Effect of mirror therapy on upper extremity functional and motor skills among patients with chronic stroke

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Abstract---Background: Mirror therapy is one of the cognitive-induced interventions based on mirror neurons on neurologic grounds. Aim: to evaluate the effect of mirror therapy on upper extremity functional and motor skills among chronic stroke patients. Design: a quasi-experimental design (pre/post-test). Setting: The study was conducted at Egypt of Health care Authority, Port Said hospitals ICU departments. Subjects: All patients (50) with chronic stroke who were admitted to the previously mentioned settings at the time of data collection, which was chosen using a convenient sampling technique. Tools: Three tools were used for data collection: Tool 1: Structured interview questionnaire; Tool 2: Fugl-Meyer assessment, lower limb function (FMA); Tool 3: Brunnstrom stages, Tool 4: Functional Independence Measure (FIM). Tool 5: Modified Ashworth Scale. Results: The results of the study illustrated that the mirror therapy group showed significant differences in muscle strength, range of motion of wrist extension, and muscle tone of wrist flexors in the post-test compared to the pre-test as demonstrated by the Dualer IQ Inclinometer and Modified Ashworth Scale. (p<0.05). There was an improvement in the Brunnstrom stage and the FIM self-care score in the post-test compared to the pre-test, as well as FMA score was significantly higher with the mirror therapy application post-test than in the pre-test. Conclusion: The mirror therapy can bring positive changes to functional and motor skills of the upper extremity among

patients with chronic stroke. Recommendations: Patients with chronic stroke should be aware of mirror therapy as a simple and applicable strategy for functional and motor skills of the upper extremity. Mirror therapy should be integrated with the care of patients with chronic stroke.

Introduction

Stroke is a disease of the central nervous system caused by a partial loss of brain function that occurs due to ischemia, infarction, or hemorrhage, which can lead to movement disorders, cognitive disorders, language disorders, sensory disorders, etc. (Rostami et al., 2020). Stroke is a disease with a high incidence and mortality affecting a large proportion of the population and causing disability in survivors. Hemiplegia was reported in 85% of stroke survivors and 69% had functional limitations of the upper extremities (Kang 2019). The motor paralysis that appears after the onset of a stroke generally occurs in the distal part of the upper limb more than the lower limb and outside the functions related to motor paralysis, and finger extension is one of the functions from which recovery is delayed the most (Lamont et al., 2021).

Two out of three patients suffer from damage to the motor function of the upper limb, since most activities of daily living are done through movements of the hands including the upper limbs, patients who cannot use their hands after the onset of a stroke experience physical and mental pain. Therefore, it can be emphasized that the degree of functional recovery of the upper limb has critical effects on the level of assistance needed for activities of daily living and whether independent activities are possible after the onset of stroke (Small et al., 2020). Furthermore, stroke can lead to limitations in activities of daily living, such as eating and dressing/undressing; Deficits in bodily functions develop in about 66% of patients and in activities of daily living in about 75% of patients (Sturm et al., 2020).

The goal of stroke rehabilitation is to enable individuals to achieve maximum functional independence and improve their quality of life despite current limitations. However, the conventional treatment modalities used for this purpose are insufficient to enable functional recovery of the upper limb (Lamont et al., 2021, and Kang 2019). Various techniques have been proposed to restore upper limb function in stroke patients, These techniques include exercise training for arm paresis, directed training for arm weakness or Bobath therapy for severe arm paresis after stroke, functional electrical stimulation, robot-assisted rehabilitation, and movement therapy induced by bilateral arm training restriction. However, most rehabilitation techniques for upper extremity paresis are intensive, involve high equipment costs, and require prolonged manual interaction with the therapist, making the administration of these therapies difficult for all patients (Luo et al., 2020, and Yun et al., 2019).

Mirror therapy (MT) is also one of these techniques which is a relatively new treatment that restores the motor function of the upper limbs by inducing brain reorganization and it's an inexpensive, easy, and most importantly patient-oriented treatment that may improve recovery of functional hand movement skills (Yun et al.,2019, and Lappchen et al., 2018).

The mirror therapy (MT) technique was established by Ramachandran et al. (1996) to reduce phantom limbs pain in amputes. MT consists of repeated symmetrical bilateral movements in which the patient moves the affected body part as much as possible while observing the reflection of the same unaffected body part in a mirror placed between those body parts while obscuring the affected part (Gandhi et al., 2020). In this way, the reflection in the mirror of the healthy arm tricks the brain into thinking that the affected arm is functioning as it was before the stroke by creating an optical illusion and thus activating the damaged brain area (Shaker et al., 2020, and Caligiore et al., 2017). Neuroactivities research has reported that MT may stimulate regions within the somatosensory cortex, motor cortex, and/or mirror neuron system in the frontal region and superior temporal gyrus. Such cortical stimulation may produce a motor output in stroke patients (Stevens & Stoykov, 2020, and Dohle et al., 2019).

