict of interest.

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