Research Paper: Effect of Mirror Therapy on the Motor Recovery in Patients After Stroke: A Randomized Clinical Trial

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ABSTRACT

Objectives: One of the most important problems seen in patients after stroke is that they cannot develop normal muscle strength. In recent years, the use of Mirror Therapy (MT) in the recovery of this condition has been noticed in different studies. This study investigated the effect of MT on motor recovery in patients after stroke.

Methods: In this clinical trial, 93 patients were divided into three groups, including MT, non-reflective surface, and control groups. The tools used in this study included the patient's profile questionnaire, Mini-Mental State Examination Test, and Brunnstrom Recovery Stages. After the routine physiotherapy program, the intervention groups underwent MT for 20 sessions. The analysis of data was performed by SPSS software v. 22.

Results: There was a significant difference between the non-reflective surface and MT groups (P=0.043) in pairwise comparison of their motor recovery stages in the 20th session, but the difference between the non-reflective surface and control groups was not significant. There was also a significant statistical difference between the MT and control groups in motor recovery stages in the 20th session, (P=0.0332)

Conclusion: The obtained findings suggest that MT can increase patients' motor recovery after stroke. This method can be used as a simple, cheap, and usable method at home.

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Highlights

- Stroke patients need simple and accessible rehabilitation methods to improve motor impairment. Mirror therapy is one of these methods.
- In order to control the placebo effect of mirror therapy, a third group, a non-reflective group, was used in the present study.
- The results of this study showed that mirror therapy significantly affected the motor recovery of stroke patients.
- Mirror therapy can be used besides routine rehabilitation programs in the recovery of a patient's motor function. To do this therapy at home, the patients and their families need to be trained by a rehabilitation expert.

Plain Language Summary

Mirror therapy is a feasible and inexpensive rehabilitation method that can improve the outcomes of routine physiotherapy programs among stroke patients. Moreover, this method is so simple that can be taught to the patients or their families. Thus, they can perform it themselves at home.

1. Introduction

Stroke is the second leading cause of death in the world [1, 2]. Ten percent of 55 million deaths occurring worldwide each year is due to stroke. The number of people who died from stroke increased from 5.29 million (5.22-5.40) to 6.17 million (6.04-6.33) between 2007 and 2017 [3]. In the United States, From 780,000 strokes occurring each year (one in every 40 seconds), 150,000 people died (one in every 4-3 minutes) [4]. According to the World Health Organization (WHO), there will be a 30% increase in stroke incidence in the EU between 2000 and 2025 [5]. Based on the data collected from 1990 to 2008 in Iran, the annual stroke incidence in various ages ranged from 23 to 103 per 100,000 [6]. A study done in 2016 indicated that the crude annual incidence rate of First-Ever Stroke (FES) was 144 for men and 133 for women in Iran. Totally, stroke occurs in 139 per 100000 people [7].

One of the most important problems seen in patients after stroke is that they cannot develop normal muscle strength, and they also have problems in maintaining normal balance, initiation, and control of their movements. This muscle weakness is due to the reduction in the number of functioning motor units, change of fiber type from low force-producing fibers to high force-producing fibers, and decrease in motor unit firing rates [8]. The two most common motor deficits in these patients are hemiparesis and hemiplegia [9]. Up to 85% of stroke survivors experience hemiparesis, and 55%–75% continue to have limitations in upper extremity function [10]. About one-third of these patients are dependent on others in most of the Activities of Daily Living (ADL). Therefore, the stroke seems to be one of the most disabling diseases globally [11, 12].

Neurological recovery does not occur at a constant rate at all times after stroke. The maximum rate of recovery is observed in the first three months. However, according to some studies, there are also some degrees of recovery in the months or years later. In the past, researchers believed that much of this recovery was spontaneous, and rehabilitation strategies could not improve patients' condition, but new findings have shown that these strategies could help the brain recover more quickly [13].

The brain's self-recovery results from the brain's effort to rebalance its information systems and reaction mechanisms responding to damage, which is called neuroplasticity. Rehabilitation can help the brain in this procedure [14].

