Research Article

The Effectiveness of Mirror Therapy to Upper Extremity Rehabilitation in Acute Stroke Patients

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Abstract
Rehabilitation is a crucial part of stroke recovery to help them regain use of their limb. This study aimed to compare the effectiveness of long-term mirror therapy training with conventional rehabilitation therapy on neurological and recovery of the upper limb in acute stroke patients. In this randomized and assessor-blinded control study, 20 acute stroke patients were analyzed and allocated to a case (n = 10, 50.6 ± 17.90 years) and control group (n = 10, 55.9 ± 11.25 years). All the participants performed daily home exercises for 12 weeks. The patients in the control group were treated with Conventional Therapy (CT), and a group of cases was treated with Mirror Therapy (MT) alone program. The outcome measurements were assessed by a therapist blinded assessor using Fugl-Meyer Assessment (FMA) upper extremity score, Brunnstrom recovery stages (BRS), Modified Ashworth Scale (MAS) and Muscle Strength to evaluate upper limb motor function and motor recovery. Data were analyzed using Wilcoxon and Mann-Whitney U tests to compare within-groups and between-group differences. The results revealed that, after 12 weeks of treatment, patients of both groups presented statistically significant improvements in all the measured variables (p-value < 0.05). Compared with the control group, the patients of the MT group had greater improvement in the proximal movement portion of the FMA upper extremity mean score change (15.8 ± 3.2 versus 10.0 ± 2.7, p = 0.002). While, there were no differences in other variables (p-value > 0.05). There were also no adverse events. It suggests that 12 weeks of MT training alone was likely to improve the upper limb's motor recovery and daily living activity in acute stroke patients than conventional therapy, if treated early.

Keywords: Acute stroke, Rehabilitation, Upper extremity, Mirror therapy, Clinical research

1 Introduction

Stroke remains a major public health disease in the 21st century, despite understanding its causes and treatment options. It is usually associated with damage to the motor functions and other functional disabilities resulting in death and loss of well-being in which the survivors often have a disability. According to the statistics of leading causes of death from 1990 to 2013, the World Health Organization (WHO) announces that the second reason of leading death is stroke, and the finding from all stroke cases proposed that two-thirds of these deaths occur in people living in the developing countries, including Thailand [1]. Although stroke incidence, prevalence, and mortality rates tend to decline, the overall stroke burden has increased across the globe in all ages. Concerning prospective multicenter countrywide cohort study, a total of 1,222 patients were found. However, only 26% of patients get good therapeutic effect when discharged from hospitals, a study in ischemic stroke patients who admitted in hospitals throughout Thailand between June 2008 and November 2010 [2]. Based on the study by communities, in 2011, the Thai Epidemiology Stroke Study (TES Study) reported the epidemiology of stroke in 19,997 subjects from 5 regions in Thailand, found 376 stroke patients, equivalent to 1.88%. The prevalence among adults aged ≥ 60 years as 2.56% presented the increasing prevalence of stroke in Thailand when compared to the previous study (1.12%) in 1998 [3]. In our catchment area, Pathum Thani province, the prevalence of stroke was one percent in adults age more than 30 [4]. The severity and clinical manifestations of stroke patients is variable depending upon the site and periods of brain ischemia. Stroke patients require rapid treatment and continuous therapy, particularly in the acute phase, to reduce the mortality rate and the cost of treatment. However, majority of stroke survivors have movement disabilities, especially the impairment of upper limbs, as result of weakened or stiff muscles, hypertonia, imbalance, and sensory disturbances. It causes inconvenience to their lifestyle and social life. These patients need assistance with activities of daily living from a care provider. It will result in a better level of competence and quality of life if the patient has been appropriately treated and continuously rehabilitated.

