Rehabilitative Intervention regarding Mirror Therapy for Elderly Patients' Post-Stroke to Improve Upper Extremity Sensory Motor Function

Nagwa Ibrahim El-khayat, Tayser Bauomei Fahmei, 3Manal Mohamed Ahmed Ayed, 4Amel Ahmed Elsayed, 5 Ghalia Elmoghazy Elkasaby, 6 Hanan Hassan Elezaby

1 Lecturer of Geriatric Nursing, Faculty of Nursing, Menoufia University, Egypt
2 Lecturer of Gerontological Nursing, Faculty of Health Sciences Technology, Borg Al Arab Technological University, Alexandria, Egypt
3 Pediatric Nursing Department, Faculty of Nursing, Sohag University, Egypt
4 Assistant professor of Community Health Nursing, Faculty of Nursing, Mansoura University
5 Fellow of Nursing - Community Health Nursing, Urology and Nephrology Center Mansoura University
6 Assistant Professor of Family and Community Health Nursing Department, Faculty of Nursing, Port Said University, Egypt

Abstract

Background: Stroke is a serious medical condition that is one of the main causes of death for the elderly and impairment of sensory-motor function in the upper limbs. To assist people recover from a stroke and regain use of their upper extremity, rehabilitation is essential. Using evidence-based therapies, such as mirror therapy, which is being employed in stroke rehabilitation for senior patients to speed up upper limb sensory-motor recovery, is essential to this process. **Aim:** To evaluate the effect of rehabilitative intervention regarding mirror therapy for elderly patients' post-stroke to improve upper extremity sensory motor function. **Design:** A quasi experimental pre and post-test design was used. **Subjects:** A purposive sample of fifty elderly patients post-stroke was included. **Setting:** The study was carried out in the Rehabilitation Unit of Mansoura University Hospital and at elders' homes. **Tools:** Three standardized tools and an interview schedule sheet were used. **Results**: During the pre- and follow-up phases of the intervention, a highly statistically significant difference was observed in all parameters of the upper limb's sensory-motor recovery in the intervention group (p<0.01). Additionally, in post-test I and II, there were extremely statistically significant differences (p<0.01) observed for all parameters between the two groups. **Conclusion**: Rehabilitative intervention regarding mirror therapy as practical, simple, and affordable, nursing intervention that can be used to enhance upper extremity sensory motor function in elderly patients' post-stroke. **Recommendations**: It is advised that mirror therapy training be given in both clinical and community settings.

Keywords: Mirror therapy, Rehabilitative intervention, Sensory-motor recovery, Upper extremity, Elderly patients & Stroke

Introduction

All body systems experience a progressive reduction in function as we age, and the nervous system is no exception. Changes in the nervous system start out small and build up over time. As a result, aged brains exhibit various anomalies such as neurological degradation and brain malfunction brought on by neuronal death (**Mattson et al, 2018**). Every 10 years after the age of fifty-five, aging is thought to be the largest non-modifiable risk factor for stroke. According to **Yousufuddin et al. (2019**), there is a likelihood that the frequency of stroke incidents among the elderly would increase due to the growing population of people 65 years of age and above. As a result, almost all strokes occur in this age group.

A stroke is a type of acute neurological impairment resulting from ischemia or bleeding into specific parts of the brain, which interrupts blood supply. Stroke is defined by the WHO as "a neurological deficit of cerebrovascular cause that is interrupted by death within 24 hours or persists beyond 24 hours" (**Rai et al., 2020**). In both industrialized and underdeveloped nations, it significantly raises morbidity and mortality rates. Stroke is one of the main causes of death and serious disability in the majority of countries because its prevalence rises sharply with age. Stroke is therefore seen as a major epidemic that would likely result in many senior individuals being incapacitated and fatalities in the coming years (**Sharrief et al., 2019**).

A stroke can result in permanent disability or even death when the blood supply to the brain is cut off. The location and degree of brain tissue loss after a stroke determines how functionally impaired a person is, with upper extremity paresis being the most common source of functional impairments. According to **Chinnavan et al. (2020),** upper extremity paresis is the reduced ability to actively activate muscles, which causes weakness and slow or inefficient motions of the upper extremities.

Every daily task requires the use of the upper limb as an essential tool. Unfortunately, two out of every three stroke patients will experience a severe reduction in upper limb motor function, which will negatively limit their ability to handle, grip, and reach, all of which are necessary for most daily activities. Research indicates that over 75% of older people with stroke have limits in their everyday activities, and roughly 66% have body function impairments (**Klinkwan et al., 2021 & Rössler, et al., 2020**).

According to mortality and disability, this disease is currently the second most common cause of death globally (González-Santos et al., 2023). 101 million common strokes and 12.2 million total strokes were observed (Simats, & Liesz, 2022). Since most stroke cases can be prevented by reducing exposure to risk factors like diabetes, hypertension, obesity, sedentary lifestyles, and tobacco use, there is still much work to be done in improving stroke prevention (**Namaganda. et al., 2022**). This is because the majority of stroke cases are caused by avoidable risk factors. Stroke is ranked as the second most common cause of dementia and the top cause of adult impairment in Spain (**González-Santos et al., 2023**). It dramatically lowers the quality of life for both patients and the people in their immediate social circle, which has a direct impact on the healthcare system.

One of the most common aftereffects of a stroke is a considerable loss of functionality, particularly in the upper limbs that are afflicted. It is typical to have a deterioration in upper limb function after a stroke event, which is manifested by challenges completing instrumental activities of daily living (IADLs) or activities of daily living (ADLs) (**Park et al., 2021).** This loss of function could be caused by a lack of motor coordination, weakening in the muscles, or an inability to control movement. About 80% of survivors experience motor impairment in their upper extremities, and 50% of them report upper limb pain within the first year following the incident (**Fernández-de-Las-Peñas et al., 2021).**

Moreover, there may be changes in the limb's sensibility. Changes in temperature or pressure perception may occur, as well as problems with tactile sensitivity, such as diminished or absent touch sensitivity. These alterations in perception may make it more difficult to perform precise movements or identify objects with your fingers. Similarly, following a stroke, there may be a loss in range of motion, or the capacity to move the joints of the upper limb. The completion of daily chores may become more difficult as a result of limited natural movements in the fingers, wrist, elbow, or shoulder (**Raghavan, 2019).**

All these side effects can make living a complicated everyday life and recovering from a stroke more difficult. To regain as much functioning as possible in the damaged upper limb, rehabilitation in these circumstances typically attempts to address these issues by attempting to enhance function, sensitivity, and range of motion as well as to control discomfort. Early initiation of this post-stroke rehabilitation period is recommended, as function recovery usually happens in the first few weeks (**Coleman et al., 2017**). However, other studies suggest that patients experience a phase of spontaneous recovery in the first few weeks. It is imperative to perform a comprehensive assessment to ascertain the aftermath of the stroke prior to beginning therapeutic rehabilitation. If you want to undertake great rehabilitation, you must know where to start. The functional state of stroke survivors is evaluated using a variety of tools in order to accomplish this. The most popular quantitative assessment tool for gauging functioning and motor recovery following a stroke is the Fugl–Meyer Assessment—Upper Extremity (FMA–UE) scale (**Prange-Lasonder et al., 2021**).

In terms of rehabilitation, therapies that are backed by scientific data are essential since they are proven to be beneficial in restoring lost abilities and enhancing functionality through studies and outcomes. Task-oriented training, cognitive therapeutic exercise, and mirror therapy (MT) are a few of these. A common rehabilitation method for those who have had strokes, limb injuries, or lost functionality in a limb is called "many therapies," which uses visual illusion to improve motor function. In this type of therapy, a mirror is used to provide the impression that the injured limb is functioning normally (**Zhang et al., 2022).** A mirror is placed so that the injured limb is hidden behind it and the unaffected limb is reflected back. By moving the unaffected limb, the affected limb's reflection in the mirror mimics movement in the unaffected limb, fooling the brain into thinking that there is normal movement. This type of therapy involves repeatedly performing precise, regulated motions, which may support neuroplasticity—the brain's capacity to restructure and adapt as a result of experience and repeated practice. It is thought that this treatment could improve coordination, help with motor function restoration, enhance coordination, and alleviate chronic pain associated with the affected limb (**Zeng et al., 2018**).