Recently, several studies have introduced new methods in rehabilitating stroke patients, including robotic-assisted training and constraint-induced movement therapy. Unfortunately, there are some problems with these strategies. For example, some of them are expensive. They also often require a person, preferably a specialist, to train the patient continuously. On the other hand, there is another rehabilitation program called Mirror Therapy (MT), which is cheap and can be simply done by the patients themselves [15]. This method was firstly developed by Ramachandran and Roger-Ramachandran to treat patients with phantom limb syndrome after arm amputation in 1996 [16]. In the mentioned study, the pa-

tients considered the reflection of the intact arm in the mirror as their amputated arm. MT is based on two concepts: Mirror neurons and neuroplasticity. Mirror neurons are the neurons that not only activate when you are performing an action but also when you are looking at the same action but not performing it [17, 18]. Furthermore, neuroplasticity is the brain's ability to learn new things by changing the ways it uses to deliver signals between neurons [19].

In recent years, the use of MT in the treatment of some complications of diseases, such as complex regional pain syndrome [11, 20, 21] and phantom pain syndrome [22, 23] has been studied. Mazlom et al. [24] investigated the effect of MT on 38 stroke patients in a randomized clinical trial. They found that motor recovery was significantly better in the intervention group. Besides, some other studies have examined the application of this treatment for complications following a stroke. Many of them had some limitations. For example, they reviewed the use of MT in the upper or lower limbs separately [15, 25-27].

Also, the number of samples studied was limited, and it is not clear how many sessions MT should be performed and how many minutes each session should be. Moreover, in none of the previous studies, the possible placebo effect of MT has been assessed. It is, therefore, necessary to investigate the effect of MT on stroke complications in a larger population and evaluate their motor recovery.

It is hoped that the results of this study will provide a way for patients to live better. This study was done to evaluate the effect of MT on motor recovery in patients after stroke and related factors.

2. Material and Method

Study design & participants

In this clinical trial, the effect of MT was evaluated on the motor recovery of patients after stroke. The study was done in the physiotherapy center of Rasht (a city in the north of Iran) Disabled and Elderly Center. Cases with stroke who were referred to this center for rehabilitation in 2016 formed the study population. The sample size required to compare the effects of MT on the motor recovery of patients with stroke was calculated based on the results of the study by Mazlom et al. [24]. The sample size for comparing two groups was determined 66 cases with 99% confidence interval and 95% power in a two-tailed test. According to the below formula, the sample size for comparing three groups was calculated at 93.3, which was considered to be approximately 93 (31 for each group).

$$For\ three\ groups = n = n_0 \times \sqrt{g-1} = 66 \times \sqrt{3-1} = 93.3 \approx 93$$

These people were divided into three groups, including MT, non-reflective surface intervention, and control (routine physiotherapy) groups.

Sampling was performed using block randomization. Accordingly, people referring to the physiotherapy center were first stratified into blocks (block size of 6) according to their Brunnstrom motor recovery stages before the intervention. Then, the people in each block were randomly divided into three groups with a 1:1:1 ratio. The inclusion and exclusion criteria of the study were as follows:

Inclusion criteria

• Patients who had a history of stroke for the first time, confirmed by a neurologist with Computerized Tomography (CT) scan or Magnetic Resonance Imaging (MRI).

• At least one month should have passed since the patients' stroke because it is only in the subacute and chronic stages that the patients go to rehabilitation centers to continue their treatment.

• The patients should be under the routine rehabilitation program when entering the study

• Their Brunnstrom stages (the index of functional recovery) must be 0 to 3.

• Moreover, their scores based on the mini-mental state examination test should be more than 24. They should not have any underlying motor defects that may interfere with the study, such as myasthenia gravis, multiple sclerosis, etc.

• The patient's specialist physician should have confirmed that the patient does not have any verbal disturbances, previous dementia, globular aphasia, and any visual impairment.

Exclusion criteria

• If patients for any reason could not participate in the program for more than four intermittent sessions or two consecutive sessions, they were excluded from the study.

