



Original Article

## Effects of mirror therapy combined with motor tasks on upper extremity function and activities daily living of stroke patients

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**Abstract.** [Purpose] The objective of this study was to investigate the effects of mirror therapy combined with exercise tasks on the function of the upper limbs and activities of daily living. [Subjects and Methods] Twenty-five stroke patients who were receiving physical therapy at K Hospital in Gyeonggi-do, South Korea, were classified into a mirror therapy group (n=12) and a conventional therapy group (n=13). The therapies were applied for 30 minutes per day, five times per week, for a total of four weeks. Upper limb function was measured with the Action Research Arm test, the Fugl-Meyer Assessment, and the Box and Block test, and activities of daily living were measured with the Functional Independence Measure. A paired test was performed to compare the intragroup differences between before training and after four weeks of therapy, and an independent t-test was performed to compare the differences between the two groups before and after four weeks of therapy. [Results] In the intragroup comparison, both groups showed significant differences between measurements taken before and after four weeks of therapy. In the intergroup comparison, the mirror therapy group showed significant improvements compared with the conventional therapy group, both in upper limb function and activities of daily living. [Conclusion] The findings of this study demonstrated that mirror therapy is more effective than conventional therapy for the training of stroke patients to improve their upper limb function and activities of daily living.

**Key words:** Mirror therapy, Upper extremity, Stroke

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## INTRODUCTION

Stroke is a disease of the central nervous system caused by partial loss of brain function<sup>1)</sup>, which can lead to motor disorders, perception disorders, language disorders, sensory disturbances, etc., and two out of three patients experience damage to motor function in the upper limbs<sup>2, 3)</sup>. Furthermore, stroke can bring about limitations in activities of daily living, such as eating and dressing/undressing; also, disability in bodily functions develops in about 66% of patients and in activities of daily living in about 75% of patients<sup>4)</sup>. Therefore, the upper limb function of stroke patients is an important factor in daily living that needs to be emphasized in the rehabilitation field<sup>5)</sup>.

Various techniques for recovery of upper limb function in stroke patients have been suggested, including mirror therapy, which is a relatively new treatment that recovers the motor function of the upper limbs by inducing a reorganization of the brain<sup>6)</sup>. Mirror therapy is a therapeutic intervention that uses the motions of the unaffected side of the body, reflected in a mirror, as visual feedback<sup>7)</sup>. This visual feedback enables bilateral motor training and stimulates functional improvement of

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the brain<sup>8)</sup>.

Among recent studies on mirror therapy with stroke patients, Radajewska et al.<sup>9)</sup> verified significant improvements in hand function and activities of daily living through various motor-training exercises of the hands in 60 subacute stroke patients. Thieme et al.<sup>6)</sup> analyzed the effects of mirror therapy in 60 stroke patients who were classified into three groups: individual mirror therapy, group mirror therapy, and a virtual therapy control group. An analysis of the results showed that all three groups improved significantly in motor function, functional levels, and activities of daily living. However, they reported that the individual mirror therapy group showed greater improvement in the spasticity of finger bending compared with the mirror therapy group.

However, there are only a few studies that have investigated the effects of mirror therapy combined with exercise tasks on upper limb function and activities of daily living in stroke patients. Focused and repetitive approaches to tasks promote the recovery of the upper limbs and enhance the motor patterns, agility, and manipulation skills of these limbs<sup>10)</sup>. Therefore in this study, mirror therapy combined with exercise tasks was applied to stroke patients, and the changes in upper limb function and activities of daily living were examined in order to provide reference data for intervention settings aimed at improving these parameters in stroke patients.

## SUBJECTS AND METHODS

The subjects of this study were 25 stroke patients, who were at least six months past their initial diagnosis and who were being treated as outpatients at K Hospital in Seongnam City, Gyeonggi Province, South Korea. The selection criteria were as follows: a diagnosis of hemiplegia due to stroke, stroke of at least 6 months in duration, a score on the Mini-Mental State Examination not lower than 24 points, understood the procedure and purpose of the study, and volunteered to participate in the study. This study was approved by the Institutional Human Research Review Board of Sahmyook University.

The study was structured as a pretest-posttest two-group design. Subjects who signed an informed consent from received a pretest one week before the beginning of the four-week exercise program and a posttest after completion of the program. The pretest and posttest consisted of measurements of upper limb function and activities of daily living. Bias of the tester was minimized through the blinding method. To minimize selection bias, the 25 subjects who had been identified by the selection criteria threw dice before starting the exercises and were classified into the mirror therapy combined with exercise (MT) group if they threw an odd number or to the conventional therapy (CT) group if they threw an even number. Both groups performed one 30-minute exercise session per day, five days per week, for a total of four weeks. Two therapists trained and supervised the subjects during the exercise program.

