Effects of Mirror Therapy on Motor and Sensory Recovery in Chronic Stroke: A Randomized Controlled Trial

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Abstract

Objective: To compare the effects of mirror therapy (MT) versus control treatment (CT) on movement performance, motor control, sensory recovery, and performance of activities of daily living in people with chronic stroke.

Design: Single-blinded, randomized controlled trial.

Setting: Four hospitals.

Participants: Outpatients with chronic stroke (N=33) with mild to moderate motor impairment.

Interventions: The MT group (n=16) received upper extremity training involving repetitive bimanual, symmetrical movement practice, in which the individual moves the affected limb while watching the reflective illusion of the unaffected limb’s movements from a mirror. The CT group received task-oriented upper extremity training. The intensity for both groups was 1.5 hours/day, 5 days/week, for 4 weeks.

Main Outcome Measurements: The Fugl-Meyer Assessment; kinematic variables, including reaction time, normalized movement time, normalized total displacement, joint recruitment, and maximum shoulder-elbow cross-correlation; the Revised Nottingham Sensory Assessment; the Motor Activity Log; and the ABILHAND questionnaire.

Results: The MT group performed better in the overall (P=.01) and distal part (P=.04) Fugl-Meyer Assessment scores and demonstrated shorter reaction time (P=.04), shorter normalized total displacement (P=.04), and greater maximum shoulder-elbow cross-correlation (P=.03). The Revised Nottingham Sensory Assessment temperature scores improved significantly more in the MT group than in the CT group. No significant differences on the Motor Activity Log and the ABILHAND questionnaire were found immediately after MT or at follow-up.

Conclusions: The application of MT after stroke might result in beneficial effects on movement performance, motor control, and temperature sense, but may not translate into daily functions in the population with chronic stroke.

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Among people who have experienced a stroke, 55% to 75% have a paretic arm that causes motor impairments1 and experience difficulty in incorporating the affected hand into their activities.2 Although studies have shown that novel interventions, such as robotic-assisted training3 and constraint-induced movement therapy,4 promote motor recovery, these interventions are often costly and labor intensive, consequently limiting their implementation on a larger scale.5,6

Mirror therapy (MT) may be a suitable alternative because of its low cost and simplicity.5,7 In MT, the patient sits in front of a mirror placed in the midsagittal plane. When looking into the mirror, the patient sees the mirror reflection of the intact limb as if it were the affected one. The movement of the intact limb gives the patient the illusion of which inputs are perceived through the affected limb behind the mirror. Substantial evidence has demonstrated the immediate efficacy of MT on motor recovery in
people with stroke. Enhanced performance is often measured by clinical evaluations, such as the Fugl-Meyer Assessment (FMA), or self-report measures of daily function, such as the Motor Activity Log (MAL). These clinical evaluations, however, do not assess aspects of motor control that may be important for understanding the motor learning mechanisms responsible for task improvement. Some have proposed that the visual illusion during MT generates positive feedback to the motor cortex and might remodulate cortical mechanisms of sensation and movement. How the possible cortical changes influence motor control has not been studied.

To address the motor control mechanism, kinematic analyses can be used to detect the spatial and temporal characteristics of upper extremity (UE) movements. Kinematic information, including movement timing, displacement, and multitjoint coordination, might help us understand whether a true increase occurs in skill and movement timing, displacement, and multijoint coordination, might help us understand whether a true increase occurs in skill and movement.

The investigational review board of each participating site approved the study protocol, and participants provided informed consent. Twelve participants dropped out of the study owing to scheduling difficulties at 6-month follow-up.

### Methods

#### Participants

From 4 different hospitals, we recruited 33 participants who lived at home after stroke (table 1). The inclusion criteria were as follows: (1) a first-ever unilateral ischemic or hemorrhagic cerebrovascular accident with onset of more than 6 months; (2) mild to moderate motor impairment (total FMA-UE scores of 26–56); (3) mild spasticity in all joints of the affected limb (Modified Ashworth Scale score <3); and (4) sufficient cognitive ability to follow instructions (Mini-Mental State Examination score ≥24). The exclusion criteria were as follows: (1) participation in another drug or experimental rehabilitation project within 6 months; (2) serious vision or visual perception impairments (eg, neglect and poor visual field) as assessed by the National Institutes of Health Stroke Subscales; and (3) severe neuropsychologic, neuromuscular, or orthopedic disease. The investigational review board of each participating site approved the study protocol, and participants provided informed consent. Twelve participants dropped out of the study owing to scheduling difficulties at 6-month follow-up.