Electrical stimulation therapy, electromyographic (EMG) biofeedback, Constraint-Induced Movement Therapy (CIMT), Sensory-Motor Imagery Training, Robotic-Assisted Rehabilitation, and Mirror Therapy are only a few of the several therapies available for the rehabilitation of motor dysfunction (**Chinnavan et al., 2020**). The majority of these medicines are not widely used in clinical practice because they frequently need costly, challenging-to-operate technology. Otherwise, mirror therapy is an affordable, safe, practical, and simple method that was initially created in 1995 by Ramachandran and colleagues to treat phantom limb pain syndrome following arm amputation (**Guémann et al., 2023**). At present, it is employed in the rehabilitation of senior stroke patients in order to mitigate sensory-motor deficiencies and expedite the functional rehabilitation of the damaged limb (**Dave, 2020).**

A mirror therapy applied by placed a mirror between the limbs in the sagittal plane is used for mirror treatment. By creating a visual and kinesthetic illusion, the patient moves their normal limb in a way that is mirrored in a mirror and is therefore seen by the brain as movement from the affected limb. Mirror treatment expedites hemiparesis recovery and fosters cortical reconfiguration, leading to gains in function and motor abilities. It does this by stimulating the mirror-neuron system (MNS) and the corticospinal tract. Mirror therapy has been demonstrated to be a practical and successful approach for stroke recovery since it enhances the execution and control of movements (**Jaafar et al, 2021).**

Mirror therapy is one method of doing this. It is a mirror that is placed in the midsagittal plane of an individual to reflect the motions of one side of the body. This allows the brain to perceive the reflected image of the moving extremity as the opposing limb moving normally. When receiving post-stroke therapy, the brain frequently interprets the non-paretic limb as the paretic limb because it reflects it. Although there are many variants in the setup and procedure of mirror treatment, all of them function by activating the brain regions linked to pain, movement, and sensation in order to aid in the limb's rehabilitation. It is well established that homologous cortical motor regions in the brain are involved in both performing and observing movement and that MT likely contributes to increased cortico- muscular excitability. While this provides a basic understanding as to how MT works, precise mechanisms remain unclear (**Thieme, 2018**). Therefore, this study aimed to evaluate the effect of rehabilitative intervention regarding mirror therapy for elderly patients' post-stroke to improve upper extremity sensory motor function.

One technique for producing a reflecting illusion to aid limbs in pain in moving more effectively is mirror therapy (MT). In order to conceal the weak limb behind the mirror and reflect the good limb movement, the patient in the practice stares into the mirror. The patient is supposed to visualize taking back control of a limb that is weakening. This treatment stimulates many brain regions related to movement, pain, and sensation. Patients can do mirror illusion at home with this low-cost, simple, and safe technique. Even though MT has been shown in numerous research to promote nervous system recovery and enhance motor skills linked to motor recovery and motor function of weak hands and arms in stroke patients during a 4–6 weeks exercise (**Zhang et al., 2022).**

Significance of the study

A stroke is a medical emergency that, depending on the site, intensity, and speed of diagnosis and treatment, can result in motor, perceptual, sensory, and linguistic impairments. This is because strokes occur frequently and can have a negative influence on a patient's independence. Approximately 88% of elderly stroke patients have reduced motor function, leading to functional restrictions and disabilities that lower independence and lower quality of life for patients (**Chinnavan et al., 2020**). Upper limb hemiparesis is a common and unpleasant result of strokes. Up to 85% of stroke patients suffer hemiparesis, and between 55% and 75% of them still have functional difficulties in their upper extremities (**Dave, 2020**).

In 2030, there will likely be three times as many stroke patients as there are today. One in five people are said to die from a stroke in less than a month, and one in three within a year. According to **Pu et al. (2023**), millions of individuals worldwide suffer from stroke each year, leaving 5 million permanently crippled and taking another 5 million lives. There are between 150,000 and 210,000 new instances of stroke annually in Egypt, where the crude prevalence rate of stroke is high generally (963/100,000 people). As per the official national statistics of Egypt, stroke ranks third in importance after cardiovascular and gastrointestinal ailments, accounting for 6.4% of all deaths, especially among older individuals. While numerous countries have decreased the number of deaths related to stroke, Egypt has seen a relatively stable rate over the past ten years (**Zakaria et al., 2018)**.

Aim of the study:

The study aimed to evaluate the effect of rehabilitative intervention regarding mirror therapy for elderly patients' post-stroke to improve upper extremity sensory motor function.

Research hypotheses:

Elderly patients' post-stroke in mirror therapy group who will received the rehabilitative intervention regarding mirror therapy will exhibit more mean score regarding upper extremity sensory motor function than conventional therapy group.

Subjects and Method

Design:

A quasi experimental pre and post-test design was used to achieve the aim of this study.

Setting:

The study was carried out in the Rehabilitation Unit of Mansoura University Hospital as well as at the studied elders' homes through home visits.

Sample:

A purposive sample of 50 elderly patients post-stroke was included**.**

Calculation of sample size and sampling procedure

Sample size calculation:

The sample size that is appropriate for this investigation was determined using the formula below.

$$N_{group} = 2 \times \frac{\left[Z_{\alpha} + Z_{\beta} \right]^2}{d^2}$$

2.1.1 Inclusion criteria

The following were the inclusion criteria:
1) first acute stroke
2) Enough cognitive function to follow directions
3) getting at least three points on the upper extremity test. Phases of motor rehabilitation in Brunnstrom

.

2.1.2 Exclusion criteria

The following were the main exclusion criteria:
1) There is depression among the participants
2) limb weakness that is not related to a stroke, such as spinal cord injury, Parkinson's illness, or aphasia brought on by misunderstanding;
3) In cases where patients or physicians are unable to participate in research, in their judgment. Individuals with a history of contracture or fracture on the stroke-affected extremity were eliminated, as were those with notable hearing and visual impairments.

Data collection tools:

Four tools were used to collect the necessary data as follows:

Tool I: Structured Interview Schedule of Patients post-stroke: This was created by the researchers after reviewing related literature **(Dave et al., 2020 & Chinnavan et al., 2020)**. It is divided into two parts:

- **Part one: Demographic data of Patients post Stroke: -** It included age, gender, marital status, level of education, current job,and residence.
- **Part two: Clinical Data of Geriatric Patients Post-Stroke: -** It included medical diagnosis, stroke duration, dominant side, affected side, and associated illness.

Tool II: Fugl- Meyer Assessment tool (FMA). It was created by **Fugl-Meyer et al, 1975**. It was the first quantitative tool for evaluating sensory-motor recovery after a stroke, particularly in terms of joint pain, passive joint motion, and motor function. The FMA has an established reliability of 0.95 (**Richard, 2008)**. The FMA is a numerical scoring system that evaluates four facets of physical performance: motor performance, sensation, passive joint motion, and joint pain. The motor performance scores range from 0 to 66, with scores ≥36 indicating normal motor function, and ≤ 32 indicating severe motor function. Scores for sensation, vary from 0 to 24, where a score≥ 10 indicates normal sensation and a score of ≤ 3 indicates severe sensory impairment. For passive jointmotion, the scores vary from 0 to 24, where, a score≥19 indicates normal movement and a score ≤12 indicates no movement. Finally, for joint pain, a score ranges from 0 to 24, where zero indicates the absence of pain and a score ≥16 indicates severe pain.

Tool III: Brunnstrom Motor Recovery Scale:

It was developed by the Swedish occupational and physical therapist Signe Brunnstrom in 1960. It is a reliable tool used to evaluate the motor recovery ofthe upper limb following a stroke according to the degree of spasticity and involuntary movements**(Soofia et al., 2010)**. A patient examination took 5-10 minutes. This tool proposes seven stages of sequential motor recovery post-stroke. **Stage I**: This stage follows the stroke attack where; there is a period of flaccidity in which there is no movement on the affected limb. **Stage II**: At this stage, the recovery begins with the development of spasticity, increased reflexes, and obligatory synergies, which are synergic movement patterns. These obligatory synergies arise as a result of stimulus reactions or limited movement responses and might emerge as the inclusion of all or a portion of the synergic movement pattern. **Stage III:** Spasticity increases at this stage, and obligatory synergies strengthen. The synergy pattern provides the patient with voluntary control, but it may be limited in range. **Stage IV:** where the patient canmove more freely and spasticity and synergy diminish. At this stage, the ease of movements goes from challenging to easy. **Stage V:** The patient can now move more easily away from the synergy patternas the spasticity keeps waning. In this position, the patient can also exhibit more complex movement combinations and single-joint movements. **Stage VI**: At this stage, spasticity has disappeared, allowing for near-normal movement and coordination. **Stage VII**: It is the last recovery stage where; a normal motor function has been re-established.

Tool IV: The Modified Ashworth Scale (MAS)

Utilizing a 6-point MAS, wrist mobility and spasticity were evaluated. With the subject in a supine position, wrist joint spasticity was measured (Gregson et al., 1999).

Tool V: The Muscle Strength Muscle:

Using the Medical Research Council (MRC) approach, a five-point manual muscle testing (MMT) scale was used to quantify strength (**Gregson et al., 2000**). This method involves the physiotherapist applying pressure on the patient's arm in certain directions while the patient resists. Then, based on the participant's capacity to withstand pressure, a score was provided on a 0–5 scale. 0 indicates no contraction 1 = A flicker or contraction trail 2 = Active movement in the absence of gravity 3 = Active movement in defiance of gravity 4 = Active **movement against** resistance and gravity 5 = **Normal** power

Method:

Validity and reliability of the tools:

- Tool I was developed by the researchers. The content validity of tools was verified by a panel of seven (7) experts in gerontological nursing, neurology, community, and physical rehabilitation, and no alterations were made as a result. Furthermore, for the study purposes, the internal consistency of tools was examined by the researchers to determine their reliability (r= 0.88).