The subjects in the MT group sat on chairs in front of a desk and bent their hip joints, knee joints, and ankle joints at 90°, with both feet on the floor at shoulder width. A mirror was stood on the desk, parallel with the median line of the body and facing the unaffected upper limb. The size of the mirror was identical to that of the mirror used in the study by Stevens and Stoykov<sup>11)</sup>. Each group performed the tasks with their unaffected side sequentially, from task 1 to task 9, slowly and under the supervision of a therapist. It was agreed that each task would be performed 10 times. The therapists encouraged the subjects to conduct the exercises with purpose while watching themselves in the mirror. The exercise program for the MT group included reaching, grasping, manipulation, towel folding, table wiping, sponge squeezing, pegboard, card turnover, and typing. The therapist randomly chose each exercise task, and the subjects performed the nine tasks alternately for 30 minutes<sup>12, 13)</sup>.

The CT group performed 30-minute training sessions for the improvement of upper limb function and activities of daily living. The subjects performed a total of nine tasks consisting of tasks 1 through 9 (arm bicycling, peg board exercise, skateboard-supported exercises on a tabletop, donut on base putty kneading, double curved arch, bimanual placing cone, block stacking, graded pinch exercise, plastic cone stacking, shoulder curved arch) alternately, while the therapist guided them on how to perform the patterns and tasks accurately.

The Action Research Arm Test (ARAT) is an assessment tool used to identify the functional improvement of an upper limb's performance ability<sup>14)</sup>. It subitems include holding (six items), grasping (four items), picking up (six items), and total movements (three items). The total score for these 19 items is 57, and a higher score is associated with a higher performance level. The inter-rater reliability and test-retest reliability of this test are  $r=0.99$  and  $r=0.98$ , respectively, which are quite high<sup>15)</sup>.

The Box and Block Test (BBT) consists of 2.54 cm cubic wood pieces and a 53.7×8.5×27.4 cm rectangular box with a partition at the center. This test measures the number of wood pieces passed in one minute from one hand to the other after being picked up with one hand. The test-retest reliability of this tool is 0.99 for the left hand and 0.94 for the right hand. The inter-rater reliability is 0.99 for the left hand and 1.00 for the right hand<sup>16)</sup>.

The Fugl-Meyer Assessment (FMA) was developed as an evaluation tool by Fugl-Meyer et al.<sup>17)</sup>, who defined 50 detailed motions based on Brunnstrom's classification of hemiplegia and six-step recovery. The total score for upper limb motor function is 66, including 18 items each for the shoulder, elbow, and forearm, five items for the wrist, seven items for the fingers, and three items for the coordination of the upper limbs. The score may be recorded as a percentage of recovery<sup>18)</sup>. Each small test is performed three times, and the highest score is adopted. The test duration is about 30 minutes. The inter-rater reliability and intra-rater reliability are high at 0.995 and 0.992, and the test-retest reliability interval is 0.94–0.99<sup>19)</sup>.

The Functional Independence Measure (FIM) was developed by Granger and others in 1983. It is divided into two do-

**Table 1.** The general characteristics of the subjects (N=25)

Group variable	MT (n=12)	CT (n=13)
Age (years)	45.2 ± 4.7	52.6 ± 3.0
Weight (kg)	65.3 ± 2.7	67.5 ± 2.0
Height (cm)	162.0 ± 1.9	164.7 ± 1.1
MMSE (score)	26.8 ± 0.5	27.2 ± 0.5
Gender		
Male	8 (66.7%)	8 (61.5%)
Female	4 (33.3%)	5 (38.5%)
Diagnosis		
Infarction	4 (33.3%)	4 (30.8%)
Hemorrhage	8 (66.7%)	9 (69.2%)
Affected side		
Right	4 (33.3%)	5 (38.5%)
Left	8 (66.7%)	8 (61.5%)
Brunnstrom stage		
3	1 (8.3%)	1 (7.7%)
4	6 (50.0%)	6 (46.2%)
5	5 (41.7%)	6 (46.2%)

Values are shown as the N (%) or mean ± SD. MT: mirror therapy group; CT: conventional therapy group; MMSE: Mini-Mental State Examination

General characteristics and dependent variables were calculated using the  $\chi^2$  test and the independent t-test.

mains: functional and perceptual. The FIM instrument comprises 18 items in six categories: self-care, sphincter control, transfers, locomotion, communication, and social cognition. This method can objectively evaluate the activities of daily living and has a high inter-rater reliability, ranging from 0.83 to 0.96<sup>20</sup>).

All statistical analyses in this study were conducted using PASW Statistics 18.0 for Windows. Among the general characteristics of the two groups, Chi-squared tests were used to analyze gender, diagnosis, and Brunnstrom stage. The age, weights, heights, and Mini-Mental State Examination scores of the patients were analyzed through independent sample t-tests. Normality was tested using Kolmogorov-Smirnov tests. Within-group comparisons for all variables were performed by using the paired t-test. Independent sample t-tests were performed to compare paretic upper-extremity function and the abilities of the two groups to perform activities of daily living before and after the intervention. The statistical significance level of all data was set to  $\alpha = 0.05$ .

