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ORIGINAL ARTICLE

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

Ching-Yi Wu, ScD, OTR,[a,b] Pai-Chuan Huang, ScD, OTR,[a] Yu-Ting Chen, MS, OT,[a] Keh-Chung Lin, ScD, OTR,[c,d] Hsiu-Wen Yang, MS, OT[e]

From the [a]Department of Occupational Therapy and Graduate Institute of Behavioral Sciences, College of Medicine, Chang Gung University, Taoyuan; [b]Healthy Aging Research Center, Chang Gung University, Taoyuan; [c]School of Occupational Therapy, College of Medicine, National Taiwan University, Taipei; [d]Division of Occupational Therapy, Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital, Taipei; and [e]Division of Occupational Therapy, Department of Physical Medicine and Rehabilitation, Zhongxiao Branch of Taipei City Hospital, Taipei, Taiwan.

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 impairments[1] and experience difficulty in incorporating the affected hand into their activities.[2] Although studies have shown that novel interventions, such as robotic-assisted training[3] 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

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people with stroke.[8,9] Enhanced performance is often measured by clinical evaluations, such as the Fugl-Meyer Assessment (FMA),[5,7,9,10] or self-report measures of daily function, such as the Motor Activity Log (MAL).[11] 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.[12] 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.[11,13-18] 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 multijoint coordination, might help us understand whether a true increase occurs in skill[12,19-23] and reflect the possible MT-induced reorganization of the brain.[24-26]

Given that the visual illusion of MT might modulate the primary somatosensory cortex, MT may facilitate sensory recovery.[19,27] One study[10] has reported a positive effect of MT on light touch. In addition, the benefits of MT on activities of daily living (ADL) are not yet conclusive.[8] Moreover, few studies have reported that MT has prolonged effects after 6 months.[8] The limited evidence that exists suggests that further studies are needed regarding the effects of MT on sensory recovery and ADL immediately after an intervention and at follow-up.[6,10]

From this background, we aimed to examine the effects of MT on motor and sensory recovery. We hypothesized that MT would improve motor performance, motor control strategies, sensory recovery, and daily function more than the control treatment (CT). We also hypothesized that the positive effects on ADL would be retained at 6 months after MT.

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)[28-30]; (3) mild spasticity in all joints of the affected limb (Modified Ashworth Scale score<3)[31]; and (4) sufficient cognitive ability to follow instructions (Mini-Mental State Examination score≥24).[32] 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[33]; 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.

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

Variable	MT (n=16)	CT (n=17)	Statistic†	P
Sex (n)			0.01	.91
Male	11	12		
Female	5	5		
Age (y)	54.77±11.66	53.59±10.21	−0.31	.76
Side of brain lesion (n)			0.26	.61
Right	8	10		
Left	8	7		
Stroke type, n (%)			0.05	.83
Hemorrhagic	6±37.5	7±41.2		
Ischemic	10±62.5	10±58.8		
Months after stroke onset	19.31±12.57	21.88±15.55	0.52	.60
MMSE score	29.00±1.00	28.06±1.98	−1.65	.11
Years of education	12.06±4.54	11.79±3.50	−0.19	.85
NIHSS score	1.20±1.15	1.53±1.55	0.21	.50
FMA total score	45.94±8.91	44.41±10.69	−0.44	.66

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.

† Statistic associated with the χ^2 test or the Fisher exact test for categorical variables and with the analysis of variance for continuous variables.

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).[28] 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

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