The recovery of the nervous system and muscle power usually may occur after the limb weakness. However, the rate of arm strength recovery is slower than the legs, makes the stroke patient unable to use weak hands and arms. Therefore, these patients must adapt by using good hands and arms instead of the weak side, causing them to reduce the usage of the weak hand and resulting in complications, such as muscle atrophy and constriction followed [5], [6]. Previous studies have reported that upper limb rehabilitation of stroke patients is more difficult than lower limb due to the amount of muscle and the complexity of the motor function. The prognosis of upper extremity function can be achieved within 3 and 6 weeks in patients with moderate and severe stroke. It was reported that 5–20% of stroke patients could fully recover their arms within the first 6 months, while 30–60% are not able to fully use their arms [7], [8]. After 1 year or more, patients with weak arms may be worried and feel a poor quality of life. [9], [10]. Therefore, rehabilitation for stroke patients is an important part of improving the quality of life after stroke. The patients who still have disabilities should be rehabilitated within 24–48 h after neurological symptoms, and vital signs are stable. The rehabilitation program depends on the duration of the disease, the problems that patients have, and the level of competence of each patient.

Although there have been several rehabilitation methods that promote the motor function of the affected upper limbs, such as robotic-assisted rehabilitation and functional electrical stimulation (FES). In addition, the application of virtual reality (VR) technology, previously used for maintenance training, to create images for the rehabilitation of weak limbs in stroke patients [11], [12]. However, these methods have high maintenance costs and have not been as particularly widespread in developing countries. MT is utilized to create a reflective illusion to help affected limbs move more efficiently. In practice, the patient looks into the mirror to reflect the good limb movement and hide the weak limb behind the mirror. The goal is for the patient to imagine regaining control over a weakened limb. This procedure stimulates the different brain regions for movement, sensation, and pain. This method is safe, not complicated, inexpensive, and the patients can bring mirror illusion back home. However, several studies have demonstrated the effect of MT that can stimulate the recovery of the nervous system and improve the motor skill related to motor recovery and motor function of weakened hands and arms in stroke patients during a 4–6 weeks exercise [13]–[16]. According to a Cochrane Review by Pollock *et al.*, they proposed that examining functional recovery and mobility following stroke suggests that higher volume therapy (5 times per week) is more effective than lower volume therapy (3 times per week). An increase in therapy volume may have led to better outcomes in the MT group [17]. However, no studies have been designed to evaluate the effectiveness of long-term training MT alone in acute stroke patients. Based on literature reviews, previous studies have only been designed to evaluate the outcome of 12 weeks of training in chronic stroke patients and followed the conclusion of the intervention for 8 weeks of MT training in subacute stroke patients [13], [18], [19]. The purpose of this study was to investigate 12 weeks of training and recover-relates effects of CT versus MT to upper extremity rehabilitation in acute stroke patients.

2 Materials and Methods

2.1 *Participants and recruitment*

A total of 52 participants recruited in the study were admitted to the stroke rehabilitation unit of Thammasat University and network hospitals and were diagnosed with acute stroke by a neurologist. After the initial screening, 30 participants were selected for the study based on inclusion and exclusion criteria by the physiotherapist and provided written informed consents. The criteria for the inclusion and exclusion of the study are listed below. All participants were randomly assigned to either the CT group or MT group. During the assessment, 10 of them relocated to another province. Thus they had to leave their participation. A total of 20 participates completed the training course, 10 participants per group, were analyzed in this study. The participant selection chart is shown in Figure 1. The formula below is used to calculate a sample size adequate for this study. The calculated sample size from the previous study was 5 samples per group, but this study used 10 participants per group [12], [20].

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

The protocol was approved by the Thammasat University Ethics Committee (No. MTU-IC-IM-2-045/60 on October 9th, 2017).

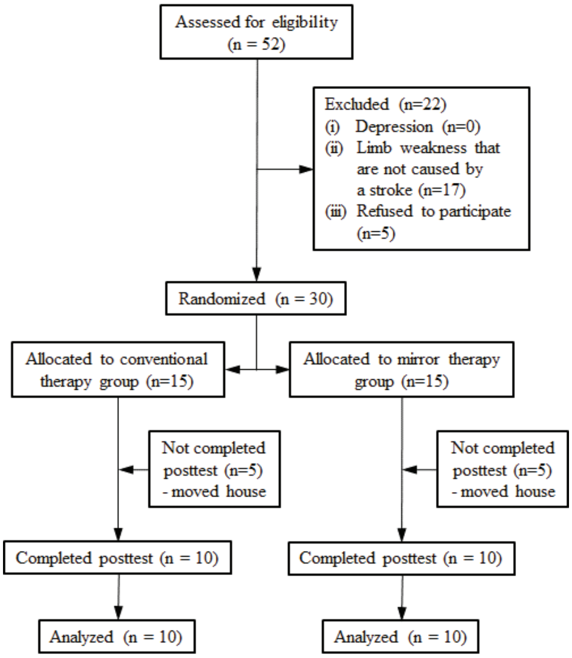

Figure 1: Flowchart of participants.