• Death of the patient

• The dissatisfaction of the patient or his companions to continue cooperation in the research

The present study was approved by the Ethics Committee of Guilan University of Medical Sciences with the code IR.GUMS.REC.1394.11 and registered at the Iranian Registry of Clinical Trials with the code IRCT201504224787N5. The sampling period was five months (July to November 2016). If the patients referring to the physiotherapy had all the inclusion criteria, they would enroll in the study after giving written consent. For illiterate cases, their companions gave written consent.

Out of 263 patients with stroke who were referred to the center, a total of 93 patients who had inclusion criteria were enrolled in the study. These patients were divided into three groups, two intervention groups (MT and non-reflective surface) and one control group. Of the 93 patients admitted, two were discharged from the MT group (due to absence in physiotherapy sessions and lack of regular visits) and one from the control group (due to death). These patients were replaced by new ones (Figure 1).

Measures

The tools used in this study included the patient's profile questionnaire (consisting of two parts: demographic and disease-related information), Mini-Mental State Examination Test (MMSE), and Brunnstrom Staging (the index of functional recovery). The demographic part of the patient's profile questionnaire includes sex, age, height, weight, body mass index, level of education, income, occupation, and marital status. The disease-related part consists of the post-stroke period, the type of stroke, the affected side of the patient's body, the dominant hemisphere, and the muscular tone of the upper and lower limbs. This information was obtained through interviews with the patient or a companion or extracted from the patient profile.

Mini-Mental State Examination Test (MMSE) is a patient cognitive assessment tool that briefly measures patients' awareness of location and time, immediate memory, short-term verbal memory, calculation, language, and drawing ability. Based on the MMSE, patients are divided into three levels: Absence of cognitive defect (24-30 points), mild (18-23 points), and severe defect (0-17 points). Patients whose scores were above 24 were included in the study. The instrument had been used by Wu et al., Mazlom et al., Bahrami et al., and Khandare et al. [15, 24, 28, 29].

Based on Brunnstrom stages (the index of motor recovery), patients were divided into six stages according to their legs, arms, and hands function. Stage 1 and stage 6 represent the lowest and highest motor recovery, respectively (Table 1). This tool has already been used by Yavuzer et al., Sütbeyaz et al., and Mazlom et al. [24, 25, 28].

Procedure

Initially, according to the inclusion criteria, the Brunnstrom staging tool and MMSE test were completed by the researcher for all patients who were referred to the center. Then, if the score needed to enter the study was obtained, they were introduced to the sampler colleague. Both the intervention groups (MT and the non-reflective surface) and the control group received the usual physiotherapy program, which included neuromuscular electrical stimulation, and then a motor rehabilitation program, which totally lasted for one hour per session. This program was taught to a nurse expert colleague during three 1-hour sessions; thus, at the end of the training, the colleague could correctly explain and perform the exercises in the three study groups. After the usual physiotherapy program for one hour, the intervention groups underwent another rehabilitation program for 30 minutes (15 minutes for the upper limb and 15 minutes for the lower limb) on alternate days in the physiotherapy department during twenty sessions.

The practices used in this study included isotonic active exercise in the range of joints' motion and isometric ones in the front of the mirrors. The colleague exercised the patients during this rehabilitation program. MT was as follows: for the lower limb, the patient was placed in a semi-sitting position on the bed, and the affected leg was placed inside a mirror box measuring 70 by 40 cm so that the patient could not see that leg. The patient was asked to actively move the ankles (dorsiflexion/plantarflexion, eversion/inversion) and knees (flexion/extension) of their unaffected in their range of motion in front of the mirror, while only looking at the image of the intact foot in the mirror and did not receive any verbal feedback during the MT. For the upper limbs, the patient sited on a chair. The affected hand was placed inside a mirror box with dimensions of 35 by 35 cm, in the middle line on the table, and the patient was asked to move his fingers, wrist, and arm in the sagittal plane (flexion/extension), while only paying attention to the movements of the intact hand in the mirror.