Several studies on the effectiveness of mirror therapy in post-stroke upper limb rehabilitation presented different types of mirror therapy programs and used different intervention durations such as the treatment time applied (Yun, et al., 2019). Recent studies on mirror therapy for stroke patients confirmed a significant improvement in hand motor function and activities of daily living with various hand motor training exercises in subacute stroke patients (Thieme et al., 2019, Radajewska et al., 2018, and Shaker et al., 2020). While no difference was found between patients who received mirror therapy and those who received conventional rehabilitation in other studies (Yavuzer et al., 2018). Therefore, this study aimed to evaluate the effect of mirror therapy on upper extremity functional and motor skills among chronic stroke patients.

Significance of study

In the United States, Europe, and many developing countries, stroke is the third largest cause of death and disability (Stromberg 2021). As stroke is the leading cause of motor and functional disability, 85% of stroke patients complain of hemiplegia and 55 to 75% of them suffer from insufficiency in upper extremity activities. Approximately 30-66% of stroke patients never regain functional motor skills of the hand, which seriously affects their performance in activities of daily living (Lappchen et al., 2018).

Stroke is a serious health problem in developing countries, and the rulers of Egypt suffer from a stroke incidence rate much higher than that of other Arab countries (Figueiredo et al., 2017). After a stroke, these motor and functional abnormalities require ongoing care (Katrak et al., 2019). Mirror therapy is a simple, inexpensive, and patient-oriented treatment. Functional brain imaging studies in healthy individuals have shown that the excitability of the ipsilateral primary cortex increases when observing a mirror image of the hand during

unilateral hand movements (Nogueira et al., 2021, and Garry et al., 2020). Mirror therapy involves superimposing reflections of the movements of the healthy limbs onto the affected limbs so that the patient watches them as if his limbs are moving (Toh & Fong 2019).

Aim of the study

To evaluate the effect of mirror therapy on upper limbs motor and functional skills in chronic stroke patients.

Research hypothesis

Patients with chronic stroke who have applied mirror therapy are expected to improve their upper extremity motor skills after implementing mirror therapy compared to before implementing mirror therapy.

Subjects and Method

Research design:
This study used a quasi-experimental research design.

Setting:
This study was carried out in ICU departments of three hospitals affiliated with the Egypt of Health care Authority, Port Said hospitals namely (Al Salam Hospital, Al Mobara Hospital, and Al Zohor Hospital).

Subject:
All patients (50) with stroke who were admitted to the previously mentioned settings at the time of data collection, which was chosen using a convenient sampling technique

Sample:
A convenient sampling technique was utilized in the current study.

Data collection tools:
Five tools were used for data collection in this study:
Tool 1: Structured interview questionnaire: was created by the researchers after reviewing previous related studies and pertinent literature (Yavuzer et al., 2018, Michielsen et al., 2019; Rothgangel et al., 2020, and Dennison et al., 2021) it consisted of two parts: -
Part 1: Patient's demographic data: It included items related to the demographic variables such as age, gender, residence, and educational level.
Part 2: Includes the patient's clinical data such as lesion type and paretic side.

Tool 2: Fugl-Meyer Assessment
Fugl-Meyer assessment, limb function; timed get up and go on time; 10-meter walking test; 6- minute walk test; gait analysis (stride length, step length, velocity, cadence, single stance, swing phase, stance phase, and step width); functional categories of ambulation.

The Fugl-Meyer assessment (FMA) upper extremity score has been used to assess various aspects of motor impairment it was developed by (Fugl-Meyer et al., 1975). FMA is a quantitative assessment tool to measure motor recovery after a stroke in the hand, wrist, forearm, elbow, and shoulder. Scores are assigned from 0 to 2 for each item according to performance in the motor function assessment (fully performing scored 2, partially performing scored 1, unable to perform scored 0). The maximum upper extremity motor performance score was 66 points. The scale has high inter-rater reliability (r = 0.94), intra-rater reliability (r = 0.99), and constructive validity.

Tool 3: - Brunnstrom stages assessment:
Upper extremity motor recovery was assessed using Brunnstrom's stages the tool was adopted from (Gurbuz et al., 2016) and modified by researchers after reviewing the related literature. The Brunnstrom stage evaluates the motor development of paraplegic patients. In this test, the recovery process is divided into Six stages. The upper and lower limbs and the hand are evaluated separately. The lower stage is defined as stage I (flaccid, involuntary movement), and the higher stage is stage VI (isolated joint movement).

Tool 4: - Functional Independence Measure (FIM Instrument): It was developed by (Tur et al., 2003 and Kohler et al., 2009) and modified by researchers after reviewing the related literature. To understand the amount of assistance required to perform daily activities and the degree of independence, the Functional Independence Measure (FIM) was determined. This consists of 18 items, including 13 motor tasks and 5 cognitive tasks. Among the 13 motor tasks, items corresponding to self-care such as feeding, grooming, upper dressing, lower dressing, toileting, and bladder and bowel control were evaluated. The inter-tester reliability of the FIM was found to be 0.124 (Tur et al., 2003).

The level of functional impairment was assessed by a self-care subscale of the Functional Independence Scale (FIM). The FIM measures physical and cognitive dysfunction and the need for help and consists of 18 items. These items were grouped into 6 subscales measuring self-care, sphincter control, shunting, locomotion, communication, and social cognition. Changes in the performance of activities are measured objectively through performance monitoring. Each item is assessed on a 7-point Likert scale that quantifies the amount of help required (1 = complete dependence, 7 = complete independence). The maximum total score is 126 and the maximum self-care score is 42. The validity and reliability of the Turkish version have been demonstrated.