Administrative and ethical considerations:

- A letter issued by the dean of Mansoura University's faculty of nursing was used to secure the directorsof the study setting's official consent to conduct the study. The letter explained the study's purpose and procedures and was supported by a copy of the data collection form. The existing study was accepted by the Ethical Committee of Faculty of Nursing in Egypt.
- Some Egyptian elderly and/or their families would rather express oral consent to participate in the current study than sign a form. So, after presenting all study participants and their relatives with an appropriate understanding of the study's purpose and procedures informed written and/or oral consent was obtained. The researchers battled to safeguard the privacy and anonymity of the study participants, as well as the confidentiality of their acquired data. The researchers notified the study participants that they could refuse or withdraw from the study at any time for any reason and that the study maneuvers would not cause actual or prospective harm.
- **Pilot study:**
  A pilot study was done on five patients, representing roughly 10% of the projected sample size, to test the clarity of the data collecting form and the feasibility of the research process. The tools were finalized following the improvements that had to be made in light of the pilot study's findings. The patients who shared in the pilot study were included from i n the study sample.

Fieldwork:

Assessment phase:

- The researchers attended the study setting six days per week from 9 a.m. to 2 p.m. for consecutive ten working days to recruit the study participants (Three to four elders were selected each day). Where, all participants who met the inclusion criteria were examined individually by the researchers in a quiet corner of the study setting to assess their sociodemographic and clinical data, cognitive functions, degree of spasticity, and sensory-motor recovery after a stroke using tools.
- Completing the study tools took 45-50 minutes for cooperative elders to establish the pre-test baseline data. The patients were assigned randomly to the intervention group (Mirror therapy, n=25) or the control group (Conventional therapy, n=25).

- The researchers and the study participants discuss the appropriate schedule for future home visits to start the mirror or the sham therapy sessions. This schedule is usually on the opposite three days of the participants' routine schedule of physiotherapy at the Rehabilitation Unit (Conventional therapy).

Planning phase:

Based on a review of the literature, the researchers prepared the scenario of sessions and designed the mirror and the Conventional **therapy (Lee et al, 2020 & Jaafar etal, 2021)**.

Implementation phase:

Conventional therapy

In this therapy, the patient's weak side will be moved by the caregiver's hands and arms, as illustrated in Figure 1. In order to practice each action, the patient will move slowly, completing 20 sessions every cycle and two cycles per day (one cycle takes between 30 and 60 minutes). 21]. mirroring The patient was positioned in a vertical position, as indicated in Figure 2, with the mirror at a distance of 70 by 40 cm. Next, place the strong arm across from the mirror and the weak hand behind it. Both the training position (Figure 1. positions 1–8) and regular hand movements will be executed by the patient [21]. Observing their symptoms, the patient should lift their arms slowly in each position, with assistance from the caregiver. By doing this, the patient can fool themselves into believing that their weak hand is moving by gazing at the mirror image of their normal arm and hand.

Outcome measurements:

Upper extremity function measures were taken 12 weeks following rehabilitation treatment (posttest) and at the first rehabilitation baseline (pretest). Every examination was conducted by a single assessor, whose was blind to the intervention allocation. The results were assessed using the Fugl Meyer Assessment (FMA), the Brunnstrom recovery stage (BRS), the Modified Ashworth Scale (MAS), and the Muscle Strength.

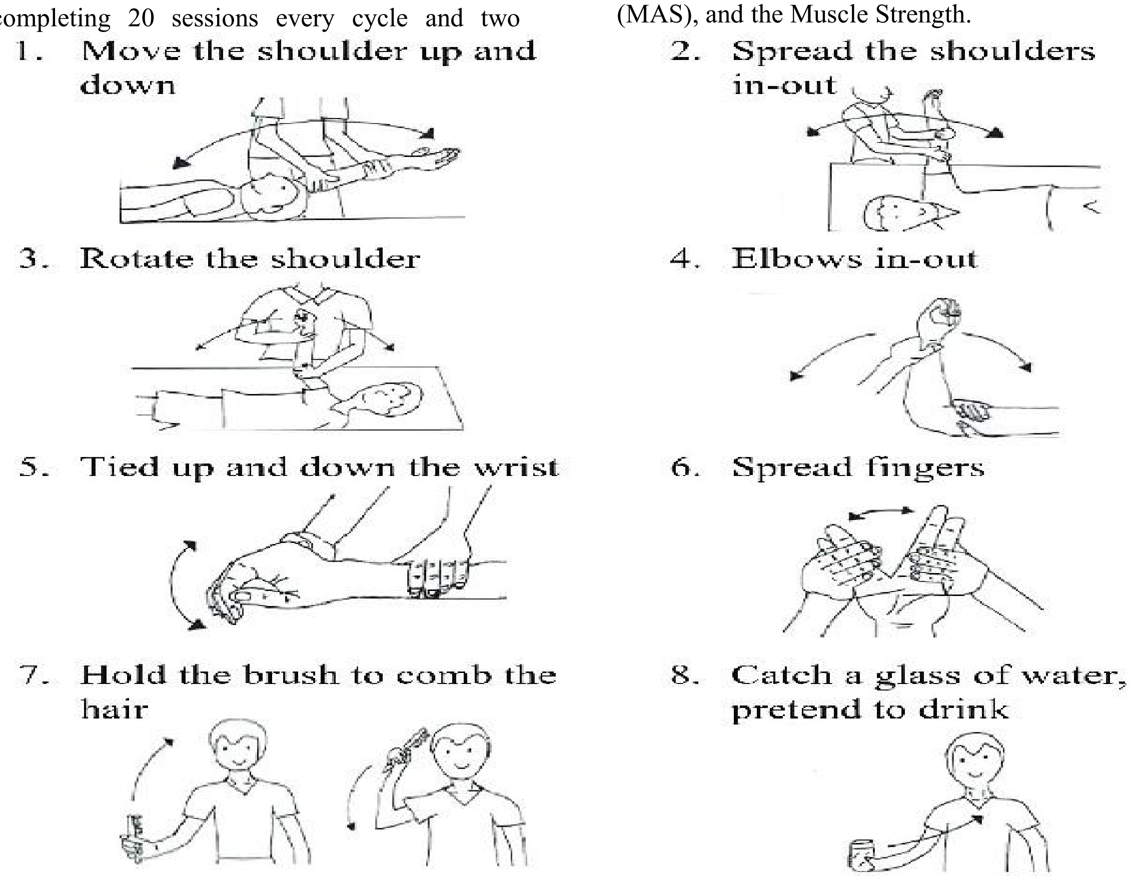

Figure (1): Conventional physical therapy. The trainingprocess consists of 8 positions. Stroke patients and assist providers are trained by the researchers before returning home.

- In the 1st session for both groups, after introducing themselves and welcoming the elderly and their family members, the researchers presented the sessions' goals, timetable, required equipment, and procedures to be followed during the upcoming sessions.
- The 2nd session for both groups was devoted to discussing the various stroke-related problems and therapy approaches for elderly patients.
- For the intervention group, the third session coveredthe idea and fundamentals of mirror therapy as well as its function in improving the elderly person's independence after a stroke. For the comparison group, this session covered the value, variety, and principles of upper-limb exercises for stroke elderly patients.
- During sessions four through eighteen, the researchers led the participants through practical exercises. The participant was seated at a table with a suitable chair positioning. At the participant's midline, the researchers placed either a mirror or sham box vertically on the table. The participant was instructed to place both hands on the table. For the participant in the intervention group, the affected hand was placed behind the reflective side of the mirror box, while the unaffected hand was placed in front of it. For participants in the comparison group, the affected hand was placed in the space between the two non-reflective sides of it, the sham box, while the unaffected hand was placedin front of it.
- The researchers demonstrated for both groups each exercise, such as; fanning out the hand, finger, and thumb abduction, making a fist and release, wrist flexion, extension, abduction, and adduction. As well as, finger flexion, and extension, lateral prehension, pad-to-pad, pad-to-side, pad-to-pad grip, grasping objects (card, pencil, small ball, key, disposable cup, and tweezers), single finger movement, thumb opposition, and the participant redemonstrated the same exercises using their unaffected hand and try to move the affected hand as much as possible to mimic the movements of the unaffected hand.
- While performing exercises the participant in the intervention group was instructed not to look at the affected hand and instead to focus on the reflection of the unaffected hand in the mirror.

- **Evaluation phase:**

To test the study hypotheses, the sensory-motor functions were assessed for participants in both groups at three points using the same tools used in the (pre-test), at the end of the 8th session (post- test I), and again at the end of the 12th session (post- test II). A second post-intervention assessment and a follow-up visit three months after the second evaluation were conducted to assess patient progress during the subacute phase of recovery.

- **Statistical Analysis**

Using a Personal Computer (PC), the data gathered from the study sample was revised, coded, and input. The Statistical Package for Social Sciences (SPSS) version 22 was used for computerized data entry and statistical analysis. Descriptive statistics were used to present the data in the form of frequencies, percentages, and Mean ± SD. A correlation coefficient "Pearson correlation" is a numerical measure of some type of correlation, meaning a statistical relationship between two variables. A t-test is a statistical test that is used to compare the means of two groups. The one-way analysis of variance (ANOVA) is used to determine whether there are any statistically significant differences between the meansof the two groups. Chi-square is a statistical test that examines the differences between categorical variables from a random sample to determine whetherthe expected and observed results are well-fitting. Monte Carlo exact test and Fisher exact test (FET) are alternatives for the Chi-square test if there were many small expected values.

Results:

As shown in **Table (1)**: That elderly patients mean age ±SD in the Mirror therapy and the Conventional therapy group was 65.66±6.33 and 65.44±7.22 years, respectively. Regarding gender 72% in Mirror therapy group were male compared to 68% in Conventional therapy group, (76% and 72% respectively) of the patients in Mirror therapy group and a Conventional therapy group were living in rural areas. There is no statistically significant difference between both Mirror therapy and Conventional therapy groups as regards their age, gender, andeducational level.

