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The Effects of Mirror Therapy on Clinical Improvement in Hemiplegic Lower Extremity Rehabilitation in Subjects with Chronic Stroke

Hassan M. Abo Salem, Xiaolin Huang

***Abstract*—**Background: The effectiveness of mirror therapy (MT) has been investigated in acute hemiplegia. The present study examines whether MT, given during chronic stroke, was more effective in promoting motor recovery of the lower extremity and walking speed than standard rehabilitation alone. Methods: The study enrolled 30 patients with chronic stroke. Fifteen patients each were assigned to the treatment group and the control group. All patients received a conventional rehabilitation program for a 4-week period. In addition to this rehabilitation program, patients in the treatment group received mirror therapy for 4 weeks, 5 days a week. Main measures: Passive ankle joint dorsiflexion range of motion, gait speed, Brunnstrom stages of motor recovery, plantar flexor muscle tone by Modified Ashworth Scale. Results: No significant difference was found in the outcome measures among groups before treatment. When compared with standard rehabilitation, mirror therapy improved Ankle ROM, Brunnstrom stages and waking speed ($p < 0.05$). However, there were no significant differences between two groups on MAS ($P > 0.05$).Conclusion: Mirror therapy combined with a conventional stroke rehabilitation program enhances lower-extremity motor recovery and walking speed in chronic stroke patients.

***Keywords*—**Mirror therapy, stroke, MAS, walking speed.

I. Introduction

STROKE is the leading cause of death and adult disability in the China [1], with about 2.5 million new strokes reported each year and 7.5 million stroke survivors [2].Among people who have experienced a stroke, 72% have motor impairments in the lower limb [3]. Mirror therapy is a new modality designed to improve the recovery of paretic limbs after stroke. Mirror therapy was initially introduced by Ramachandran and colleagues for the treatment of phantom limb pain [4]. In the late 1990s, Altschuler et al. introduced mirror therapy for stroke rehabilitation; they reported that mirror therapy improved range of motion, speed and dexterity of the affected arm [5]. Since then, a number of trials have reported the effect of mirror therapy in the treatment of upper limb impairment after stroke. Although various studies reported a significant positive effect of mirrortherapy on motor function [6] and reduced pain in patients with complex regional pain syndrome type I after stroke [7], the possible mechanism remains unclear. Sütbeyaz et al. reported that 4 weeks of mirror therapy resulted in a significant improvement in lower limb motor recovery and function in subacute stroke patients [8].The main purpose of this study is to investigate the effectiveness of the mirror therapy on motor recovery and gait speed in chronic stroke patients.

Hassan M. Abo Salem is Assistant lecturer at the Department of Physical Therapy for the Neuromuscular Disorders and its surgery, Faculty of Physical Therapy, Cairo University, Egypt and a PhD candidate, Department of Rehabilitation, Tongji Hospital Affiliated to Tongji Medical College, Huazhong University of Science and Technology, China (phone: 0086-152-509-920-76; e-mail: dr_hassan1983@yahoo.com).

Xiaolin Huang is a Professor and Head, Department of Rehabilitation, Tongji Hospital Affiliated to Tongji Medical College, Huazhong University of Science and Technology, China.

II. Methods

A. Participants

Thirty patients with hemiplegia were enrolled in this study. The patients were randomly assigned into two groups. Fifteen patients were assigned to the experimental group and 15 patients to the control group. The inclusion criteria were:(1) First episode of unilateral stroke with hemiparesis, (2) disease duration with more than 12 months, (3) ability to walk with supervision and/or with aids >10 meters, (4) ability to understand and follow simple verbal instructions.

The exclusion criteria were: (1) any pre-existing neurological disorder other than the stroke, (2) any additional psychological or medical condition that would affect patient's ability to comply with study protocol, (3) patients with impaired vision or aphasia, (4) fixed ankle or foot contracture.

B. Intervention

Both the experimental group and the control group received in a conventional stroke rehabilitation program 5 days a week, 2 to 5 hours a day, for 4 weeks. The conventional program was patient-specific and consisted of occupational therapy, physiotherapy, electrotherapy, neurodevelopmental facilitation techniques and gait training.