Tool 5: Modified Ashworth Scale
MAS, adopted from (Arya & Pandian, 2013) and modified by researchers after reviewing the related literature. by applying muscle resistance to upper extremity passive stress place the patient in a supine position If you are testing a muscle that primarily flexes the joint, place the joint in the position of maximum flexion and move it to the position of a maximum extension within 1 second (count "one thousand one") If you are testing a muscle that is primarily extending the joint, place the joint in the maximally extended position and move into the maximal flexion position within 1 second (count "one thousand one") Score based on the rating below

Scoring was if No increase in muscle strength recorded 0, the slight increase in muscle strength scored 1, manifested by gripping and releasing or by minimal resistance at the end of the range of motion when the affected part(s) move in flexion OR extension 1+ slight increase in muscle tone, manifested by snapping, followed by minimal resistance during the remaining (less than half) ROM 2, the marked increase in muscle strength through most ROMs, but affected part(s) move easily 3 marked increase in muscle tone, difficulty in passive movement. 4The affected parts are rigid in flexion or extension.

Validity of the tools

The content validity of the tools, their clarity, comprehensiveness, appropriateness, and relevance were reviewed by three experts in the medical-surgical nursing field and medical-surgical medicine. No modifications were made according to the panel judgment to ensure sentence clarity and content appropriateness.

Reliability of the tools

The internal consistency method was employed in the current study to assess the reliability of the two scales. The first tool's Cronbach alpha coefficient was 0.97, the third tool was 0.91, and the sixth tool was 0.93 demonstrating both tools' good dependability.

Methods
- Port-Said Faculty of Nursing's Ethical Research Committee gave its approval before the study could be carried out. -The directors of the previously selected setting gave their consent for this study to be conducted through a letter that was issued from the Dean of the Faculty of Nursing at Port-Said University. To get consent to gather research data, the study's goal was described.

A pilot study

To assess the clarity and feasibility of the research method, a pilot study was conducted on 10% (5 patients) of the total sample. To produce the final form of the tools, no modifications were made. Patients included in the pilot study were included in the study.

Ethical considerations

Before starting the study, the researchers met with the medical-surgical directors of the selected setting to secure their participation and to explain the purpose of the study. In exchange for their cooperation, patients gave their oral approval. Chronic stroke patients were informed of the study's objectives. Patients were advised that enrollment in the study was completely optional and that they could withdraw their consent at any moment, without having to provide a reason. Patients were informed that their data would be kept private and solely used for research.

The procedure of data collection

Two days a week, from 9 am to 1 pm, the researchers went to the settings they had previously chosen. The collection of data took place over six months, from the start of August 2021 to the end of February 2022. Each interview tool took roughly 30 to 40 minutes to complete. In previously chosen locations, the researchers visited with patients individually and introduced themselves before explaining the purpose of the study. The patients were interviewed face-to-face by the researchers, who also read the questions and potential answers to them to assist them in filling out the tools. Implementation of the study included three phases (preparatory phase, implementation phase, and evaluation phase).

A-Preparatory phase: To create the instruments for data collecting and to create instructional recommendations, the researchers looked at the recent and related literature that was accessible as textbooks, periodicals, magazines, and internet searches.

B- Implementation phase:

Data collection for the study began with the collection of demographic and clinical data. The researcher conducted individual interviews with each patient to obtain the necessary data using Tool 1, Part 1 (Patient Demographic and Clinical Data: A Structured Interview Schedule), before the start of the application, and Tools 2, 3, 4, 5, and 6, were used before and after the start of the application.

The mirror therapy group set comfortably in the chair, and the participant placed both his arms on the table and placed one of his arms in the mirror box so as not to be seen. The mirror box was placed on the midline of the participant's body and the unaffected arm was placed in front of the mirror surface so that the affected arm could be seen normally when the participant viewed the mirror. In this study, mirror therapy was applied for 30 minutes a day, five days a week for four weeks. Building on programs implemented in previous studies, the mirror therapy program asked participants to perform physiological movements for 10 minutes including elbow, wrist, and finger flexion and extension, forearm supination and pronation, finger counting, resistance, elbow flexion and extension on the edge of a table and object-related movements For 20 minutes including sponge squeezing, wrist flexion and extension boldly in hand, going over the table with the towel, pegboard, transferring beans with a spoon, and keyboard typing.

Mirror therapy involved flexion and extension movements of the non-abnormal upper limb wrist and fingers. The patients sat on a chair with a table in front of them. The mirror is placed between the ends and perpendicular to the table in front of them so that the non-evil hand is reflected. Patients were asked to perform periodic flexion and extension movements of the wrist and fingers on the non-malignant side and to observe the reflection of these movements in a mirror under supervision. Patients can only see the non-demon hand in the mirror. These movements were performed at the speed desired by the patients.

Figure 2.