2.1.1 Inclusion criteria

The inclusion criteria were as follows: 1) first acute stroke; 2) cognitive ability is sufficient to follow instructions (Mini-Mental State Examination (MMSE) score > 23); 3) having a score ≥ 3 points on the Brunnstrom motor recovery stages of the upper extremity.

2.1.2 Exclusion criteria

The main exclusion criteria were as follows: 1) participants have depression; 2) limb weakness that is not caused by a stroke such as aphasia due to misunderstanding, Parkinson's disease, and spinal cord injury; 3) According to the opinion of doctors or patients when unable to cooperate in research.

2.2 *Study design*

This study was a single-blinded and randomized controlled trial with pre-test and post-test assessments. After signing informed consent, the participants

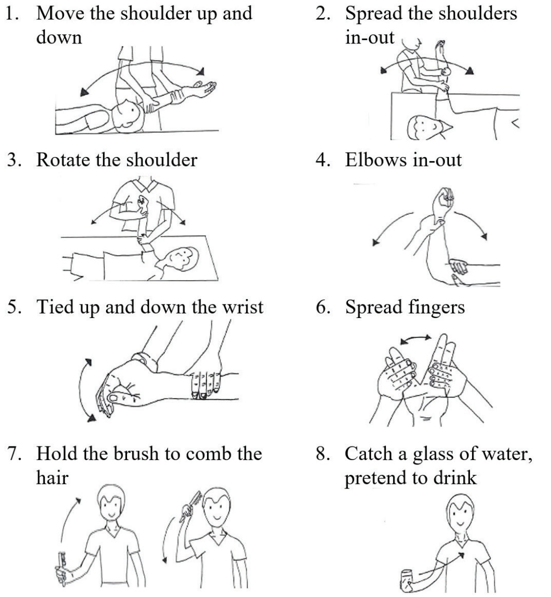

Figure 2: Conventional physical therapy. The training process consists of 8 positions. Stroke patients and assist providers are trained by physical therapists before returning home.

were randomly allocated as CT group and MT group before the baseline measurement. All the participants will receive standardized training regarding the study protocol, treatment methods, and assessments. They will practice with the same postural control as shown in Figure 2, but different according to the methods of each group. The interventions will be performed 5 days a week, 1 hour a day, for 12 weeks.

2.3 *Intervention*

2.3.1 Conventional therapy

In this therapy, the care giver will assist the treatment by moving the arms and hands of the patient's weak side, as shown in Figure 2. In the practice of each motion, the patient will move at a low speed by performing 20 sessions/cycle, 2 Cycles/day (1 cycle takes about 30–60 min) [21].

2.3.2 Mirror therapy

In this way, the patient was seated close to a mirror (70 × 40 cm) was placed vertically, as shown in Figure 3.

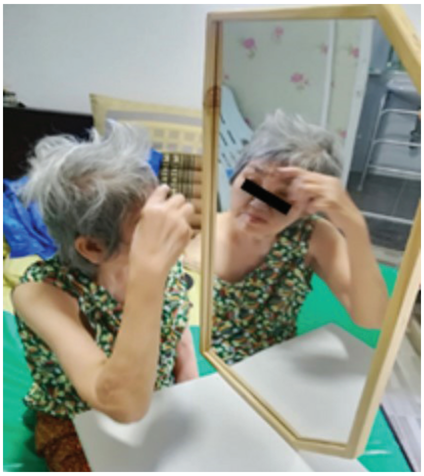

Figure 3: The exercise position by using a mirror. The patient was trained with mirror therapy.