The same exercises were performed for the non-reflective surface group, but instead of the mirror, they did these exercises in front of a non-reflective surface, such as a wooden surface, similar in size to the mirror box. The patients looked at the non-reflective surface during the practice (Figure 2). This procedure was repeated in each session. The index of motor recovery of the trained patients

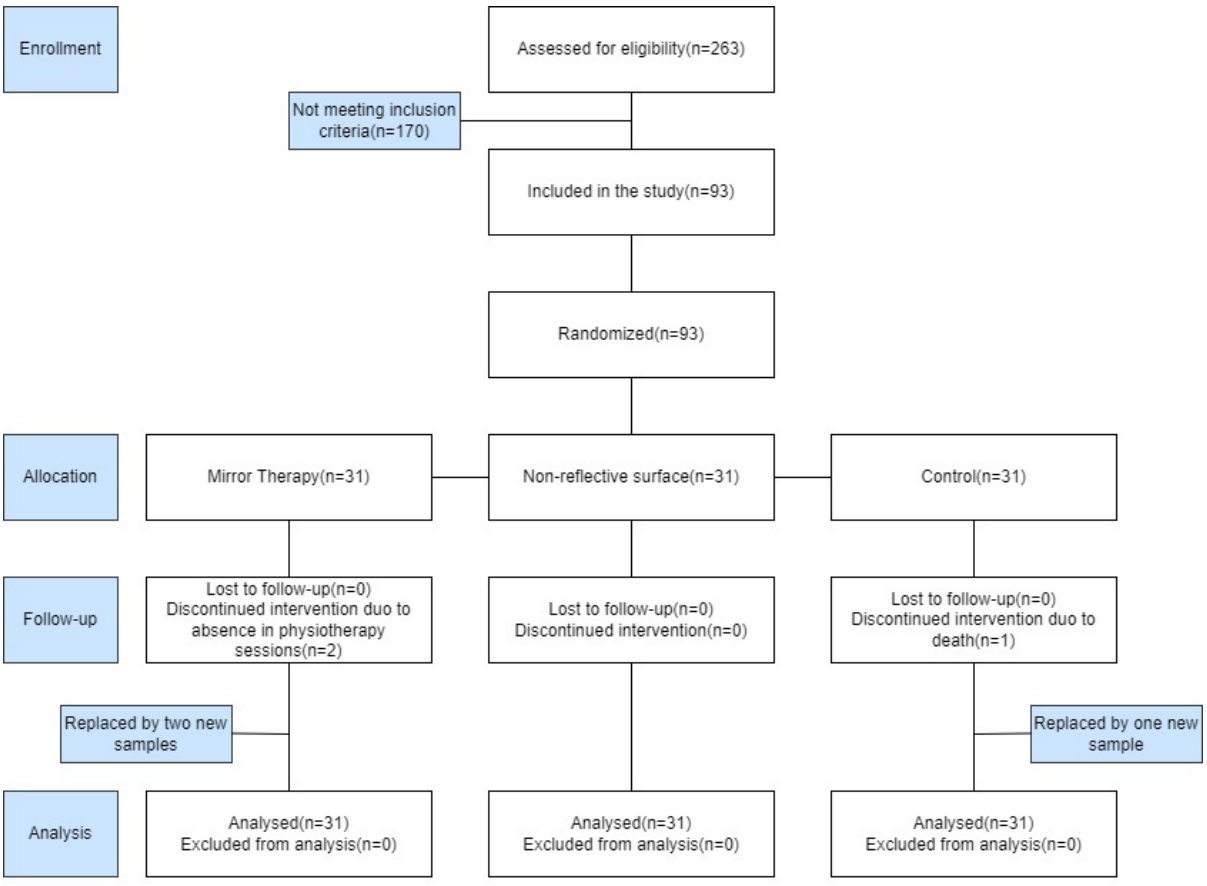

Figure 1. Flow diagram of the study

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was re-examined by one of the personnel blinded to the patients who underwent MT before the start of treatment, and at the end of sessions 5, 10, 15, and 20 with the Brunnstrom staging tool [24, 28-30]. Also, the motor recovery of the control group was examined at the mentioned times.