The participants were divided randomly into two groups: The Functional Activities Group (FAG) and the Motor Pattern Group (MPG). Before the mirror treatment, movement therapy was applied during the first 10 minutes of the session, with passive muscle stretching and joint movement in the upper extremities. When treating with a mirror, a rectangular platform measuring 40 x 70 cm was used, on which a mirror was placed in the sagittal plane and could be removed according to the paraplegic aspects of each patient (Fig. 1). The platform extension and sides are closed to avoid drawing environmental attention to the patients. The platform with the mirror is installed on a table where the patient sits, on a comfortable chair with a backrest, with legs resting on the floor. The patients were instructed to see the reflection of their normal hand in the mirror where the affected hand was and to perform the activities bilaterally. The sessions lasted 30 minutes and the focus of the intervention was on repetition of the task. To avoid muscle strain, patients can rest for 1 to 2 minutes between tasks. The FAG subjects carried out activities in the mirror with playful objects (cups, cubes, balls, toys, bottles) in a variety of colors, sizes, and shapes. The activities were related to functional scope, installation, transportation, and stacking. MPG subjects performed movements of finger flexion and extension, finger adduction/abduction, forearm pronation and supination, and elbow extension, without relating them to functional activities (Figure 2). During treatment, the examinees verbally instructed the subjects, so they were motivated and corrected when activities were performed incorrectly.

C-Evaluation phase

In this phase reassessment occurred to determine the effect of mirror therapy on upper extremity functional and motor skills among patients with chronic stroke the researcher used the same tools used in the pretest.

Administrative design

The director of the previously selected setting received formal approval from the Port-Said faculty of nursing to conduct the study and to ask for permission to gather data from the studied population.

Statistical analysis

Data from earlier tools and outcome assessments were coded, processed, and analyzed by researchers using Microsoft Excel software. Data were entered into SPSS version 25 (the Statistical Package for the Social Sciences) for data analysis and graphical presentation. While qualitative categorical variables were expressed by frequencies and percentages, quantitative variables were described by mean and Standard Deviation (SD). Categorical variables were tested for independence using the chi-squared method. The correlation between two quantitative variables in a group was found using Pearson's correlation and the linear correlation coefficient (r). The significance (p-value) was considered Non-significant (NS) P-value < 0.05, Significant (S) P-value ≤ 0.05, and highly significant (HS) P-value ≤ 0.001.

Results

Table (1): Distribution of the studied patients with chronic stroke regarding their demographic data

Demographic data	**(n=50)**	**(%)**
Age (in years):		
<40-	10	20.0
≥40	40	80.0
Mean ± SD = 50.33 ± 11.78		
Sex:		
Female	34	68.0
Male	16	32.0
Residence:		
Rural	35	70.0
Urban	15	30.0
Level of education:		
Illiterate	30	60.0
Read & write	13	26.0
University education	7	14.0

Table (1): shows that the average age of the study participants was 50.33 ± 11.78 years. 68% of the participants were female. More than two-thirds of the patients (70%) live in rural areas and 60% are illiterate.

Table (2): Distribution of the studied patients with chronic stroke regarding their clinical data

Clinical History	(n=50)	(%)
Paralytic Side:		
▪ Right	30	60.0
▪ Left	20	40.0
Lesion type:		
▪ Ischemic	30	64.0
▪ Hemorrhagic	20	36.0

Table (2): shows that with regard to the paralyzed side, 60% of the patients studied had right-sided paralysis, and 64% of the sample reported having had ischemic strokes.

Table (3): Distribution of the studied patients with chronic stroke regarding their Brunnstrom stage

Brunnstrom stage	(n=50)	(%)
Stage 3	5	10.0
Stage 4	27	54.0
Stage 5	18	36.0

Table (3): Showed that regarding the Bronstrom stage of patients with chronic stroke, it was observed that 54% of them were in stage 4, and 36% of them were in stage 5

Table (4): Correlation between pre, and post implementation of mirror therapy on upper extremity functional and motor skills among patients with chronic stroke related to Brunnstrom stages

Item	Pre the mirror therapy implementation	Post the mirror therapy implementation	t-test
	Mean ± SD	Mean ± SD	
Brunnstrom stages	1 (1–3)	2.5 (1–5)	15.89 (0.001) *

*Statistically significant

Table (4): Revealed that there was a significant correlation was found between pre and post implementation of mirror therapy on upper extremity functional and motor skills among patients with chronic stroke related to Brunnstrom stages with p value 0.001.

Table (5): Correlation between pre, and post implementation of mirror therapy on upper extremity functional and motor skills among patients with chronic stroke related to FMA

Item	Pre the mirror therapy implementation	Post the mirror therapy implementation	t-test
	Mean ± SD	Mean ± SD	
FMA score	32.0 ± 3.4	37.6 ± 3.4*	17.89 (0.000) *

Significance at p≤0.05

Table (5): Revealed that there was a significant correlation was found between pre and post implementation of mirror therapy on upper extremity functional and motor skills among patients with chronic stroke related to FMA with p value 0.000.

Table (6): Correlation between pre, and post implementation of mirror therapy on upper extremity functional and motor skills among patients with chronic stroke related to FIM

Item	Pre the mirror therapy implementation	Post the mirror therapy implementation	t-test
	Mean ± SD	Mean ± SD	
FIM **score**	71.4 ± 4.8	77.6 ± 7.2*	14.33(<0.001) *

Significance at p≤0.05

Table (6): Illustrated that there was a significant correlation was found between pre and post implementation of mirror therapy on upper extremity functional and motor skills among patients with chronic stroke related to FIM with p value 0.000.