Then, take the weak hand behind the mirror and place a strong arm opposite the mirror. The patient will perform regular hand movements and the training position (Figure 2. positions 1–8) [21]. In each position, the patient should raise the arms at low speed and have the caregiver help to observe the patient's symptoms. This practice allows the patient to look at the mirror image of the standard hand and arm and think that the weak hand moves.

2.4 *Outcome measurements*

The measurements of upper extremity function were assessed at the initial rehabilitation baseline (pre-test) and 12 weeks after rehabilitation treatment (post-test). At each examination, the measurements were done by the same assessor who was blinded to treatment allocation. The Fugl Meyer Assessment (FMA), the Brunnstrom Recovery Stage (BRS), the Modified Ashworth Scale (MAS), and the Muscle Strength were used to determine the outcomes.

2.4.1 Primary outcome

Fugl Meyer Assessment (FMA) was utilized to assess sensorimotor functioning in the upper limb. The motor score of tests ranged from 0 to 66 points for the upper extremity movement. However, the score was not assessed in the sensation, passive joint motion, and pain categories. A higher score indicates better motor recovery. The FMA takes approximately 30 min to test [22], [23].

2.4.2 Secondary outcome

The secondary outcome measures included the BRS, the MAS, and the Muscle Strength for evaluating the motor recovery of the arm and hand. The assessment score designates the sequence of motor recovery after stroke based on the degree of spasticity and the appearance of voluntary movement.

Brunnstrom Recovery Stage (BRS)

The seven Brunnstrom stages developed in the 1960s by Signe Brunnstrom were used to examine the motor recover of upper limb. This approach describes the sequences of motor recovery after stroke based on the degree of spasticity and involuntary movement [24], [25].

The Modified Ashworth Scale (MAS)

Spasticity and movement of the wrist were assessed using a 6-point MAS. Spasticity was measured at the wrist joint with the participant in the supine position [26].

The Muscle Strength

Muscle strength was measured with a Manual Muscle Testing (MMT) on a five-point scale using the Medical Research Council (MRC) system [27]. For this approach, the physiotherapist will push on the participant's arm in specific directions while the participant resists the pressure. A score was then assigned as 0 to 5 scale, depending on ability to resist the pressure of participant accordingly,

0 = No contraction
1 = Flicker or trace of contraction
2 = Active movement, with gravity eliminated
3 = Active movement against gravity
4 = Active movement against gravity and resistance
5 = Normal power

2.5 *Statistical analysis*

Data analysis was performed using PSPP for Windows, version 1.4.1. The qualitative data of demographic variables and outcome measures for each group were presented as the mean ± standard deviation (SD). In contrast, non-normal distribution was presented with the range (minimum – maximum), and qualitative data were presented by number and percentage. Wilcoxon signed ranks test and Mann Whitney U test were used to statistically analyze the data in term of within group and between group comparison, respectively [28].

3 Results and Discussion

Recruitment of participants was conducted at the stroke unit of Thammasat University and network hospitals between October 2017 to May 2019. Although many acute stroke patients in the stroke ward participated in the project, many people did not meet inclusion criteria on the study design. Also, some participants have left the experiment during the trial because they have to move with relatives in the provinces to take care them. No adverse events occurred during this research. A total of 20 analyzed patients, who completed 12 weeks of training, were included in this study. These patients were randomly assigned to the CT or MT. Among them, 10 patients underwent conventional rehabilitation therapy, and 10 received MT. CT trained control group had 8 males and 2 females between the age of 40 to 74 years with a mean age of 55.9 ± 11.26 years). Moreover, the intervention group trained by MT included 6 males and 4 females, between 25 to 78 years, with a mean age of 50.6 ± 17.90 years). All of the participants in both groups had suffered from an ischemic stroke. The characteristics of 20 participants are summarized in Table 1. Baseline demographic showed no statistically significant difference among age between the groups (p-value > 0.05).