Figure (1): Shows that the 80% and 75% of the elderly patients their duration of stroke in the Mirror therapy and the conventional therapy group was ranged from one month -<4 months respectively.

Figure (2): Shows that the 60% and 55% of the elderly patients in the Mirror therapy and the Conventional therapy group were affected in the right side respectively.

Figure (3): Illustrates that the 95% and 85% of the elderly patients in the Mirror therapy and the Conventional therapy group, **their Dominant side** were in the right side respectively.

Figure (4): Portrays that the 35% and 40% of the elderly patients in the Mirror therapy and the Conventional therapy group, had other chronic diseases as renal and liver diseases respectively.

Table (2): Reflects that there is a highly statistically significant difference between the Conventional therapy and Mirror therapy groups on motor recovery, spasticity, and hand-related functioning pre and post **intervention** at ($p < 0.001$). Also, revealed a statistically significant improvement in Mirror treatment in comparison to a group receiving conventional therapy.

Table (3): Indicates that there is a highly statistically significant difference between the conventional therapy and mirror therapy groups on motor recovery, spasticity, and hand-related functioning post 12 week of **intervention** at ($p < 0.001$). Also, demonstrated a statistically significant improvement and change was found in Mirror treatment in comparison to a group receiving conventional therapy.

Figure (5): Clarifies that at post- **intervention**, one fifth of the **Conventional** group (20%) had sever motor impairment, compared to no one of the **Mirror therapy** group (0) had severe motor impairment.

Figure (6): Indicates that at post- **intervention**, less than one fifth of the **Conventional** group **Conventional therapy** group (15%) had severe sensory impairment, while nearly three-fifths of the **Mirror therapy** group (55%) had normal sensory impairment.

Figure (7): Portrays that at post- **intervention**, more than two- thirds of the **Conventional** group **Conventional therapy** group (60%) had hypo- mobility of passive joint motion, while less than three quarters of the **Mirror therapy** group (70%) had normal passive joint motion.

Figure (8): Portrays that at post- **intervention**, half of the **Conventional** group **Conventional therapy** group (50%) had joint pain, while three quarters of the **Mirror therapy** group (75%) had no joint pain.

Table (1): Elderly patients distribution in both Conventional therapy and Mirror therapy groups regarding to their demographic data (n=50)

Demographic data	Mirror therapy group (n=25)		Conventional therapy group(n=25)		(P value)
	n	%	n	%	
Age:					X^2 1.789 (>0.05)
60 - <65	16	64	17	68	
65 - <70	5	20	5	20	
70 - 75	4	16	3	12	
Mean± SD	65.66±6.33		65.44±7.22		
Gender:					X^2 2.003 (>0.05)
Male	18	72	17	68	
Female	7	28	8	32	
Education level:					MC=1.675 (>0.05)
Illiterate	3	12	4	16	
Read and write	4	16	4	16	
Primary	2	8	3	12	
Preparatory	5	20	5	20	
Secondary	7	28	6	24	
Bachelor	4	16	3	12	
Residence					X^2=2.005 (>0.05)
Urban	6	24	7	28	
Rural	19	76	18	72	

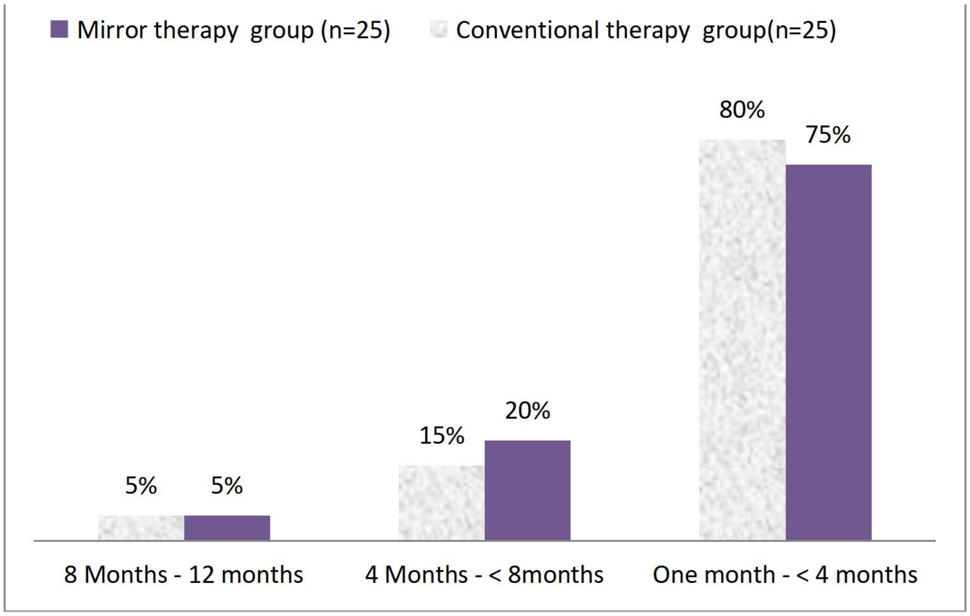

Figure (1): Elderly patients distribution in both Conventional therapy and Mirror therapy groups regarding to their Duration of affection (n=50)

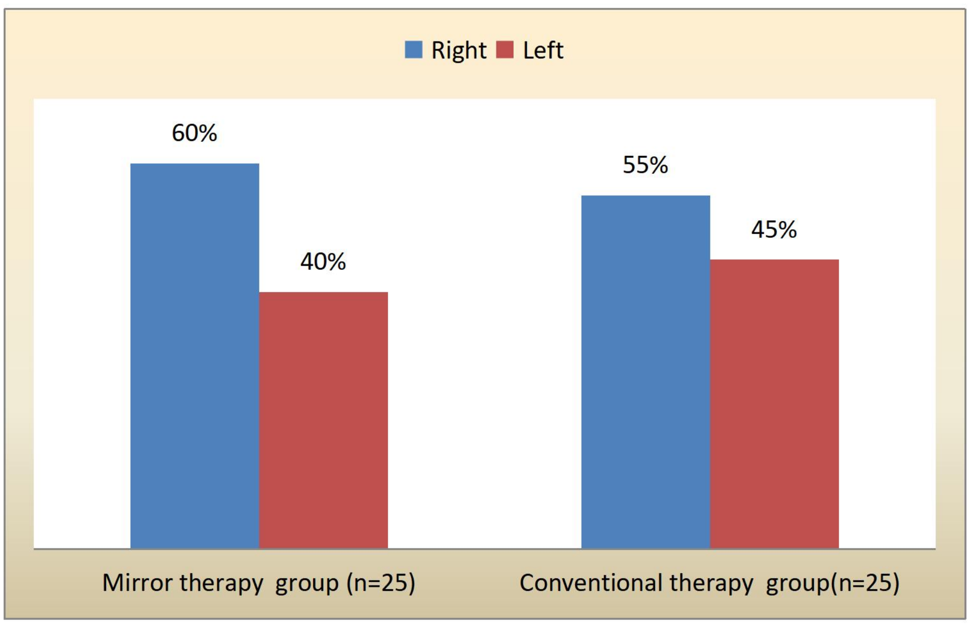

Figure (2): Elderly patients' distribution in both Conventional therapy and Mirror therapy groups regarding to their affected side (n=50)

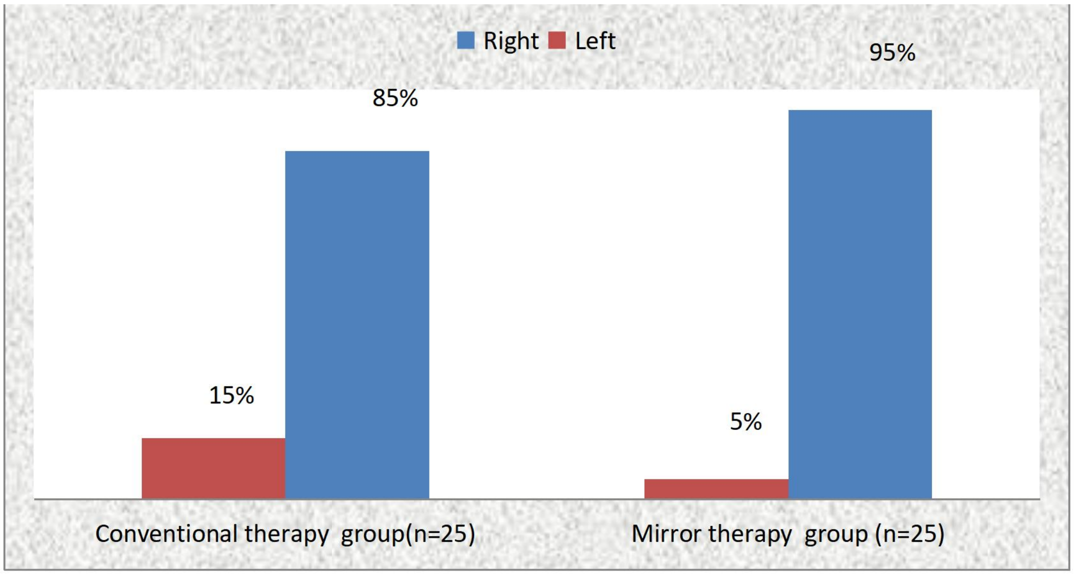

Figure (3): Elderly patients' distribution in both Conventional therapy and Mirror therapy groups regarding to their Dominant side (n=50)