Statistical analysis

Types of variables used in this study included continuous numeric (age, duration after stroke, and body mass index) and discrete numeric (muscular strength of the upper limb, muscular strength of the lower limb, mini-mental state test scores, and motor recovery stages). Categorical-nominal variables included marital status, sex, type of stroke, the side of the body involved, dominant hemisphere, occupation, and the categorical-ordinal variables were education level and monthly income level. Also, in this study, the dependent variable was patients' motor recovery stages, and the independent variable was the type of intervention (MT or non-reflective surface).

The data were analysed by SPSS v. 22. The homogeneity of numeric and categorical variables was confirmed by Analysis of Variance (ANOVA) and Chi-square test, respectively. Also, the patients' MMSE scores homogeneity was evaluated by the Kruskal-Wallis test.

For comparison of Brunnstrom motor recovery stages in each session between different groups, the Kruskal-Wallis test was used. The motor recovery in each group was compared by the Friedman test between different sessions. The distribution of Brunnstrom motor recovery stages before and after the intervention in three study groups was determined and compared at different times by the Kruskal-Wallis test. The groups' pairwise comparison was made by the Mann-Whitney U test.

Moreover, in multiple analyses to determine the effect of MT with controlling the effects of demographic and disease-related variables on motor recovery, GEE (a generalized linear data analysis model) was used and the significance level was considered less than 0.05.

3. Results

All three groups were not significantly different regarding sex, age, body mass index, level of education, monthly income, job, and marital status, and all three groups were ho-

Figure 2. A: Mirror therapy, B: Non-reflective surface

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mogeneous. Also, regarding the disease-related variables, including the duration of the stroke, the type of stroke, the affected side, the dominant hemisphere, the muscle strength score of the upper and lower affected limbs, and the MMSE test score, the groups showed no significant difference and all three groups were homogeneous (Table 2).

The trend of change in motor recovery stages in all three study groups was statistically significant, separately (P=0.0001), furthermore, this trend was upward in the non-reflective surface and MT groups, but in the control group based on the mean rank, the trend was downward. Moreover, a comparison of the motor recovery stages in the three study groups separately between different sessions showed no significant difference between the three groups in these sessions. However, it should be noted that in the twentieth session, this difference was nearly significant (P=0.053), and the mean rank of the MT group in terms of motor recovery was higher than the two other groups (Table 3).

There was a significant difference between non-reflective surface and MT groups (P=0.043) in pairwise comparison of the motor recovery stages in the twentieth session, but the difference between the non-reflective surface and control group was not significant. Regarding the results of the twentieth session between the MT and

Table 1. Brunnstrom motor recovery stages

Stages	Hand	Arm	Leg
1	Flaccidity	Flaccidity	No motor function
2	Gross grasp; very little finger flexion possible	the basic synergies of the limbs manifest as weakly associated reactions	A bit voluntary movement; minimal increase in spasticity
3	Gross grasp; grasping objects in hook form without releasing	Maximum spasticity; the voluntary performing of basic limb synergies	Maximum spasticity; the flexion and extension of the hip, knee, and ankle joints' flexion and extension in sitting and standing position
4	The ability of lateral prehension (grasping delicate objects with the thumb and other fingers); a small degree of finger extension and limited thumb movements	Decrease in muscle spasticity; the ability to perform combination movements deviating from limb synergies	Ninety-degree flexion of the knee in sitting position, while the foot sliding backward on the ground; dorsiflexion of the foot with the heel on the ground & 90-degree flexion of the knee
5	Spherical and cylindrical grasp while releasing possible; palmar prehension	Synergies are not significant anymore; ability to perform more combination movements deviating from limb synergies	Ankle dorsiflexion with the hip and knee extended; knee flexion with the hip extended in the standing position
6	All types of prehension; isolated finger movements in their full range of motion; voluntary flexion of the fingers at all angles	The disappearance of spasticity except while performing rapid movements; isolated joint movement easily possible	Hip abduction in sitting or standing position; bilateral hip internal and external rotation with ankle inversion and eversion in sitting position

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Table 2. Demographic and disease-related characteristics of the patients (n=93)