### Design

This study was a single-blinded, randomized controlled trial with pretest, posttest, and follow-up assessments (fig 1). Participants were randomized by stratifying by the lesion side and motor impairment level (FMA-UE scores between 26 and 40 vs between 40 and 66). A set of numbered envelopes was prepared for each stratum that contained cards indicating the allocated group. When a new eligible participant was registered, an envelope was randomly extracted and the relevant therapist was informed of the group allocation. Two certified occupational therapists, blinded to the allocation of each subject, conducted the examinations before the first treatment, immediately after treatment, and at about 6 months after the last treatment.

### Interventions

The intervention was conducted within the regularly scheduled occupational therapy sessions, and all other interdisciplinary rehabilitation proceeded as usual. The primary investigators trained 5 certified occupational therapists to ensure consistent treatment protocols. Treatment intensity, which was matched for both groups, was 1.5 hours/day, 5 days/week, for 4 weeks.

### Mirror therapy

In each session, participants received 60 minutes of MT, followed by 30 minutes of task-oriented functional practice. During

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**Table 1** Characteristics of study participants (n = 33)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>MT (n = 16)</th>
<th>CT (n = 17)</th>
<th>StatisticP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (n)</td>
<td>11</td>
<td>12</td>
<td>0.01</td>
</tr>
<tr>
<td>Male</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>11</td>
<td>12</td>
<td>0.01</td>
</tr>
<tr>
<td>Male</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>54.77 ± 11.66</td>
<td>53.59 ± 10.21</td>
<td>−0.31</td>
</tr>
<tr>
<td>Side of brain lesion (n)</td>
<td></td>
<td></td>
<td>0.26</td>
</tr>
<tr>
<td>Right</td>
<td>8</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>8</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Stroke type, n (%)</td>
<td></td>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>Hemorrhagic</td>
<td>6 ± 37.5</td>
<td>7 ± 41.2</td>
<td></td>
</tr>
<tr>
<td>Ischemic</td>
<td>10 ± 62.5</td>
<td>10 ± 58.8</td>
<td></td>
</tr>
<tr>
<td>Months after stroke onset</td>
<td></td>
<td></td>
<td>0.52</td>
</tr>
<tr>
<td>MMSE score</td>
<td>29.00 ± 1.00</td>
<td>28.06 ± 1.98</td>
<td>−1.65</td>
</tr>
<tr>
<td>Years of education</td>
<td>12.06 ± 4.54</td>
<td>11.79 ± 3.50</td>
<td>−0.19</td>
</tr>
<tr>
<td>NIHSS score</td>
<td>1.20 ± 1.15</td>
<td>1.53 ± 1.55</td>
<td>0.21</td>
</tr>
<tr>
<td>FMA total score</td>
<td>45.94 ± 8.91</td>
<td>44.41 ± 10.89</td>
<td>−0.44</td>
</tr>
</tbody>
</table>

Abbreviations: MMSE, Mini-Mental State Examination; NIHSS, National Institutes of Health Stroke Scale.

* Continuous data are shown as mean ± SD and categorical data as indicated.

1 Statistic associated with the χ² test or the Fisher exact test for categorical variables and with the analysis of variance for continuous variables.

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**List of abbreviations:**

- ADL: activities of daily living
- CT: control treatment
- FMA: Fugl-Meyer Assessment
- MAL: Motor Activity Log
- MT: mirror therapy
- rNSA: Revised Nottingham Sensory Assessment
- UE: upper extremity
the MT training (see fig 2 for setting), participants were instructed to look at the reflection of the unaffected hand in the mirror as if it were the affected hand and perform bilateral symmetrical movements as much as possible. The activities consisted of (1) transitive movements, such as fine motor tasks of squeezing sponges, placing pegs in holes, or flipping a card; (2) gross motor tasks of reaching out to touch a switch or keyboard; and (3) intransitive movements, including the distal part movement of wrist repetitive extension-flexion or finger opponent and the proximal part movement of forearm pronation-supination.