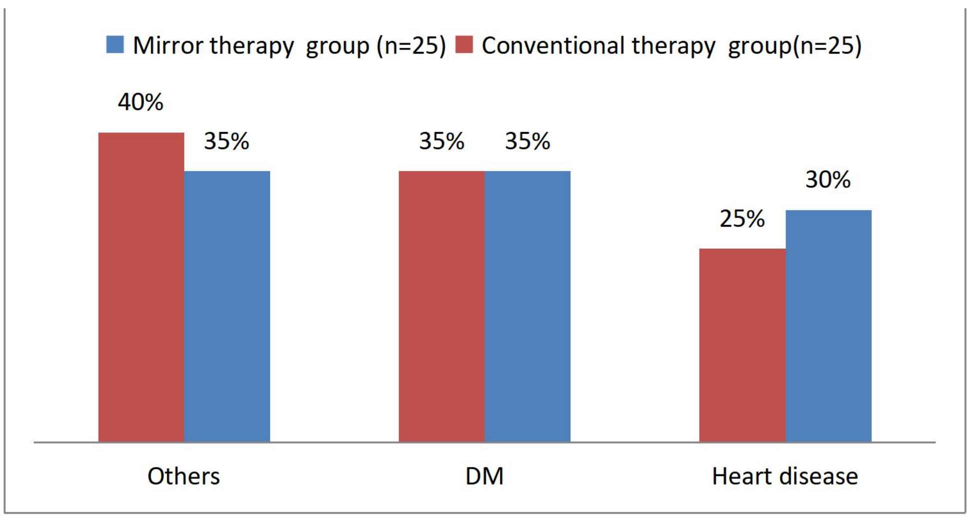

Figure (4): Elderly patients' distribution in both Conventional therapy and Mirror therapy groups regarding to their Associated chronic illness (n=50)

Table 2: Differences between mean score of Conventional therapy and Mirror therapy groups on motor recovery, spasticity, and hand-related functioning pre and post intervention.

Characteristic	Group	Pretest	Posttest	*p*-value
		Mean ± SD	Mean ± SD	
FMA	Conventional therapy group	6.8 ± 1.62	16.8 ± 2.86	0.005*
	Mirror therapy group	7.2 ± 1.55	23.0 ± 3.92	0.005*
BRS	Conventional therapy group	2.3 ± 0.48	4.5 ± 0.97	0.004*
	Mirror therapy group	2.4 ± 0.52	4.8 ± 0.63	0.004*
MAS	Conventional therapy group	1.7 ± 0.82	2.5 ± 0.71	0.023*
	Mirror therapy group	1.9 ± 0.57	2.6 ± 0.70	0.008*
Strength	Conventional therapy group	2.4 ± 0.52	3.5 ± 0.53	0.005*
	Mirror therapy group	2.7 ± 0.48	4.1 ± 0.57	0.004*

*** Significant differentiation (*p*-value < 0.05),**

Table 3: Comparison of change between mean score of Conventional therapy and Mirror therapy groups on motor recovery, spasticity, and hand-related functioning post 12 week of intervention

Characteristic	FMA	BRS	MAS	Strength	p-value
• Conventional therapy Group	10.0 ± 2.75	2.2 ± 0.63	0.8 ± 0.79	1.1 ± 0.57	0.002*
• Mirror therapy Group	15.8 ± 3.16	2.4 ± 0.52	0.70 ± 0.48	1.4 ± 0.52	

*** significant differentiation (*p*-value < 0.05)**

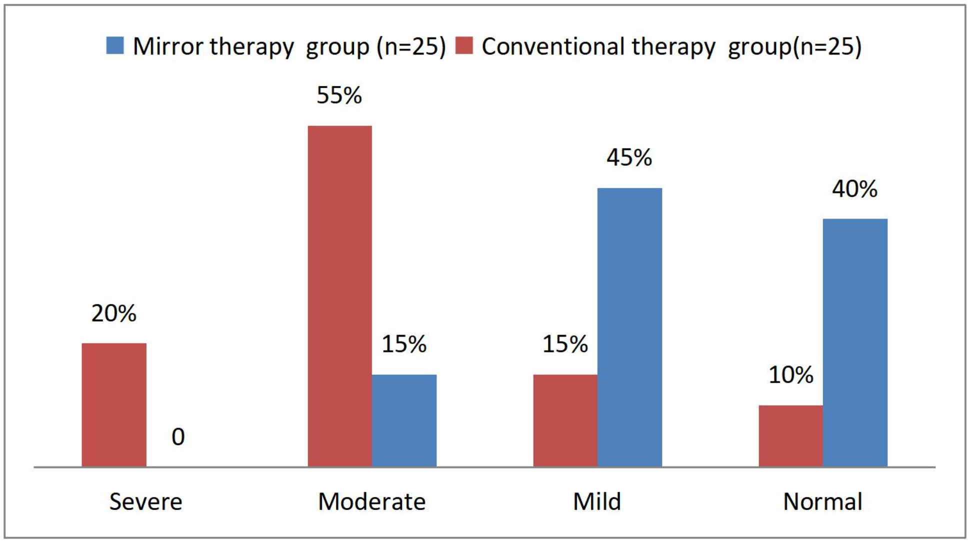

Figure (5): Elderly patients' distribution in both Conventional therapy and Mirror therapy groups regarding to their motor performance post intervention (n=50)

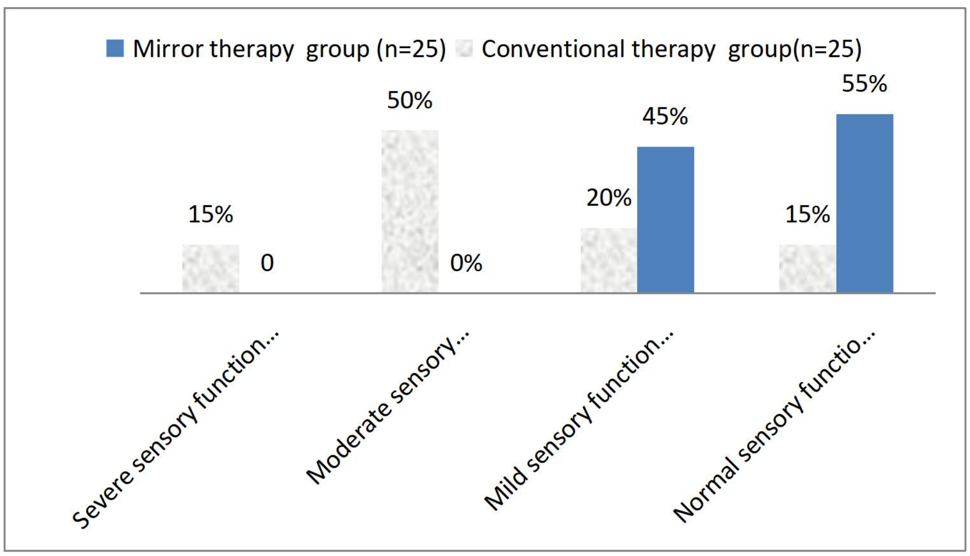

Figure (6): Elderly patients' distribution in both Conventional therapy and Mirror therapy groups regarding to their sensory function post intervention (n=50)

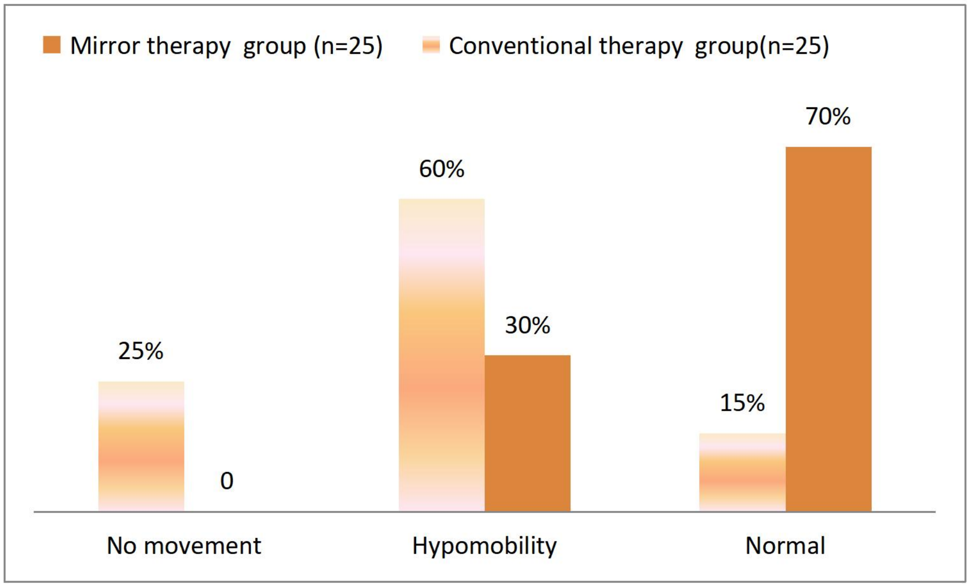

Figure (7): Elderly patients' distribution in both Conventional therapy and Mirror therapy groups regarding to their passive joint motion post intervention (n=50)