Variable		Mean±SD or No. (%)			Sig.
		Non-Reflective	Mirror Therapy	Control	
Age (years)		58.8±6.7	57.5±7.5	57±9.1	0.658**
Sex	Male	21(67.7)	20(64.5)	18(58.1)	0.723*
	Female	10(32.3)	11(35.5)	13(41.9)	
Marital status	Single	3(9.7)	3(9.7)	7(22.6)	0.239*
	Married	28(90.3)	28(90.3)	24(77.4)	
Body Mass Index (kg/m^2)		25.53±2.77	25.09±2.38	24.93±3.85	0.725**
Monthly income	Less than adequate	9(29.0)	9(29.0)	11(35.5)	0.818*
	Adequate	22(71)	22(71)	20(64.5)	
	More than adequate	0(0)	0(0)	0(0)	
Level of education	Junior High School	14(45.2)	13(41.9)	14(45.2)	0.999*
	High school	15(48.4)	16(51.6)	15(48.4)	
	Academic	2(6.5)	2(6.5)	2(6.5)	
Job	Employee	12(38.7)	11(35.5)	10(32.3)	0.6*
	Self-employment	5(16.1)	10(32.3)	7(22.6)	
	Housekeeper	14(45.2)	10(32.3)	14(45.2)	
Post-stroke duration (years)		5±5	4±5	5±6	0.649**
MMSE score (0-30)		25.87±1.26	25.61±1.65	26±1.24	0.157***
Type of stroke	Ischemic	29(93.5)	27(87.1)	26(83.9)	0.486*
	Hemorrhagic	2(6.5)	4(12.9)	5(16.1)	
Damaged side of the brain	Right	7(22.6)	27(87.1)	26(83.9)	0.688*
	Left	24(77.4)	4(12.9)	5(16.1)	
Dominant hemisphere	Right	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	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)	

*Chi-square; **ANOVA; ***Kruskal-Wallis test

Table 3. Comparing Brunnstrom stages before and after the intervention between three study groups

Sessions	Stages	No.(%)			Sig.*
		Non-reflective	Mirror Therapy	Control	
Before the intervention	1	4(12.9)	3(9.7)	2(6.5)	0.237
	2	16(51.6)	10(32.3)	14(45.2)	
	3				
Mean Rank		41.24	51.52	48.24	
Session 5	1	0(0)	0(0)	1(3.2)	0.481
	2	5(16.1)	5(16.1)	4(12.9)	
	3	17(54.8)	11(35.5)	13(41.9)	
	4	9(29)	15(48.4)	13(41.9)	
Mean Rank		42.89	50.44	47.68	
Session 10	2	1(3.2)	0(0)	1(3.2)	0.524
	3	10(32.3)	8(25.8)	11(35.5)	
	4	14(45.2)	14(45.2)	10(32.3)	
	5	6(19.4)	8(25.8)	9(29)	
	6	0(0)	1(3.2)	0(0)	
Mean Rank		44.02	51.1	45.89	
Session 15	3	3(9.7)	1(3.2)	5(16.1)	0.361
	4	13(41.9)	11(35.5)	11(35.5)	
	5	11(35.5)	12(38.7)	9(29)	
	6	4(12.9)	7(22.6)	6(19.4)	
Mean Rank		44.24	52.35	44.4	
Session 20	3	1(3.2)	0(0)	3(9.7)	0.053
	4	9(29)	6(19.4)	9(29)	
	5	14(45.2)	10(32.3)	11(35.5)	
	6	7(22.6)	15(48.4)	8(25.8)	
Mean Rank		43.37	56.02	41.61	
Sig.**		0.001	0.001	0.001	

* Kruskal-wallis test; ** Friedman test.

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control group, there was also a significant statistical difference (P=0.0332) (Table 4).

The motor recovery stages of the twentieth session in the non-reflective and MT groups did not have any significant relationship with any demographic variables, but in the control groups, it showed only a significant difference with the income level (P=0.0029). Furthermore, the motor recovery stages of the twentieth session in the non-reflective surface group did not have any significant relationship with any of the disease-related variables. However, in the MT group, it showed a significant relationship only with the upper limb muscle strength scores (P=0.009), in the control group, the difference was only significant between the lower limb muscle strength scores and motor recovery stages (P=0.04).