Table 7. Correlation between pre, and post implementation of mirror therapy on upper extremity functional and motor skills among patients with chronic stroke related to MAS

MAS variables	Pre the mirror therapy implementation	Post the mirror therapy implementation	P-value
Shoulder flexors	0.56±0.57	1±0.98	0.006
Shoulder extensors	0.34±0.58	1.69±0.88	0.004
Shoulder Abductors	0.67±0.59	1.33±0.67	0.003
Shoulder Adductors	0.34±0.58	1.66±0.59	0.001
Shoulder internal rotators	0.35±0.58	1.33±0.58	0.375a
Shoulder external rotators	0.34±0.56	132±0.59	0.001
Elbow flexion	0.35±0.55	1.34±0.59	0.480a
Elbow extension	0.36±0.55	1.37±0.58	0.001
Forearm supination	0.51±0.85	1.38±0.59	0.001
Forearm pronation	0.52±0.87	1.52±0.89	0.368a

MAS variables	Pre the mirror therapy implementation	Post the mirror therapy implementation	P-value
Finger flexion	0.34±0.59	1.53±0.87	0.574[a]
Finger extension	0.68±0.54	1.31±0.58	0.211[a]
Wrist flexion	0.68±0.54	1.67±0.56	0.212[a]
Wrist extension	0.04±0.59	1.68±0.59	0.574[a]

Table (7) Revealed that there was a significant correlation was found between pre and post implementation of mirror therapy on upper extremity functional and motor skills among patients with chronic stroke related to the Modified Ashworth Scale (MAS) mainly in items shoulder flexors, shoulder extensors, shoulder abductor, shoulder adductor, shoulder external rotators, elbow extension, and forearm supination with a P-value (0.006, 0.004, 0.003, 0.001, 0.001, 0.001, and 0.001, respectively)

Discussion

Stroke can cause many disabilities in a person's life although new advances in the treatment of acute ischemic stroke have led to an increase in life expectancy (Aly and Shaheen 2021, Shaheen et al., 2019, and Langhorne et al., 2019). The goal of stroke rehabilitation should be to improve the patient's physical, cognitive, emotional, and social quality of life. Upper limb paralysis, which is common after a stroke, is one of the most limiting problems for the patient (Yun et al.,2019, and Lappchen et al., 2018). New approaches and treatments aim to reactivate the plastic properties of the brain to restore lost brain functions or preserve what is left. The motor cortex can be modulated by repetitive muscle activity, supporting the concept of neural plasticity (Gandhi et al., 2020, and Thieme et al., 2019).

Mirror therapy is a simple, easy-to-use, low-cost rehabilitation method for patients and staff, and it can be integrated into the home environment. Studies on the effectiveness of mirror therapy have mostly focused on upper limb function. However, the number and content of published studies are insufficient to support any strong conclusions (Radajewska et al., 2018).

The results of the current study confirmed that after the implementation of the mirror therapy, there was a statistically significant increase in the upper extremity Brunnstrom stages with a high statistical difference between pre- and post-mirror therapy implementation. From the researchers' point of view, it confirmed the positive effects of mirror therapy in improvements of the patient's upper extremity functional and motor skills. The improvements in hand movement functional skills that were facilitated by mirror therapy may be explained in light of Shaker et al., (2020) who concluded that mirror therapy can improve movement and performed with both hands. This result is supported by Arfianti et al., (2022) who stated that the mirror group showed a significant improvement in Brunnstrom scores compared with the control group after 5 weeks of mirror therapy.

On the contrary, the results of the current study disagree with Gurbuz et al., (2016) who confirmed that after mirror therapy, we did not find significant differences between the pre-and post-treatment upper limbs and Brunnstrom's manual phases of the groups. However, there were statistically significant differences in upper limbs Brunnstrom stages and Brunnstrom hand stages between the experimental and control group.

The findings of the current study also displayed that the mean score for The Fugl-Meyer assessment (FMA) after the mirror therapy implementation significantly increased with a high statistical difference between pre- and post-mirror therapy implementation. From the researchers' point of view, it reflected the good impact of mirror therapy on improving FMA among patients with chronic stroke.

This finding is consistent with Dohle et al., (2019) who reported that Mirror therapy had a significant improvement in the motor score of FMA. They also found a significant improvement in surface tactile sensation in the mirrored group compared with the control group. They clarified that mirror therapy not only activates the motor cortex but also alters the somatosensory expression of the cortex. Similarly, Thieme et al., (2019) revealed improvement in FMA scores in all patients after treatment. In addition, Michielsen et al., (2020) applied a rehabilitation program of 60 minutes per day, 5 days per week at home, and 1 day per week in the hospital for 6 weeks in both groups in a randomized controlled study for patients with chronic stroke. Patients were evaluated before and after treatment and after 6 months of follow-up. The patient's upper extremity FMA score was found to be significantly higher in the mirror group.