**Control treatment**

The CT provided 90 minutes of traditional therapeutic activities on the basis of task-oriented treatment principles. Functional tasks were selected in accord with the abilities of the participants. The CT focused on improving motor control skills in the affected UE, coordination, and unilateral and bilateral fine motor tasks as well as enhancing static and dynamic standing and sitting, balance, and compensatory practice on functional tasks.

**Outcome measures**

**Primary outcome measures: motor performance—FMA-UE assessment**

The FMA uses a 3-point ordinal scale to assess the level of sensorimotor function in the affected UE. We used only the UE motor function items. The maximum total motor score is 66, with higher scores indicating better motor recovery. The total motor scores were divided into the proximal part (shoulder/elbow/forearm and coordination/speed) and the distal part (wrist and hand). The FMA has high intrarater and interrater reliability.

**Primary outcome measures: motor performance—kinematic analysis**

The participant was asked to press a desk bell while sitting on a chair with his/her trunk restrained to the chairback. The bell was positioned at a distance of 90% of the arm length (from the acromion to the third fingertip) along the participant’s midsagittal plane. If the patient’s maximum reaching distance was less than the functional arm length, the distance was adjusted to the

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Fig 1  Flow chart shows enrollment of patients and completion of study according to the Consolidated Standards of Reporting Trials statement.
maximum reachable distance. After a practice trial, the participant performed the task 3 times for data collection.

A 7-camera motion-analysis system (VICON MX<sup>c</sup>) was linked to a personal computer to capture the movements of markers that were placed on the acromion, middle of the humerus, the lateral epicondyle, the styloid process of the ulna and radius, and the index nail of the affected side. Movements were recorded at 120Hz and digitally low-pass filtered at 5Hz using a second-order dual-pass Butterworth filter. Movement onset was defined as the time when the tangential wrist velocity rose 5% above the peak value for each trial. Movement offset was defined as the bell being pressed and was identified by the digital signal connected to the computer.

An analysis program coded by LabVIEW<sup>b</sup> language was used to process the kinematic data. The variables collected were reaction time, normalized movement time, normalized total displacement, joint recruitments (ie, normalized shoulder flexion, normalized elbow extension, and normalized maximum shoulder abduction angle), and maximum shoulder and elbow cross-correlation. Because the task distance varied across participants, values were normalized as needed.

Reaction time and normalized movement time represent the temporal efficiency of movement. Reaction time is defined by the interval from the start signal to movement onset, and normalized movement time is the interval between the movement onset and offset. Normalized total displacement, indicating the spatial efficiency, refers to the path of the index finger in a 3-dimensional space. Joint recruitment is defined as the change of the joint from the beginning to the end of the movement. The maximum shoulder and elbow cross-correlation represents the maximum similarity of the time-angle waveforms of shoulder and elbow movements as a function of a time-lag applied to the initiation of elbow movement. Higher values of cross-correlation indicate a better interjoint coordination between the shoulder and elbow.34,35

Secondary outcome measures: sensory and ADL functions—Revised Nottingham Sensory Assessment

The Revised Nottingham Sensory Assessment (rNSA) examines sensation impairment using a 3-point scale (0, absent; 1, impaired; 2, normal), with a total score of 48. The tactile subtest, including light touch, temperature, pinprick, pressure, tactile localization, and bilateral simultaneous touch, was administered to the affected shoulder, elbow, wrist, and hand. Higher scores represent better sensory function. The rNSA has good intrarater and interrater reliability.36 Only those participants who scored less than 48 points at pretest, indicating sensation impairments, were included in the data analysis.