## RESULTS

The general characteristics of the study subjects are shown in Table 1.

In the intragroup comparison, both groups showed significant differences between measurements taken before and after the four weeks of therapy ( $p < 0.05$ ). In the intergroup comparison, the MT group showed significant improvements compared with the CT group, both in upper limb function and activities of daily living ( $p < 0.05$ ) (Table 2).

## DISCUSSION

Many therapeutic methods based on the principle of brain plasticity are currently applied. Among them, mirror therapy is widely used as a treatment that promotes the functional recovery of paralytic upper limbs by promoting the recovery of motor function and encouraging movement on the affected side. Both groups in the present study showed significant intragroup differences in upper limb function and activities of daily living. The intergroup comparisons revealed that the MT group showed more significant improvements than the CT group.

In this study, both mirror therapy combined with exercise tasks and conventional therapy were applied to stroke patients, and the effect on upper limb function and functional independent measures was investigated. Both groups showed inter-group improvement, and the MT group showed greater improvement in a comparison between the two groups. The upper limb function testing revealed intragroup improvements in both groups, and between the two groups, the MT group showed greater improvements. The findings of this study corresponded with the results of Thieme et al.<sup>6</sup>), who analyzed the effects of mirror therapy on 60 subacute stroke patients classified into individual mirror therapy, group mirror therapy, or virtual therapy

**Table 2.** Comparison of the test results between the two groups (N=25)

Group variable		MT (n=12)	CT (n=13)
ARAT	Pretest	30.5 ± 3.8	30.6 ± 3.2
	Posttest	36.2 ± 3.4*	33.4 ± 3.1*†
FMA	Pretest	31.0 ± 3.5	30.2 ± 2.4
	Posttest	36.9 ± 3.3*	33.6 ± 3.2*†
BBT	Pretest	15.8 ± 2.1	15.2 ± 2.0
	Posttest	20.0 ± 1.5*	18.0 ± 2.5*†
FIM	Pretest	70.5 ± 5.9	68.9 ± 4.6
	Posttest	77.3 ± 6.3*	72.6 ± 4.3*†

Values are shown as the mean ± SD. \*p<0.05, †significantly different in results of posttests between the two groups by Independent t-test. ARAT: Action Reach Arm Test; FMA: Fugl-Meyer Assessment; BBT: Box and Block Test; FIM: Functional Independence Measure

control groups and found that while all three groups exhibited significant improvement in motor function, functional levels, and activities of daily living, the subjects who received individual mirror therapy showed more significant improvement than the subjects who received group mirror therapy in the spasticity of finger bending. The neurological mechanism of these results can be found in the premotor area, which is the core area of motor control and plays a key role in motor recovery after brain damage<sup>21</sup>). Kantak et al.<sup>22</sup>) reported that mirror therapy activated this premotor area, thereby increasing the activity of the partially damaged primary motor area and enhancing residual upper limb motor function. Furthermore, visualization of voluntary movement of the affected upper limb through a mirror can activate the complementary motion area in the bilateral inferior parietal lobe and the primary motion cortex, and this influences the recovery of motor function through reorganization, in which the functions of the damaged part of the brain are substituted by surrounding areas after a stroke<sup>23</sup>).

The FIM results showed intragroup improvement in both groups, and the MT group showed greater improvement between the two groups. This result corresponded with the findings of Invernizzi et al.<sup>24</sup>), who carried out a four-week program of upper limb exercises consisting of mirror therapy and false mirror therapy in 26 stroke patients and found that both groups showed significant improvement in upper limb function and activities of daily living, but the mirror therapy experimental group showed greater improvement than the control group. Our present results are also consistent with a study conducted by Park et al.<sup>25</sup>), who reported that when a mirror therapy program was conducted for 30 stroke patients, upper-extremity functional ability improved, and activities of daily living values increased. Furthermore, the results of the present study also agree with the study of Yavuzer et al.<sup>8</sup>), who found that mirror therapy had significant effects on the recovery of upper limb function in subacute stroke patients and that it also improved the self-care domain of the FIM.

This study is limited in its generalization to all stroke patients, and because the activities of daily living cannot be fully controlled, the possibility of other factors influencing the recovery of upper limb ability and activities of daily living cannot be fully excluded. Furthermore, since the types of tasks were limited, the functional transfer of the upper limbs has limitations. In the future, studies with more functional and diverse tasks are required.

In conclusion, the two groups showed intergroup differences in upper limb function and activities of daily living after four weeks of therapy, and the mirror therapy group showed greater improvement. This result indicates that mirror therapy has positive effects on the recovery of upper limb function and activities of daily living in stroke patients.

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