GEE model showed that the effect of MT with controlling of the demographic and disease-related variables was not significant on motor recovery. The data showed

Table 4. Pairwise comparison of Brunnstrom stages between study groups

Session	Stages	No.(%)			Sig.			
		Non-Reflective	Mirror Therapy	Control	Three Groups*	Non-Reflective and MT**	Placebo and Control**	MT and Control**
Session 20	3	1(3.2)	0(0)	3(9.7)	0.053	0.043	0.738	0.032
	4	9(29)	6(19.4)	9(29)				
	5	14(45.2)	10(32.3)	11(35.5)				
	6	7(22.6)	15(48.4)	8(25.8)				

*Kruskal-Wallis test; **Man-Whitney test

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Table 5. The related factors to motor recovery using the GEE model in the mirror therapy group

Groups & Variables	Regression Coefficient	Standard Error	95%CI		Sig.
			Lower	Upper	
Non-reflective	-0.112	0.109	-0.326	0.102	0.304
Mirror therapy	0.236	0.1294	-0.018	0.489	0.069
Control	**Ref**				
Junior high school education	-0.762	0.1761	-1.108	-0.417	0
High school education	-0.689	0.1743	-1.031	-0.347	0
Academic education	**Ref**				
Inadequate income	-0.295	0.1512	-0.591	0.001	0.051
Adequate income	**Ref**				
Employee	-0.042	0.0648	-0.169	0.085	0.512
Self-employment	-0.36	0.0762	-0.509	-0.211	0
Housekeeper	**Ref**				
Age<50 years	-0.348	0.1217	-0.587	-0.11	0.004
50-60 years	0.011	0.0426	-0.073	-0.094	0.801
Age≥60 years	**Ref**				
Married	-0.39	0.1587	-0.701	-0.079	0.014
Single	**Ref**				
Right Dominant hemisphere	0.168	0.1773	-0.179	0.516	0.343
Left Dominant hemisphere	**Ref**				
Body mass index (BMI)	-0.005	0.0013	-0.008	-0.003	0
Upper limb muscle strength	-0.066	0.0197	-0.105	-0.028	0.001
Lower limb muscle strength	0.513	0.1364	0.245	0.78	0

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that education level was one of the effective variables on the outcome of MT in motor recovery (P=0.0001). MT was less effective in the group with low income than with high income (P=0.051). There was also a significant relationship between age and the effect of MT on motor recovery (P=0.004) so that it was less effective in patients under 50 than in patients over 60 years old. Also, the effect of the intervention was less in married patients than that in single patients (P=0.014). A significant relationship was found between motor recovery stage and body mass index (P=0.0001), upper limb muscle strength score (P=0.001), and lower limb muscle strength score (P=0.0001). MT was less effective in patients with higher body mass index, and muscular strength of the upper limbs, and this relationship was direct with the muscular strength of the lower limbs (Table 5).

4. Discussion

According to the results of this study, motor recovery stages increased in all three groups of MT, the non-reflective surface, and the control, but the stages of the MT group increased more (P=0.0001). In patients, after stroke, there is some self-improvement in their motor functions, but it is not remarkable, and it will disappear if the patients do not receive physiotherapy programs and adjuvant therapies. By moving the intact limb in the front of the mirror, not only the motor cortex relates the moving limb activates but also the contralateral motor cortex is activated, as a result of the reflection of the movement in the mirror [31].

The functional magnetic resonance imaging proved that MT makes the asymmetry in beta desynchronization (related to the movement) between hemispheres more symmetrical [32]. Although MT has influenced the motor function of the affected organs in all studies, this effect varies in different studies. The results of a study done by Wu et al. showed that MT had significant effects on the motor function of the distal parts of the hand, as the upper limb motor function, measured by the Fogel Meyer tool, increased by 3.7% [15]. In this study, more minor improvement in motor function was reported compared to the present study (3.7% versus 8.7%). Perhaps this difference can be attributed to the selection of patients with chronic stroke, mild spasticity, and mild to moderate motor disability in Wu et al.'s study. However, in the present study, subacute and chronic patients with moderate to severe motor disabilities were examined. Spasticity of the joints was also not investigated.