Secondary outcome measures: sensory and ADL functions—MAL and ABILHAND

The MAL uses a semistructured interview to assess the amount of use and quality of movement of the affected hand in 30 ADL. Each item is rated from 0 to 5 points, and higher scores indicate better performance. The test has good internal consistency, interrater reliability, and construct validity.37

The ABILHAND questionnaire is a subjective measure examining the participant’s difficulty in performing 23 activities that require bimanual manipulation by using a questionnaire with a 3-point response scale (0, not at all; 1, only partially or with great difficulty and slowly; 2, fully and easily), with a maximum score of 46. The Rasch reliability, responsiveness, and construct validity are high in people with stroke.38

Statistical analysis

Data were analyzed with IBM SPSS 19.0 software. Analysis of covariance was used to control the variance in the pretest scores. The pretest score was the covariate, group was the independent variable, and posttest or follow-up score was the dependent variable. To index the magnitude of group differences in performance, \( \eta^2 = SS_g/SS_{total} \) was calculated for each outcome variable.39 A large effect is represented by an \( \eta^2 \) of at least .14, a moderate effect by .06, and a small effect by .01.40 The alpha level was set to .05. One main point of the present study was to demonstrate the feasibility of adopting kinematic analysis in MT efficacy research and to examine the efficacy at the kinematic parameter level. The sample size of 16 or 17 in 1 group was considered appropriate for the randomized controlled trial at the demonstration-concept stage, such as the current study.41 No multiple testing corrections were made to control type II errors,42 given that the nature of this study was to establish a knowledge base for a novel intervention.43

Results

Participant characteristics

The baseline demographic and clinical characteristics of the participants in the MT and CT groups did not differ significantly (see table 1). No adverse events were reported.

Primary outcome measures: motor performance and kinematic characteristics

The results of the FMA and kinematic variables (table 2) showed significant and large to moderate effects favoring the MT group on the FMA total (\( F_{2,31} = 6.32, P = .009, \eta^2 = .17 \)) and distal part (\( F_{2,31} = 3.25, P = .041, \eta^2 = .10 \)) scores. Kinematic results displayed significant and large effects favoring MT on reaction time.
One-tailed test was used to estimate the effect size (h).

**Discussion**

Our findings were partially consistent with our hypotheses. MT after stroke resulted in beneficial effects on movement performance and motor control, and patients with sensory impairments in the MT group experienced a greater temperature sensation recovery than patients in the CT group. However, patients in the MT group did not demonstrate greater improvements on subjective ADL performance assessments immediately after intervention or at 6-month follow-up.

In accord with previous studies, we found greater improvements in movement performance after MT than after CT, as measured by the FMA. The effects might result from cortical reorganization. MT could provide “proper visual input” and, perhaps, “substitutes” for absent or reduced proprioceptive input from the affected body side. MT might also facilitate self-awareness and spatial attention by activating the superior self-awareness and spatial attention by activating the superior

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Table 2: Descriptive and inferential statistics for primary outcome measures: FMA and kinematic analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pretreatment MT (n=16)</th>
<th>CT (n=17)</th>
<th>Posttreatment MT (n=16)</th>
<th>CT (n=17)</th>
<th>ANCOVA F</th>
<th>P*</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal part</td>
<td>31.13±3.20</td>
<td>30.94±4.48</td>
<td>34.19±3.31</td>
<td>33.18±3.54</td>
<td>2.10</td>
<td>.08</td>
<td>.07</td>
</tr>
<tr>
<td>Distal part</td>
<td>14.81±6.52</td>
<td>13.47±7.53</td>
<td>17.06±5.65</td>
<td>14.71±7.49</td>
<td>3.25</td>
<td>.041</td>
<td>.10</td>
</tr>
<tr>
<td>Total</td>
<td>45.94±8.91</td>
<td>44.41±10.69</td>
<td>51.25±8.14</td>
<td>47.88±9.75</td>
<td>6.32</td>
<td>.011</td>
<td>.17</td>
</tr>
<tr>
<td>Kinematic data</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaction time (s)</td>
<td>0.47±0.10</td>
<td>0.41±0.13</td>
<td>0.41±0.11</td>
<td>0.42±0.16</td>
<td>3.45</td>
<td>.041</td>
<td>.11</td>
</tr>
<tr>
<td>Normalized</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement time (s/mm)</td>
<td>0.009±0.006</td>
<td>0.006±0.002</td>
<td>0.007±0.018</td>
<td>0.006±0.007</td>
<td>1.77</td>
<td>.10</td>
<td>.06</td>
</tr>
<tr>
<td>Total displacement (mm/mm)</td>
<td>2.04±0.83</td>
<td>1.67±0.38</td>
<td>1.70±0.54</td>
<td>1.70±0.57</td>
<td>3.21</td>
<td>.041</td>
<td>.10</td>
</tr>
<tr>
<td>Shoulder flexion (deg/mm)</td>
<td>0.15±0.10</td>
<td>0.16±0.08</td>
<td>0.14±0.04</td>
<td>0.16±0.04</td>
<td>0.84</td>
<td>.18</td>
<td>.03</td>
</tr>
<tr>
<td>Elbow extension (deg/mm)</td>
<td>0.10±0.06</td>
<td>0.10±0.05</td>
<td>0.12±0.06</td>
<td>0.13±0.05</td>
<td>0.23</td>
<td>.32</td>
<td>.01</td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder abduction (deg/mm)</td>
<td>0.17±0.100</td>
<td>0.15±0.08</td>
<td>0.13±0.06</td>
<td>0.15±0.07</td>
<td>2.80</td>
<td>.05</td>
<td>.09</td>
</tr>
<tr>
<td>Shoulder-elbow cross-correlation</td>
<td>0.72±0.17</td>
<td>0.71±0.16</td>
<td>0.79±0.13</td>
<td>0.69±0.16</td>
<td>3.96</td>
<td>.031</td>
<td>.12</td>
</tr>
</tbody>
</table>