The initial and final evaluations were operated before (pre-test) and after 12 weeks of treatment (post-test). The results presented the mean score of primary and secondary outcome measures for motor recovery, spasticity, and hand-related functioning both from pre-treatment and post-treatment, as shown in Table 2. In the control group, participants showed the improvement for the FMA as presented a mean score changed from 6.8 to 16.8, accompanied with the result of pretest and posttest of BRS (2.3 vs. 4.5), MAS (1.7 vs. 2.5) and Strength (2.4 vs. 3.5). In the MT group, the result showed an increase of mean score of post-test when compared to pre-test in FMA (7.2 vs. 23.0), BRS (2.4 vs. 4.8), MAS (1.9 vs. 2.6), and strength (2.7 vs. 4.1). In this study, statistically significant improvement was found for four physical therapy assessments in both groups (p-value < 0.05) when comparing the mean score of pre-test and post-test within the group.

Table 1: Baseline information of 20 participants

Characteristic	CT Group	MT Group	p-value
	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)	
No. of patients	10	10	
Age (yrs.)	55.9 ± 11.26 (40–74)	50.6 ± 17.90 (25–78)	0.491
Gender (male/female)	8/2	6/4	
Dominance limb (left/right)	4/6	6/4	
Paretic limb (left/right)	8/2	5/5	
Type of stroke (ischemic/hemorrhagic)	10/0	10/0	

Table 2: A mean score between CT and MT group on motor recovery, spasticity, and hand-related functioning

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

* significant differentiation (p-value < 0.05), p-value determined from the Wilcoxon-Signed Rank Test

Between-group differences, a mean change score of the motor recovery, spasticity, and hand-related functioning are presented in Table 3. The result presented a mean change score in CT and MT for FMA (10.0 vs. 15.8), BRS (2.2 vs. 2.4), MAS (0.8 vs. 0.7), and strength (1.1 vs. 1.4). All measurement outcomes showed an more improvement in MT than the CT group, but mean score changes of the FMA showed a statistically significant improvement in MT compared to the CT group (p-value < 0.05). As a result of the assessment, FMA has a higher resolution than other assessments. On the other hand, this study found the mean score changes of the MAS demonstrated in the MT group less improvement than the CT group (0.7 vs. 0.8). However, no statistically significant differences were found (p-value > 0.05).

Table 3: Comparison of change score after 12 weeks treatment between CT and MT groups

Characteristic	CT Group	MT Group	p-value
	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)	
FMA	10.0 ± 2.75 (6.8–16.8)	15.8 ± 3.16 (7.2–23.0)	0.002*
BRS	2.2 ± 0.63 (2.3–4.5)	2.4 ± 0.52 (2.4–4.8)	0.579
MAS	0.8 ± 0.79 (1.7–2.5)	0.70 ± 0.48 (1.9–2.6)	0.912
Strength	1.1 ± 0.57 (2.4–3.5)	1.4 ± 0.52 (2.7–4.1)	0.353

* significant differentiation (p-value < 0.05), p-value determined from the Mann Whitney U Test

The upper limb motor impairments refer to problems in motor function and structure. In contrast, upper limb functional performance is defined as performing a task or action with the upper limbs. This study observed the effectiveness of long-term training CT and MT alone program in the upper extremity rehabilitation of motor impairment and functional performance in acute ischemic stroke patients within 12 weeks of training. Our results presented the improvement in motor functioning of upper limb (FMA), motor recovery of the arm and hand (BRS) based on the degree of spasticity and involuntary movement, spasticity and movement of wrist (MAS) and muscle strength (MMT) in both CT and MT group, based on the increasing scores. The clinical assessment scores during the 3 months of training program are listed in Figure 4. The results suggested that participants treated with MT alone recovered more distal function than CT without increasing adverse events in acute stroke patients, as indicated by FMA. In addition, the FMA scores of MT training were higher than the CT training from week 8 through week 12. Our results are consistent with the previously published data that participants who treated with MT during 4–8 weeks of training presented better FMA outcomes than the controls group. Also, an increase in therapy volume