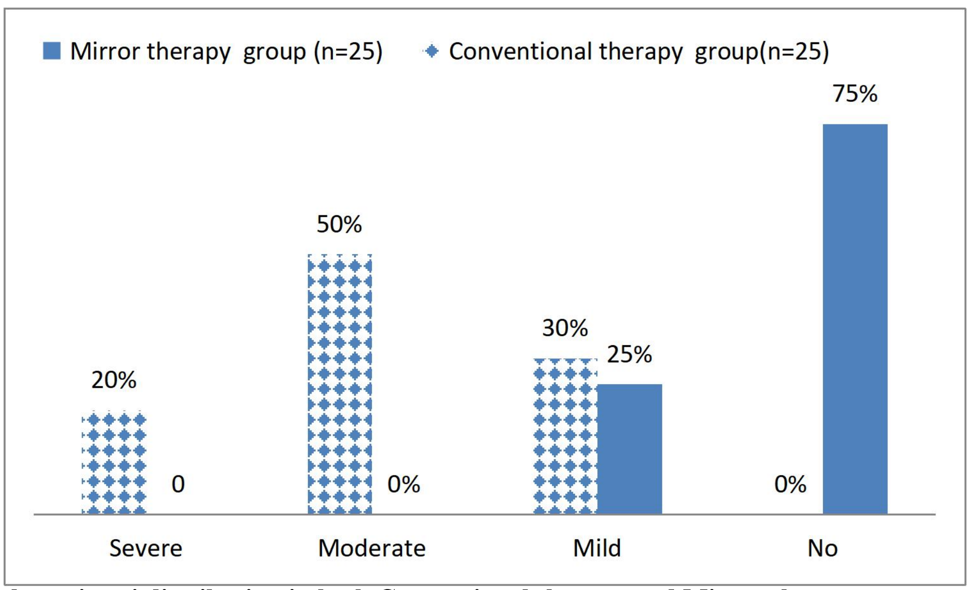

Figure (8): Elderly patients' distribution in both Conventional therapy and Mirror therapy groups regarding to their joint pain post intervention (n=50)

Discussion:

Stroke is the leading cause of severe permanent disabilities in the elderly. Over 60% of stroke survivors experience ongoing neurologic deficits that interfere with activities of daily living. Following a stroke, the extremities' motor function is often compromised, leading to functional mobility limits, causing limitations in functional mobility. It has been discovered that the motor system's functional association, including the primary motor cortex, can be modulated by both passive inspections of the contralateral limb's movement and ipsilateral limb movement. The main goal of mirror therapy, a relatively new therapeutic approach, is to move the unimpaired limb in order to create a visual illusion of the impaired limb's better movement ability, which entails performing movements of the unaffected limb while examining its mirror reflection superimposed over the (unseen) affected limb **(Chinnavan et al., 2020).**

According to the study's findings, there is a substantial statistical difference ($p<0.001$) in the motor recovery, spasticity, and hand-related functionality pre- and post-intervention between the Conventional therapy and Mirror therapy groups, revealed a statistically significant improvement in Mirror treatment in comparison to a group receiving conventional therapy. According to earlier research, MT may be able to help chronic stroke patients regain their paretic arm's neurological function in as little as two weeks (**Sathian et al., 2020**). According to a study by Sathian et al., patients with chronic paralysis who have poor upper limb functional use as a result of sensorimotor impairments can benefit from 2-weeks of MT application (**Perfetti et al., 2019).** The patients' better mobility and function of the afflicted upper limb was demonstrated by the results can be achieved through sensory inputmanipulation.

Numerous studies demonstrate that increasing upper limb functionality and motor domain through MT improves the total FMA-EU score, which enhances motor function and ADLs. Additionally, these investigations demonstrate statistically significant variations in the motor, sensory, and global limb domains of functionality.. Moreover, notable and extremely noteworthy distinctions were noted between the two EG and the CG, suggesting that both EG had improved more than the CG, with the exception of the range of motion and pain domain. These findings are in line with previous research that indicates that, in comparison to CG, groups that include MT and cognitive exercises recover more motorly and functionally and practice better self-care (**Wen et al., 2022**).

On the one hand, this study shows that patients who have had strokes and have upper limb motor dysfunction benefit from motor performance enhancements brought about by MT training. The benefits of using MT for motor and functional recovery that were documented in this study are corroborated by data from related studies. Task-oriented training has been shown to be an effective strategy to lower disability rates by promoting functional brain reconfiguration. Furthermore, alterations in neuroplasticity are critical for the recovery of motor function. But frequently, patients undergoing standard treatment exhibit a lack of focus and initiative, which has an adverse effect on the activation of the relevant brain cortex and, consequently, on neuroplasticity and functional remodeling. This is why bilateral upper limb movement is required for MT, and this can improve patient initiative. It also necessitates watching the mirror reflection of typical limb movements at the same time, which may improve patient focus and encourage greater cerebral activation than conventional rehabilitation therapy (**Kim & Shim, 2019).**

In contrast, no statistically significant changes were found in our investigation between the two experimental groups that received task-oriented training in addition to MT and CTE. This contradicts previous research showing that, in comparison to therapies such as CTE, MT produces superior outcomes in terms of performing ADLs, a higher reduction in pain, and enhanced motor function. Furthermore, it has been observed that patients undergoing MT have higher FMA scores than patients receiving other forms of therapy **(Thieme et al., 2018).**

After a 12-week intervention, the current study's results showed a highly statistically significant difference in motor recovery, spasticity, and hand-related functionality between the conventional therapy and mirror therapy groups, demonstrated a statistically significant improvement and change in Mirror treatment in comparison to a group receiving conventional therapy (**Ehrensberger et al., 2019**). As far as the researchers were concerned, it demonstrated how well Mirror treatment worked. Our findings are in line with previously published research showing that higher therapy volumes improved mirror therapy group results and that individuals receiving MT throughout a 4-to 8-week training period had superior FMA outcomes than the controls group (**Pollock et al., 2019).**

This exercise stimulates the premotor cortex of the brain, which aids in the restoration of function for the weaker hands and arms' nerve systems (**Altschuler et al., 2021**). 2) The motor imagery method involves having the patient using their imagination to imagine that their weak hand and arm can move normally (**Stevens et al., 2023**). 3) A collection of neurons in the brain known as the mirror neuron mechanism in the brain that can respond to polymodal neurons (**Yavuzer et al., 2018**).

According to earlier research, stroke patients' upper limb rehabilitation is more challenging than their lower limb rehabilitation because of the motor function complexity and the amount of muscle involved. In patients with moderate to severe stroke, upper extremity function can be restored in three to six weeks. According to the data, 20–30% of stroke patients can regain full use of their arms within the first six months, whereas 30–60% were unable to do so (**Park et al., 2021**). Patients with weak arms may get anxious and experience a lower quality of life after a year or more (**Fernández-de-Las-Peñas et al., 2021), (Tater et al., 2021**). As a result, enhancing the quality of life following a stroke is significantly dependent on rehabilitation for stroke victims. Within 24 to 48 hours after neurological symptoms and vital signs stabilize, all of these patients who are still disabled should begin their rehabilitation. The length of the illness, the patients' issues, and each patient's level of competency all influence the rehabilitation approach.

According to Pollock et al.'s Cochrane Review, larger volume therapy—applied five times a week—seems to be more beneficial than lower volume therapy when it comes to assessing functional recovery and mobility after stroke (3 times per week). Better results in the mirror therapy group could have resulted from a higher volume of treatment (**Persson et al., 2019**).

Regarding the impact of home-based mirror therapy on the upper limb sensory-motor recovery of the older adults under study, the present findings showed that the intervention group's mean scores at pre-test, post-test I, and post-test II differed significantly (highly statistically). The comparison group's mean scores for each of these factors did not, however, differ statistically significantly from one another. A very statistically significant difference was also observed when comparing the means of the FMA scale scores for the two groups on their post-test I and II.

According to the current study's results, none of the participants in the Mirror therapy group exhibited severe motor impairment at post-intervention, but one-fifth of the Conventional group did. According to the researchers, it demonstrated the advantages of applying mirror therapy. This aligns with studies carried out in Iran by **Ashrafi et al., (2022**), who found a statistically significant difference in the recovery of sensory-motor function between the mirror therapy group and the non-reflective surface group. Furthermore, the current study's findings aligned with those of previous research projects by **Gokila (2016), Choi et al. (2019), and Putri et al. (2020),** which reported that who stated that using mirror therapy following stroke is a potential technique to enhance sensory-motor recovery of the upper extremity.

The present findings are consistent with previous research conducted in India by **Yumnam et al. (2019**) and in Bangladesh by **Chinnavan et al. (2020**), which demonstrated a noteworthy enhancement in the sensory-motor recovery of the upper limb and the self-care daily activities of the participants following the use of mirror therapy when combined with a traditional stroke rehabilitation program. Furthermore, compared to the group receiving sham mirror therapy along with conventional therapy, the group receiving home-based mirror therapy along with conventional therapy demonstrated statistically and clinically significant improvements in hand functions, according to a study conducted in India by **Baby et al. (2019).**

According to the current study's findings, following the intervention, less than one-fifth of the Conventional therapy group experienced severe sensory impairment, but almost three-fifths of the Mirror therapy group experienced typical sensory impairment. It demonstrated the efficacy of Mirror treatment application, according to the researchers. Research supporting the idea that mirror treatment causes an individual's unaffected limb to reflect instead of their affected limb during exercises supported these findings. According to **Chinnavan et al. (2020**), these visual illusions give the impression that the two extremities are moving symmetrically.