This finding is supported by other studies, Jørgensen et al., (2017) who found a significant improvement in FMA was found after mirror treatment when compared to the control group. Improvement after stroke is most pronounced in the first 12 months. Other researchers agreed with our study results regarding reflects of a significant improvement in the mirror group with respect to upper extremity FMA scores (Small et al., 2020; Arya & Pandian 2013; and Agnew et al., 2018).

Moreover, Michielsen et al., (2020) and Wu et al., (2019) reported improvements in motor function after MT using FM and associated this outcome with appropriate visual input to replace reduced sensory input on the affected limb. The results of the present study revealed that the average FIM score post the application of mirror therapy have a significantly improvement with a highly statistical difference between pre and post implementation of mirror therapy. This finding is consistent with Yavuzer et al., (2018) who reported that post-treatment evaluation of patients revealed a significant improvement in Brunnstrom stages of the hand and upper limbs and FIM self-care scores compared to the control group. This significant difference was still evident at the 6-month follow-up. In contrast, this finding contradicts Arfianti et al., (2020), who stated that there was no significant difference and did not affect the development of FIM scores after 5 weeks of mirror therapy.

The result of the present study revealed that there was a significant correlation was found between pre and post implementation of mirror therapy on upper extremity functional and motor skills among patients with chronic stroke related to Functional Independence Measure (FIM). This finding agrees with Invernizzi et al., (2019) who conducted a four-week program of upper limb exercises consisting of mirror therapy and lying mirror therapy in 26 stroke patients and found that both groups showed significant improvement in upper limb function outcomes. FIM results improved within the group in the MT group, which showed greater improvement between the two groups. This result was supported with Arfianti et al., (2020), who confirmed that after 5 weeks, there was a significant improvement in FIM scores in the experimental group compared with the control group.

Moreover, the results of the current study are also in agreement with Yavuzer et al., (2018) which found that mirror therapy had significant effects on recovery of upper extremity function in subacute stroke patients and that it also improved the self-care domain of the FIM. Conversely, Dohle et al., (2019) found no difference between groups with respect to FIM motor subscale scores. While some studies have reported better response by the mirror system when movements are performed on the mirror with improvement in FIM (Small et al., 2020; Arya & Pandian 2013; and Agnew et al., 2018).

The results of the current study illustrated that there was a significant correlation was found between pre- and post-implementation of mirror therapy on upper extremity functional and motor skills among patients with chronic stroke related to the Modified Ashworth Scale (MAS) mainly in items shoulder flexors, shoulder extensors, shoulder abductor, shoulder adductor, shoulder external rotators, elbow extension, and forearm supination. This This result was consistent with Shaker et al., (2020) who showed that there was a significant increase in the active range of motion of wrist extension and forearm elongation as well as improved hand function and strength of the affected side in both groups after treatment, particularly in the study group. Hands this finding is supported by a study by Thieme et al., (2019) who confirmed a significant change in resistance to passive movements in the finger flexor muscles.

The results of the current study prove the research hypothesis of the study, which indicates that patients with chronic stroke who applied mirror therapy are expected to improve the motor skills of their upper extremities compared to before implementing mirror therapy. This finding is consistent with Ramachandran & Rogers-Ramachandran, (1996) who showed that mirror therapy can increase movements of the affected limb after a stroke. This finding is in agreement with Altschuler et al., (2019) who confirmed that mirror therapy provides visual input in relation to the normal movement of the affected arm, and this may compensate for the decrease or loss of proprioceptive input. This is also in agreement with Stevens & Stoykov, (2020) showed that mirror therapy is a type of visually administered motion illusion where movement is performed mentally without apparent application.

This finding is also supported by Dohle et al., (2019) A randomized controlled study of 36 patients who suffered acute ischemic stroke due to injury to the

middle cerebral artery. Mirror therapy (5 days a week, 30 minutes a day) was added to standard treatment for 6 weeks. Mirror therapy is beneficial for patients who have had a stroke, as reported in several studies (Lappchen et al., 2018 and Wu et al., 2019). Moreover, these results were endorsed by other researchers Song & Park, (2019) and Yavuzer et al., (2018) who revealed that acute ischemic stroke and subacute ischemic stroke patients with acute paralysis of the upper extremities receive mirror therapy, and it has been reported that mirror therapy improves upper extremity functions of patients with chronic ischemic stroke.

The results of the present study are consistent with those of Thieme et al., (2019), who analyzed the effects of mirror therapy on 60 subacute stroke patients grouped into individual mirror therapy, group mirror therapy, or virtual therapy control groups and found that all three groups showed significant improvement in motor function. This also agrees with Kantak et al., (2017) who reported that mirror therapy activates this premotor region, increasing activity of the partially damaged primary motor region and enhancing residual upper limb motor function. The present results are also consistent with a study by Bhasin et al., 2018, and Park et al., (2015) who reported that when performing a mirror therapy program for 30 stroke patients, upper limb functional capacity improved, and activities of daily living values increased.

Conclusion

Based on the results of this study, the present study concluded that mirror therapy can induce positive changes in upper limb motor and functional skills among chronic stroke patients. After applying mirror therapy, improvements in motor and functional skills were seen among the patients.