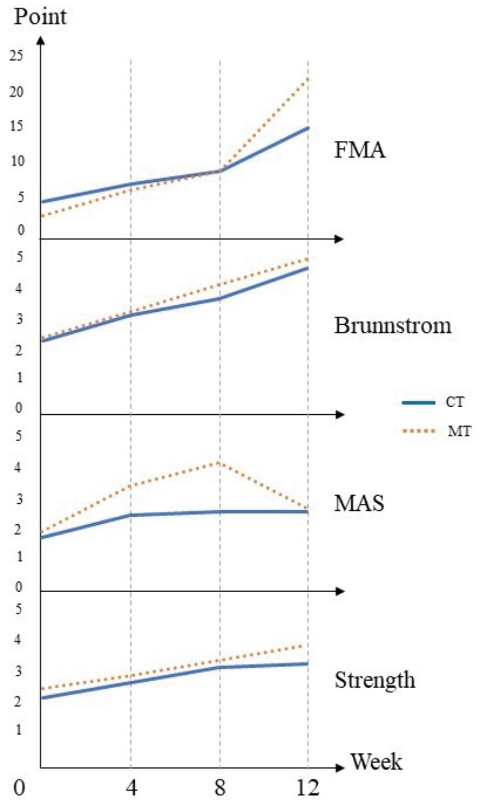

Figure 4: Recovery patterns of motor impairment assessed by the FMA, Brunnstrom, MAS, and strength in CT and MT groups.

led to better outcomes in the MT group [17], [29]. On the other hand, spasticity and muscle strength were not significantly different after 12 weeks of training by MT alone when compared to CT. However, the results showed an improvement after training in both groups. This finding supported that an early and long-term rehabilitation outcome may improve daily activities during hospitalization in ischemic stroke patients reported by Maiko *et al.* and Lee *et al.* [30], [31]. Yeldan *et al.*reported no adverse effect on the functional improvement of upper extremity function. Due to the small sample size, they did not observe any adverse effects of the very early MT in acute stroke patients [15]. The study by Antoniotti *et al.* suggested that mirror therapy did not add additional benefit to upper-limb recovery early after stroke compared with sham therapy [32].

The mechanisms that can explain the effect of mirror training in stroke patients consist of 1) mirror illusion or visual feedback mechanism, in which the patient looks at the reflection of a good hand and arm moving through that mirror to replace the lost feeling of the hand and arm that are weak. This practice induces brain stimulation in the premotor cortex, which helps restore the weak hand and arm [16]. 2) The motor imagery mechanism is a practice for the patient to use imagination to create a concept that weak hands and arms can move as usual [33]. 3) The mirror neuron mechanism is caused by a group of neurons in the brain that can respond to polymodal neurons [13]. Nevertheless, our results did not display the effect of age on moto-sensory improvement in hemiplegia patients. Almost all participants in this study were over 40 years of age, except for one patient in the MT group These patients' imperfections in motor function may be affected by the decreasing of sensory motor functions in older adults affected by the decreasing of sensorimotor functions in older adults affected from the dysfunction of the central and peripheral nervous systems and the neuromuscular system. In previous studies, E. L. Altschuler *et al.* proposed that MT can help restore the neurological function of the paretic arm within two weeks in chronic stroke patients [16]. Likewise, a study of K. Sathian *et al.* presented the effectiveness by 2-weeks MT application in chronic paralysis patients with poor upper limb functional use due to somatosensory deficits [24]. The results showed that patients had improved mobility and use of the affected upper limb. They proposed that significant motor recovery can be achieved through sensory input manipulation.

4 Conclusions

This study confirmed that MT can could used for upper extremity rehabilitation in acute ischemic stroke patients. Both CT and MT groups effectively improve the functioning of the upper limbs after 12 weeks of training when assessed with FMA, BRS, MAS, and Muscle Strength measurements. However, MT has a significantly higher ability than CT to improve the impairment of hemiplegia motors. MT is an intervention that is inexpensive, safe, and easy to exercise at home. It also stated that MT could be used safely if clinical characteristics are carefully evaluated for initiation of very early MT. Additionally, well-designed studies with a large sample size, are required in order to evaluate the effect of MT on motor function in stroke patients and sophisticated tools should be added for rehabilitation training, such as robots, to compare results and lead to guidelines for choosing tools for rehabilitation of patients. In addition, multicenter trials are needed to determine the outcomes of early application of mirror therapy in stroke rehabilitation.

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