Research by **Gokila (2016), Radajewska et al. (2017), Chinnavan et al. (2020), and Devi et al. (2022)** supported these findings by showing that, following mirror therapy, there was a reported improvement in upper-limb motor performance in the experimental group as compared to the control group. Furthermore, mirror therapy can enhance patients' upper limb motor function even in chronic phases of stroke, according to a different study by **Colomeret al. (2016).** In contrast to the results of the current investigation, a study conducted in Turkey by **Yeldan et al. (2019**) revealed that utilizing the MT had no positive effect on the participants' upper extremity's motor function. The variety of instruments utilized, the duration of the intervention, the MT session's movement patterns, and the participant selection criteria could all be contributing factors to the inconsistent findings. According to research by **Gokila (2016**), **Lee et al. (2019**), and **Chinnavan et al. (2020),** MT seems to have a notable impact on stroke patients' sensory function. **Arya et al.'s (2018**) study, which found that the experimental group using the MT had a notably higher positive touch-response ($P < .004$) of up to 30% for the hand quadrants compared to only 13.5% for the control group, corroborated these findings.

The current study's findings showed that, following the intervention, less than 25% of the Mirror treatment group had normal passive joint motion, but more than two thirds of the Conventional therapy group had hypo-mobility. Additionally, whereas three quarters of the Mirror therapy group reported no joint discomfort, half of the Conventional group experienced joint pain. Given the documented improvement in the motor and sensory function of the older persons under study, these results could be explained. Additionally, the length of the therapy that was used and the older patients' adherence to the researchers' recommendations could be contributing factors to this result. In this line, studies conducted by **Gokila, (2016) & Thieme, et al (2018)** reported improvement in passive joint motion and reduction in pain sensation among the studied participants post-stroke after using mirror therapy.

Conclusion:

According to the outcomes of the current study it can be conclude that, Rehabilitative intervention regarding mirror therapy as practical, simple, and affordable nursing intervention that can be used to enhance upper extremity sensory motor function in elderly patients' post-stroke. Therefore, it can be concluded that mirror therapy is useful in treating and rehabilitating stroke patients' upper limb pain, range of motion, sensitivity, and functionality.

Recommendation:

The following suggestions are made based on the current study's findings:

- It is advised that mirror therapy training be given in both clinical and community settings.
- A post-stroke in-service education program for gerontological nurses should be developed to expand their expertise in mirror therapy as a rehabilitative intervention to improve upper extremity sensory motor function.
- Elderly stroke patients who have impaired upper extremity sensory motor function can benefit from mirror treatment in both clinical and community settings.
- Elderly stroke patients require ongoing encouragement and support in order to ensure that their mirror therapy regimens are permanently incorporated into their daily lives.
- Future studies and repeating this study on a large sample size for generalization.

References:

- Almhdawi, K.A.; Mathiowetz, V.G.; White, M.; delMas, R.C. Efficacy of Occupational Therapy Task-oriented Approach in Upper Extremity Post-stroke Rehabilitation. *Occup. Ther. Int.* **2016**, *23*, 444–456. [CrossRef] [PubMed]
- Altschuler, S. B. Wisdom, L. Stone, C. Foster, D. Galasko, D. M. Llewellyn, and V. S. Ramachandran, “Rehabilitation of hemiparesis after stroke with a mirror,” *The Lancet*, vol. 353, pp. 2035–2036, Jun. 2021.
- Antoniotti, L. Veronelli, A. Caronni, A. Monti, E. Aristidou, M. Montesano, and M. Corbo, “No evidence of effectiveness of mirror therapy early after stroke: An assessor-blinded randomized controlled trial,” *Clinical Rehabilitation*, vol. 33, pp. 885–893, 2019.
- **Arya, K. Pandian, S. & Kumar, V (2019):** Effect of activity-based mirror therapy on lower limb motor-recovery and gait in stroke: A randomized controlled trial, Neuropsychol Rehabil, Vol. (29), No. (8), Pp.1193-1210.
- **Ashrafi, S. Mehr, MS. Mohammadi, TK. Jafroudi, S. & Leyli, EK (2022):** Effect of Mirror Therapy on the Motor Recovery in Patients after Stroke: A Randomized Clinical Trial, IRJ, Vol. (20), Pp. 65-78.
- **Baby, FM. Babu, V. Kumar, S. & Akalwadi, A. (2014):** Effectiveness of mirror therapy as a home program in rehabilitation of hand function in sub-acute stroke, Int J Physiother Res., Vol. (2), No. (1), Pp.365-71.
- **Chinnavan, E. Priya, Y. Ragupathy, R. & Wah, Y (2020):** Effectiveness of Mirror Therapy on Upper Limb Motor Functions Among Hemiplegic Patients, Bangladesh Journal of Medical Science, Vol. (19), No. (02), Pp. 208-213.
- **Choi, HS. Shin, WS. & Bang, DH (2019):** Mirror Therapy Using Gesture Recognition for Upper Limb Function, Neck Discomfort, and Quality of Life After Chronic Stroke: A Single-Blind Randomized Controlled Trial, Med Sci Monit., Vol. (25), Pp. 3271-78.
- Coleman, E.R.; Moudgal, R.; Lang, K.; Hyacinth, H.I.; Awosika, O.O.; Kissela, B.M.; Feng, W. Early Rehabilitation after Stroke: A Narrative Review. *Curr. Atheroscler. Rep.* **2017**, *19*, 59. [CrossRef] [PubMed]
- **Colomer, C. Noe, E. & Llorens, R (2016):** Mirror therapy in chronic stroke survivors with severely impaired upper limb function: A randomized controlled trial, European Journal of Physical and Rehabilitation Medicine, Vol. (52), No. (3), Pp. 271-8.
- **Dave, K (2020):** Effects of Mirror Therapy on Upper Extremity Functions among Hemiplegic Patients: An Experimental Study, Indian Journal of Surgical Nursing, Vol. (9) No (1), Pp.17-21.
- **Devi, IM. & Dutta, N (2022):** Effectiveness of Mirror Therapy to Improve Upper Extremity Motor Function in Stroke Patients at Selected Hospitals of Guwahati, Assam. International Journal of Science and Research, Vol. (11), No. (5).
- Ehrensberger, D. Simpson, P. Broderick, C. Blake,

F. Horgan, P. Hickey, J. O'Reilly, and K. Monaghan, "Unilateral strength training and mirror therapy in patients with chronic stroke: A pilot randomized trial," *American Journal of Physical Medicine & Rehabilitation*, vol. 98, pp. 657–665, Aug. 2019.