Recommendations

Based on the results of this study, the following recommendations were suggested:
- ❖ Patients with chronic stroke should be aware of mirror therapy as a simple and feasible strategy for upper limb motor and functional skills.
- ❖ Mirror therapy should be integrated into the care of chronic stroke patients.
- ❖ A repeat of the current study with a larger sample of patients in different settings is required to generalize the results.

References

Agnew ZK, Wise RJS, Leech R. Dissociating object directed and non- object directed action in the human mirror system; Implications for theories of motor stimulation. Plos One. 2018;7(4):1-9.

Altschuler EL, Wisdom SB, Stone L, et al.: Rehabilitation of hemiparesis after stroke with a mirror. Lancet, 2018, 353: 2035–2036.

Aly A. A., & Shahin E. S. Determining the Effect of a Care Bundle for Hypertension Control on the Health Outcomes of Hypertensive Patients with Stroke Risk. Recent Developments in Medicine and Medical Research. 2021; Vol. 15, 125–132. https://doi.org/10.9734/bpi/rdmmr/v15/5354F.

Arfianti, L., Rochman, F., Hidayati, H. B., & Subadi, I. The addition of mirror

therapy improved upper limb motor recovery and level of independence after stroke: a randomized controlled trial. Cadernos Brasileiros de Terapia Ocupacional,2022.e3218.https://doi.org/10.1590/2526-8910.ctoAO245932182.

Arya KN, Pandian S. Effect of task-based mirror therapy on motor recovery of the upper extremity in chronic stroke patients: A pilot study. Top Stroke Rehabil. 2013;20(3):210-7.

Cadernos Brasileiros de Terapia Ocupacional, 30, e3218. https://doi.org/10.1590/2526-8910.ctoAO245932182

Bhasin A, Padma Srivastava MV, Kumaran SS. Neural interface of mirror therapy in chronic stroke patients: a functional magnetic resonance imaging study. Neurol India, 2018, 60: 570–576.

Caligiore D, Mustile M, Spalletta G, Baldassarre G. Action observation and motor imagery for rehabilitation in Parkinson's disease: A systematic review and an integrative hypothesis. Neurosci Biobehav Rev. 2017 Jan;72:210-222. doi: 10.1016/j.neubiorev.2016.11.005.

Dennison A, Hirsch MA, Hammond FM. Rehabilitation with a mirror. Arch Phys Med Rehabil. 2009; 90:2155. 16.

Dohle C, Pullen J, Nakaten A, Kust J, Rietz C, Karbe H (2009) Mirror therapy promotes recovery from severe hemiparesis: a randomized controlled trial. Neurorehabil Neural Repair 23(3): 209-17.

Figueiredo, J., Moreno, J. C., Matias, A. C., Pereira, F., & Santos, C. P. (2019). Outcome measures and motion capture systems for assessing lower limb orthosis-based interventions after stroke: a systematic review. Disability and Rehabilitation: Assistive Technology, 1-10.

Fugl-Meyer AR, Jääskö L, Leyman I, The post-stroke hemiplegic patient. 1. a method for evaluation of physical performance. Scand J Rehabil Med, 1975, 7: 13–31.

Garry MI, Loftus A, Summers JJ: Mirror, mirror on the wall: viewing a mirror reflection of unilateral hand movements facilitates ipsilateral M1 excitability. Exp Brain Res, 2020, 163: 118–122.

Gurbuz N, Afsar SI, Ayaş S, Cosar SN. Effect of mirror therapy on upper extremity motor function in stroke patients: a randomized controlled trial. J Phys Ther Sci. 2016 Sep;28(9):2501-2506. doi: 10.1589/jpts.28.2501. Epub 2016 Sep 29. PMID: 27799679; PMCID: PMC5080161.

Gandhi, D. B. C., Sterba, A., Khatter, H., & Pandian, J. D. Mirror therapy in stroke rehabilitation: current perspectives. Therapeutics and Clinical Risk Management, 2020.16, 75-85.

Invernizzi M, Negrini S, Carda S, et al.: The value of adding mirror therapy for upper limb motor recovery of subacute stroke patients: a randomized controlled trial. Eur J Phys Rehabil Med, 2019, 49: 311–317. [Medline]

Jørgensen HS, Nakayama H, Raaschou HO, et al.: Recovery of walking function in stroke patients: the Copenhagen Stroke Study. Arch Phys Med Rehabil, 2017, 76: 27–32.

Kang YJ, Ku J, Kim HJ, Park HK. Facilitation of corticospinal excitability according to motor imagery and mirror therapy in healthy subjects and stroke patients. Ann Rebabil Med. 2019;35:747-58.

Katrak P, Black D & Peera V (2019). Do stroke patients with intracerebral hemorrhage have better functional outcomes than patients with cerebral infarctions? Physical Medicine and Rehabilitation, 1, 427-433.

Kohler F, Dickson H, Redmond H, Estell J and Connolly C (2009) Agreement of functional independence measure item scores in patients transferred from one rehabilitation setting to another. Eur J Phys Rehabil Med 45(4): 479-85.

Lamont K, Chin M, Kogan M. Mirror box therapy: seeing is believing. Explore (NY). 2021;7:369–72

Langhorne P, Coupar F, Pollock A: Motor recovery after stroke: a systematic review. Lancet Neurol, 2019, 8: 741–754.