Yavuzer et al. also reported that the increase in motor function after intervention for the upper limb was 3.8% [25]. Although the duration of MT in our study was half of that in the mentioned study, the effect was almost doubled, perhaps due to differences in how the MT program was done for the upper limb.

In another study by Invernizzi et al., improved motor function after one month of MT in the intervention group showed a significant difference from the control group. The patients' motor function scores, measured by the FIM index, were reported to increase by 31.5% in the MT group; thus, the rate of improvement in motor function was almost 3.5 times higher than our study [33]. This increase of 3.5 times may be due to the longer duration of each session of MT (30 minutes in the first two weeks and 1 hour in the second two weeks) and selecting patients with ischemic stroke in the acute stage (less than four weeks from the onset of stroke).

Thieme et al. also evaluated the effect of MT on motor recovery after stroke in their review article. According to this article, MT had a significant impact on motor function [34]. However, in our study, the motor function improvement in terms of motor recovery index was lower than other studies mentioned by Thieme et al. [34]. This difference may be due to the type of movements performed in MT, the duration of this intervention, the variety of instruments used, and the criteria for selecting the patients, participating in the study.

In another study, Mazlom et al. also illustrated that MT increases patients' motor function after stroke, and 20 sessions of MT caused significant improvement in patients' motor recovery. In the mentioned study and our study, almost equal improvement in motor function was reported (9.7% vs. 8.7%) [24].

Considering the borderline significant relationship of MT with income levels, the results show that in patients with higher income levels, MT was more effective on motor recovery (P=0.051). This effect can be due to the psychological factors caused by higher income and also the greater participation of these patients in the MT program.

Job is another variable that has an effect on motor recovery due to MT (P=0.0001). The effect of MT was higher in patients who were self-employed than housekeepers. Perhaps the reasons are higher concentration and lower anxiety in housekeepers. On the other hand, it may occur due to the practice of MT in homes by housekeepers, which is one of the limitations of our study.

There was also a significant relationship between age and the effect of MT on motor recovery (P=0.004).

Age is one of the factors that affect the outcome of this therapy after the stroke. Besides age, the severity of the neurological disorder, cause of stroke, and comorbidities can also affect the prognosis of stroke [35].

In married patients, the effect of the intervention was less than in single patients (P=0.0144). Marriage and social support have been reported to decline depression and increase the quality of life. Married people with chronic illnesses tend to recover more than divorced people. They have better physical and mental conditions, which is due to the social support that married people receive. Also, married people report fewer economic problems [36, 37]. However, in our study, intervention in married patients was less effective, which can be referred to the small number of single patients in our samples or the problems of married patients, especially in our society, like socio-economic problems, which face these problems more than single patients.

5. Conclusion

MT is one of the most practical rehabilitation programs for chronic and subacute stroke patients. Our study suggests that MT, besides routine rehabilitation programs, can help the patients recover more quickly after stroke. Also, this study indicated that many other factors can affect the outcome of MT in these patients; thus, further research is needed to determine the effect of each factor. To consider MT as a part of the routine and home-based rehabilitation program, more clinical trials should be done.

Limitation and strength

The present study has three limitations. First, the effect of MT was investigated among patients without cognitive impairment; hence, we cannot generalize this rehabilitation program to all stroke patients. Second, in this study, the patients' motor recovery was studied after twenty sessions (each session was thirty minutes); thus, we cannot suggest anything about the effect of more prolonged duration use of MT. At last, the third limitation was that we could not control the exercises patients did at home. These exercises may affect the outcome of MT.

Besides these limitations, controlling demographic and disease-related variables, and also considering three study groups (MT, non-reflective surface, and control) are the advantages of our study. To control the placebo effect of MT, a third group, the non-reflective group, was used in the present study.

Ethical Considerations

Compliance with ethical guidelines

The present study was approved by the Ethics Committee of Guilan University of Medical Sciences with the code IR.GUMS.REC.1394.11 and registered at the Iranian Registry of Clinical Trials with the code IRCT201504224787N5.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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