- Fernández-de-Las-Peñas, C.; Pérez-Bellmunt, A.; Llurda-Almuzara, L.; Plaza-Manzano, G.; De-la-Llave-Rincón, A.I.; Navarro- Santana, M.J. Is Dry Needling Effective for the Management of Spasticity, Pain, and Motor Function in Post-Stroke Patients? A Systematic Review and Meta-Analysis. *Pain Med.* **2021**, *22*, 131–141. [CrossRef] [PubMed]
- **Fugl-Meyer, AR. Jaasko, L. & Leyman, I (1975):** The post-stroke hemiplegic patient, Scand J Rehabil Med, Vol. (7), No. (1), Pp.13-31.
- **Gokila, S (2016):** A study to assess the effectiveness of mirror therapy to improve upper extremity motor function in stroke patients at PSG Hospitals, Coimbatore. Master's thesis, PSG College of Nursing, Coimbatore.
- González-Santos, J.; Rodríguez-Fernández, P.; Pardo-Hernández, R.; González-Bernal, J.J.; Fernández-Solana, J.; Santamaría- Peláez, M. A Cross-Sectional Study: Determining Factors of Functional Independence and Quality of Life of Patients One Month after Having Suffered a Stroke. *Int. J. Environ. Res. Public Health* **2023**, *20*, 995. [CrossRef]
- Gregson, M. J. Leathley, A. P. Moore, T. L. Smith, A. K. Sharma, and C. L. Watkins, "Reliability of measurements of muscle tone and muscle power in stroke patients," *Age and Ageing*, vol. 29, pp. 223–228, 2000.
- Gregson, M. Leathley, A. P. Moore, A.K. Sharma, T. L. Smith, and C. L. Watkins, "Reliability of the tone assessment scale and the modified ashworth scale as clinical tools for assessing poststroke spasticity," *Archives of Physical Medicine and Rehabilitation*, vol. 80, pp. 1013–1016, Sep. 1999.
- **Guémann, M., Olié, E., Raquin, L., Courtet, P., & Risch, N. (2023):** Effect of mirror therapy in the treatment of phantom limb pain in amputees: A systematic review of randomized placebo-controlled trials does not find any evidence of efficacy. European Journal of Pain, Vol.(27), No.(1), Pp.3-13.
- https://doi.org/10.1002/14651858.CD008449.pub3
- **Jaafar, N., Che Daud, A. Z., Ahmad Roslan, N. F., & Mansor, W. (2021):** Mirror Therapy Rehabilitation in Stroke: A Scoping Review of Upper Limb Recovery and Brain Activities. Rehabilitation Research and Practice, 2021, 1–12. https://doi.org/10.1155/2021/9487319.
- Kim, H.; Shim, J. Investigation of the effects of mirror therapy on the upper extremityfunctions of stroke patients using the manual function test. *J. Phys. Ther. Sci.* **2019**, *27*, 227. [CrossRef]
- **Klinkwan, P. Kongmaroeng, C. Muengtaweepongsa, S. & Limtrakarn, W (2022):** The effectiveness of mirror therapy to upper extremity rehabilitation in acute stroke patients. Applied Science and Engineering Progress, Vol. (15) No (4), 5084-5084.
- **Lee, D, & Gyuchang, L (2019):** Effect of afferent electrical stimulation with mirror therapy on motor function, balance, and gait in chronic stroke survivors: a randomized controlled trial, European Journal of Physical and Rehabilitation Medicine, Vol. (55) No. (4), Pp. 442 - 449.
- Lee, H. Cho, and C. H. Song, "The mirror therapy program enhances upper-limb motor recovery and motor functions in acute stroke patients," *American Journal of Physical Medicine & Rehabilitation*, vol. 91, pp. 689–696, Aug. 2022.
- **Mattson, MP. & Arumugam, TV (2018):** Hallmarks of brain aging: adaptive and pathological modification by metabolic states. Cell Metab. 27, 1176–1199. doi: 10.1016/j.cmet.2018.05.011.
- Namaganda, P.; Nakibuuka, J.; Kaddumukasa, M.; Katabira, E. Stroke in young adults, stroke types and risk factors: A case control study. *BMC Neurol.* **2022**, *22*, 335. [CrossRef]
- Park, Y.S.; An, C.S.; Lim, C.G. Effects of a Rehabilitation Program Using a Wearable Device on the Upper Limb Function, Performance of Activities of Daily Living, and Rehabilitation Participation in Patients with Acute Stroke. *Int. J. Environ. Res. Public Health* **2021**, *18*, 5524. [CrossRef]
- Perfetti, C.; Ghedina, R.; Hernández, D.J. *El Ejercicio Terapéutico Cognoscitivo Para La Reeducación Motora Del Hemipléjico Adulto*; Edika Med: Barcelona, Spain, 2019.
- Persson, H.C.; Danielsson, A.; Sunnerhagen, K.S. A cross sectional study of upper extremity strength ten days after a stroke; relationship between patient-reported and objective measures. *BMC Neurol.* **2019**, *15*, 178. [CrossRef]
- Pollock, G. Baer, P. Campbell, P. L. Choo, A. Forster, J. Morris, and V. M. Pomeroy, "Physicalrehabilitation approaches for the recovery of function and mobility following stroke," *Cochrane Library: Cochrane Reviews*, vol. 2019, no. 4, Apr., doi: 10.1002/14651858. CD001920.pub3.
- Prange-Lasonder, G.B.; Alt Murphy, M.; Lamers, I.; Hughes, A.M.; Buurke, J.H.; Feys, P.; Keller, T.; Klamroth-Marganska, V.; Tarkka, I.M.; Timmermans, A.; et al. European evidence-based recommendations for clinical assessment of upper

limb in neurorehabilitation (CAULIN): Data synthesis from systematic reviews, clinical practice guidelines and expert consensus. *J. Neuroeng. Rehabil.* **2021**, *18*, 162. [CrossRef] [PubMed]

- **Pu, L., Wang, L., Zhang, R., Zhao, T., Jiang, Y., & Han, L. (2023):** Projected Global Trends in Ischemic Stroke Incidence, Deaths and Disability-Adjusted Life Years From 2020 to 2030. Stroke, Vol. (54), No. (5), Pp. 1330-1339.
- **Putri, SJ. Jauhar, M. & Widiyanto, B (2020)**: Mirror Therapy Improved Muscle Strength of the Elderly, Advances in Health Sciences Research, Vol. (20).
- Raghavan, P. Upper Limb Motor Impairment Post Stroke. *Phys. Med. Rehabil. Clin. N. Am.* **2019**, *26*, 599. [CrossRef] [PubMed]
- **Rai, SS. & Das, AK (2020):** The Effect of Exercises to Improve Balance Using Mirror as A Feedback in Stroke Patients. VIMS J Physical Th. Vol. (2), No. (2), Pp. 2456 - 4087.
- **Rössler, R., Bridenbaugh, S. A., Engelter, S. T., Weibel, R., Infanger, D., Giannouli, E., & Hinrichs, T. (2020):** Recovery of mobility function and life-space mobility after ischemic stroke: the MOBITEC-Stroke study protocol. BMC neurology, Vol. (20), Pp.1-11.
- Sathian, A. I. Greenspan, and S. L. Wolf, "Doing it with mirrors: A case study of a novel approach to neurorehabilitation," *Neurorehabilitation and Neural Repair*, vol. 14, pp. 73–76, Feb. 2020.
- **Sharrief, A. & Grotta, JC (2019):** Stroke in the elderly, Handb Clin Neurol, Vol. (167), Pp. 393- 418.
- Simats, A.; Liesz, A. Systemic inflammation after stroke: Implications for post-stroke comorbidities. *EMBO Mol. Med.* **2022**, *14*, e16269.
- **Soofia Naghadi, Noureddin Ansari et al Brain Injury (2010):** A neurophysiological and clinical study of Brunnstrom recovery stages in the upper limb following stroke; Vol. (24) No. (11), Pp.1372-1378.
- Stevens and M. E. Stoykov, "Using motorimagery in the rehabilitation of hemiparesis," *Archives of Physical Medicine and Rehabilitation*, vol. 84, pp. 1090–1092, Aug. 2023.
- Tater, P.; Pandey, S. Post-stroke Movement Disorders: Clinical Spectrum, Pathogenesis, and Management. *Neurol. India* **2021**, *69*, 272–283. [CrossRef]
- **Thieme, H., Morkisch, N., Mehrholz, J., Pohl,M., Behrens, J., Borgetto, B., & Dohle, C. (2018):** Mirror therapy for improving motor function after stroke. The Cochrane database of systematicreviews, 7(7), CD008449.
- Thieme, H.; Morkisch, N.; Mehrholz, J.; Pohl, M.; Behrens, J.; Borgetto, B.; Dohle, C. Mirror therapy for improving motor function after stroke. *Cochrane Database Syst. Rev.* **2018**, *7*, CD008449. [CrossRef]
- Wen, X.; Li, L.; Li, X.; Zha, H.; Liu, Z.; Peng, Y.; Liu, X.; Liu, H.; Yang, Q.; Wang, J. Therapeutic Role of Additional Mirror Therapy on the Recovery of Upper Extremity Motor Function after Stroke: A Single-Blind, Randomized Controlled Trial. *Neural. Plast.* **2022**, *2022*, 8966920. [CrossRef]
- Yavuzer, R. Selles, N. Sezer, S. Sütbeyaz, J. B. Bussmann, F. Köseoglu, M. B. Atay, and H. J. Stam, "Mirror therapy improves hand function in subacute stroke: A randomized controlled trial," *Archives of Physical Medicine and Rehabilitation*, vol. 89, pp. 393–398, Mar. 2018.
- Yeldan, B. E. Huseyinsinoglu, B. Akinci, E. Tarakci, S. Baybas, and A. R. Ozdincler, "The effects of very early mirror therapy on functionalimprovement of the upper extremity in acute stroke patients," *The Journal of Physical TherapyScience*, vol. 27, pp. 3519–3524, Nov. 2019.
- **Yeldan, I. Huseyı nsınoglu, BE. Akıncı, B.Tarakcı, E. Bayb, S. & Ozdıncler, AR (2019):** The effects of very early mirror therapy on functional improvement of the upper extremity in acute stroke patients, J. Phys. Ther. Sci. Vol. (27), No. (11).
- **Yousufuddin, M. & Young, N (2019):** Aging and ischemic stroke, Aging (Albany NY). Vol. (11), No (9), Pp. 2542-2544.
- **Yumnam, N. Akoijam, JS. & Oinam, J (2019):** Effectiveness of mirror therapy through functional activities and motor standards in the motor recovery in post-stroke hemiplegic patients: a prospective randomized controlled trial in a tertiary care hospital in Northeast India, Int J Res Med Sci., Vol. (7), No. (5), Pp.1904-1908.
- **Zakaria, MF. Aref, H. Abd El Nasser, A. Fahmy,N. Tork, MA. & Fouad, MM (2018):** Egyptian experience in increasing utilization of reperfusion therapies in acute ischemic stroke, Int J Stroke, Vol. (13), No. (5), Pp. 525-9.
- Zeng, W.; Guo, Y.; Wu, G.; Liu, X.; Fang, Q. Mirror therapy for motor function of the upper extremity in patients with stroke: A meta-analysis. *J. Rehabil. Med.* **2018**, *50*, 8–15. [CrossRef] [PubMed]
- Zhang, Y.; Xing, Y.; Li, C.; Hua, Y.; Hu, J.; Wang, Y.; Ya, R.; Meng, Q.; Bai, Y. Mirror therapy for unilateral neglect after stroke: A systematic review. *Eur. J. Neurol.* **2022**, *29*, 358–371. [CrossRef] [PubMed]