Lappchen CH, Ringer T, Blessin J, SeidelG, Grieshammer S, Lange R, *et al.* Optical illusion alters M1 excitability after mirror therapy: A TMS study. J Neurophysiol. 2018;108:2857-61.

Luo, Z., Zhou, Y., He, H., Lin, S., Zhu, R., Liu, Z., Liu, J., Liu, X., Chen, S., Zou, J., & Zeng, Q. Synergistic effect of combined mirror therapy on upper extremity in patients with stroke: a systematic review and meta-analysis. Frontiers in Neurology, 2020. 11(155), 1-11.

Michielsen ME, Selles RW, Geest JNV, Eckhardt M, Yavuzer G, Stam HJ, *et al.* Motor recovery and cortical reorganization after mirror therapy in chronic stroke patients: A phase II randomized controlled trial. Neurorehabilitation Neural Repair. 2020;24(3):223-33.

Nogueira, N. G. H. M., Parma, J. O., Leão, S. E. S. A., Sales, I. S., Macedo, L. C., Galvão, A. C. D. R., Oliveira, D. C., Murça, T. M., Fernandes, L. A., Junqueira, C., Lage, G. M., & Ferreira, B. P. Mirror therapy in upper limb motor recovery and activities of daily living, and its neural correlates in stroke individuals: a systematic review and meta-analysis. Brain Research Bulletin, 2021. 177, 217-238.

Park JY, Chang M, Kim KM, et al.: The effect of mirror therapy on upper-extremity function and activities of daily living in stroke patients. J Phys Ther Sci, 2015, 27: 1681–1683.

Radajewska A, Opara JA, Kucio C, et al.: The effects of mirror therapy on arm and hand function in subacute stroke in patients. Int J Rehabil Res, 2018, 36: 268–274.

Ramachandran VS, Rogers-Ramachandran D: Synaesthesia in phantom limbs induced with mirrors. Proc Biol Sci, 1996, 263: 377–386.

Rostami HR, Arefi A, Tabatabaei S: Effect of mirror therapy on hand function in patients with hand orthopaedic injuries: a randomized controlled trial. Disabil Rehabil, 2020, 35: 1647–1651.

Rothgangel AS, Braun SM, Beurskens AJ, Seitz RJ, Wade DT. The clinical aspects of mirror therapy in rehabilitation: a systematic review of the literature. Int J Rehabil Res. 2020; 34:1–13.

Shahin E. M , Abdelsalam N. A. & Aly A. A. Effect of a Care Bundle for Hypertension Control on the Health Outcomes of Hypertensive Patients with Stroke Risk. American Journal of Nursing Research. **2019**, 7(6), 942-946. DOI: 10.12691/ajnr-7-6-5.

Shaker, H., Fahmy, E.M., Honin, A.A.N. et al. Effect of mirror therapy on hand functions in Egyptian chronic stroke patients. Egypt J Neurol Psychiatry Neurosurg 56, 96 (2020). https://doi.org/10.1186/s41983-020-00226-8.

Small SL, Buccino G, Solodkin AS. The mirror neuron system and treatment of stroke. Dev Psychobiol. 2020;54(3):293-310.

Song GB, Park EC: Effect of virtual reality games on stroke patients' balance, gait, depression, and interpersonal relationships. J Phys Ther Sci, 2019, 27: 2057–2060.

Stevens JA, Stoykov ME: Using motor imagery in the rehabilitation of hemiparesis. Arch Phys Med Rehabil, 2020, 84: 1090–1092.

Sturm JW, Osborne RH, Dewey HM, et al.: Brief comprehensive quality of life assessment after stroke: the assessment of quality of life instrument in the north East melbourne stroke incidence study (NEMESIS). Stroke, 2020, 33: 2888–2894.

Thieme H, Bayn M, Wurg M, Zange C, Pohl M, Behrens J. Mirror therapy for patients with severe arm paresis after stroke – A randomized controlled trial. Clin Rehabil. 2019; 27(4):314-24.

Toh SF, Fong KN: Systematic review on the effectiveness of mirror therapy in training upper limb hemiparesis after stroke. HKJOTH, 2019, 22: 84–95.

Tur BS, Gursel YK, Yavuzer G, Kucukdeveci A, Arasil T. Rehabilitation outcome of Turkish stroke patients: in a team approach setting. Int J Rehabil Res. 2003; 26(4): 271-77.

Wu CY, Huang PC, Chen YT, Lin KC, Yang HW. Effects of mirror therapy on motor and sensory recovery in chronic stroke: A randomized controlled trial. Arch Phys Med Rehabil. 2019; 94:1023-30.

Yavuzer G, Selles R, Sezer N, Sütbeyaz S, Bussmann JB, Köseoğlu F, et al. Mirror therapy improves hand function in subacute stroke: a randomized controlled trial. Arch Phys Med Rehabil. 2018;89(3):393–8.

Yun GJ, Chun MH, Park JY, Kim BR. The synergic effects of mirror therapy and neuromuscular electrical stimulation for hand function in stroke patients. Ann Rehabil Med. 2019; 53:316-21.