NOTE: Values are mean ± SD or as otherwise indicated.
Abbreviation: ANCOVA, analysis of covariance.
* One-tailed P value.
1 η²=SSTb/SStotal.
2 P<.05,

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Table 3: Descriptive and inferential statistics for the rNSA

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pretreatment MT (n=8)</th>
<th>CT (n=6)</th>
<th>Posttreatment MT (n=8)</th>
<th>CT (n=6)</th>
<th>ANCOVA F</th>
<th>P*</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revised NSA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light touch</td>
<td>3.75±3.73</td>
<td>5.50±2.81</td>
<td>5.88±3.40</td>
<td>6.50±1.38</td>
<td>0.07</td>
<td>.40</td>
<td>.01</td>
</tr>
<tr>
<td>Temperature</td>
<td>2.00±2.33</td>
<td>2.50±1.64</td>
<td>4.63±3.34</td>
<td>2.50±1.98</td>
<td>3.71</td>
<td>.041</td>
<td>.25</td>
</tr>
<tr>
<td>Pinprick</td>
<td>4.88±3.48</td>
<td>6.67±3.27</td>
<td>6.50±2.78</td>
<td>7.50±0.84</td>
<td>0.06</td>
<td>.40</td>
<td>.01</td>
</tr>
<tr>
<td>Pressure</td>
<td>5.50±3.12</td>
<td>7.33±1.21</td>
<td>7.38±1.06</td>
<td>7.00±2.00</td>
<td>2.63</td>
<td>.07</td>
<td>.19</td>
</tr>
<tr>
<td>Tactile localization</td>
<td>3.38±3.89</td>
<td>5.83±2.64</td>
<td>5.63±2.67</td>
<td>5.83±3.13</td>
<td>0.53</td>
<td>.24</td>
<td>.05</td>
</tr>
<tr>
<td>Bilateral simultaneous</td>
<td>3.75±3.41</td>
<td>5.83±2.79</td>
<td>5.88±3.00</td>
<td>5.83±3.13</td>
<td>2.24</td>
<td>.08</td>
<td>.17</td>
</tr>
<tr>
<td>Tactile total</td>
<td>23.25±17.87</td>
<td>33.67±12.04</td>
<td>35.88±15.14</td>
<td>35.17±10.65</td>
<td>1.86</td>
<td>.10</td>
<td>.14</td>
</tr>
</tbody>
</table>

NOTE: Values are mean ± SD or as otherwise indicated.
Abbreviations: ANCOVA, analysis of covariance; NSA, Nottingham Sensory Assessment.
* One-tailed P value.
1 η²=SSTb/SStotal.
2 P<.05.
temporal gyrus, precuneus, and the posterior cingulate cortex.\textsuperscript{45,46} Consequently, the experience during MT might help recruit the premotor cortex or balance the neural activation within the primary motor cortex toward the affected hemisphere to facilitate motor improvements.\textsuperscript{45,46} Another finding in the present study is that the improvement of the affected hand in distal motor function—but not proximal motor function—was significantly greater in the MT group. This is consistent with the findings of Dohle and colleagues.\textsuperscript{10} The visual illusion input of the mirror reflection in MT might especially activate the damaged hemisphere.\textsuperscript{18,49,50}

Our findings through kinematic analyses are the first to quantify the changes after MT at the motor control strategy level. As mentioned, MT might induce cortical reorganization and the results showed that shorter reaction time (more efficient in motor preplanning), straighter arm movement (better spatial efficiency in movement execution), and better shoulder-elbow coordination occurred after MT. The findings indicated that MT promoted normalized movement, consistent with a previous study.\textsuperscript{7} However, this previous evidence was through a subjective observation where patients showed improved coordination and fluidity of movements during MT. The positive changes in kinematic parameters we observed here extend the previous knowledge and provide objective evidence of an ongoing motor learning process toward regaining voluntary motor control after MT.\textsuperscript{24}

In contrast, temporal efficiency of movement execution and joint recruitments did not improve significantly more in the MT group than in the CT group. One reason could be that we did not stress movement speed in our treatment protocols. Furthermore, the bell during the experimental reaching task was placed at 90% arm length or the maximum reachable distance at pretest. The distance at pretest was also used as posttest; thus, the task might not have been challenging enough to probe potential gained joint ranges after the intervention.

Temperature sensation improved significantly more in the MT group than in the CT group. The benefits could relate to multimodal neurons.\textsuperscript{7} Multimodal neurons in the posterior parietal and premotor cortical areas respond to sensory stimuli, such as visual input, as well as movement stimuli.\textsuperscript{53} The visual illusion of MT could provide sensory inputs that might modulate the somatosensory cortex network and contribute to the recovery of somatosensation.\textsuperscript{18,27,54,55} In addition, recovery of temperature and pain sensation in patients with stroke usually precedes the recovery of proprioception and light touch.\textsuperscript{56} MT in the present study might have promoted temperature sensation first. Considering that our protocol focused on motor training rather than sensory training, the preliminary results on sensation are promising for further investigation of the effects of MT focusing on specific sensory training.

No significantly better effects on ADL were noted immediately after MT or at follow-up compared with CT. This finding is in accord with the study of Miichelsen et al\textsuperscript{46} and in disagreement with others.\textsuperscript{6,7,11} The inconsistency could be the nature of patients’ living settings and the control groups used. First, the participants in the Yavuzer et al\textsuperscript{6} study lived in rehabilitation centers, unlike our participants, who were outpatients living at home. Our participants might have established a stable ADL routine that was less likely to change over time.\textsuperscript{5} Second, the Sahin et al\textsuperscript{24} study, which reported gains in ADL performance at follow-up, was a case study without a comparison group.

**Study limitations**

The results, especially on the sensory recovery, should be considered with caution because of the preliminary nature and size of this study. A post hoc power analysis on the results of the total tactile assessment revealed that we had a 30% chance to detect a group difference with a type I error of .05. We suggest that future studies recruit 26 participants in each group to improve the chance to 80%.\textsuperscript{7} Besides, our results may be applicable only to people with mild to moderate motor impairment at the chronic stage of stroke living at home. In addition, MT requires participants to focus on perceiving the image in the mirror. We excluded people who could not follow instructions (Mini-Mental State Examination score<24). However, we did not assess the extent to which the participant focused on the mirror image during task practice. Future research may address this compliance issue to study the potential role of this factor in treatment success of MT.

**Conclusions**

This study first reports changes in motor control and presents seminal findings on sensory outcome after MT. Our findings suggest that in addition to positive effects on motor function, MT might improve motor preplanning and spatial efficiency in movement execution and multitjoint coordination and have promising effects on temperature sensation recovery.\textsuperscript{56} Future research on MT might refine our current protocol to study patients with sensory and perceptual deficits using a larger sample size with varying characteristics. To optimize the effects of MT, there is a need to explore the benefits of a hybrid intervention of MT with task-oriented rehabilitation or home-based MT using tele-rehabilitation technology to improve generalizability of the effects of MT to contexts other than the clinic.
Mirror therapy on motor control

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Suppliers

c. IBM SPSS Statistics, Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.

Keywords

Activities of daily living; Motor skills; Rehabilitation; Sensation; Stroke; Upper extremity

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