The experimental group received an additional 30 min of MT training. The patients were instructed to remain in sitting position with a mirror (60 cm × 90 cm) was positioned between the two legs perpendicular to the subject's midline. During the MT training, the reflecting side of the mirror was adjusted to the non-affected leg and patients were instructed to look at the reflection of the unaffected leg in the mirror as if it were the affected leg and perform bilateral symmetrical movements as much as possible. The practices consist of (1) hip-knee-ankle flexion, (2) ankle dorsiflexion, (3) ankle eversion. The control group performed the same exercises for the same duration but used the nonreflecting side of the mirror. The same therapist delivered the mirror or sham therapy to the patients.

C. Outcome Measures

All patients went through a comprehensive clinical evaluation before and 4 weeks after the treatment. Clinical evaluations were always performed by the same investigator. The parameters of this evaluation were as follows:

1) Ankle passive dorsiflexion range of motion (ROM) was measured goniometrically. The axis of the goniometer was placed 2 cm below the medial maleolous, while its moving arm placed along the long axis of first metatarsal bone and its fixed arm was placed along the long axis of leg. Then the therapist passively moved ankle joint toward dorsiflexion until any resistance was felt. Then placing the moving arm to the new position of the first metatarsal to measure the total free range of motion of ankle dorsiflexion. The average of three measurements was calculated and considered to be the dorsiflexion range of motion [9].
2) Spasticity of the affected ankle plantar-flexors was assessed with the modified Ashworth scale (MAS). The modified Ashworth scale was used to measure plantar flexors spasticity [10]. The MAS is a five-point scale to score the average resistance that is felt during passive movement of the ankle joint. A MAS of 0 indicates "normal tone", while a MAS of 4 indicates that the "rigid limb in flexion or extension". To facilitate statistical analysis, MAS scores (0, 1, 1+, 2, 3 and 4) were changed to (0, 1, 2, 3, 4 and 5, respectively [11]. For this test, the patient assumes supine lying position with his head in mid position. The therapist with one hand grasp forefoot below the ball of the foot and the other hand is placed just above ankle joint. Then the therapist passively move the ankle joint in plantarflexion and dorsiflexion through the available ROM trying to estimate the amount of resistance that is felt according to modified Ashworth's scale [12].
3) Motor recovery of lower-extremity was assessed by using the Brunnstrom stages for the lower extremity. The 6 grades of the Brunnstrom stages for the lower extremity are as follows: (1) flaccidity, (2) synergy development (minimal voluntary movements), (3) voluntary synergistic movement (combined hip flexion, knee flexion, and ankle dorsiflexion, both sitting and standing), (4) some movements deviating from synergy (knee flexion exceeding 90° and ankle dorsiflexion with the heel on the floor in the sitting position), (5) independence from basic synergies (isolated knee flexion with the hip extended and isolated ankle dorsiflexion with the knee extended in the standing position), and (6) isolated joint movements (hip abduction in the standing position and knee rotation with inversion and eversion of the ankle in the sitting position) [13].
4) Gait speed was recorded by 10-Meters Walk Test (Fig 1). 10-Meters Walk Test is quick, simple and can be done easily in the clinic or at home. For this test, participants at least can ambulate 10 meters. The test is established with a length of 14 meters by marking at 0 meters, 2 meters, 12 meters and 14 meters. Patients were asked to stand behind the start point (0 meters) and to walk until they crossed the end point (14 meters). A stopwatch was started when the subject walked cross the start point and stopped when he or she crossed the end point to measure the time taken in seconds to walk the middle 10 m of a 14-metre walkway [14].

III. Statistical Analysis

The independent Student's t –test was used to compare the baseline between the two experimental groups. The pre-treatment and post-treatment measures were compared using paired sample t-test to find any significant change in the recorded values. Obtained results were reported as mean ± standard deviation values and Significance was set at 5%.

IV. Results

A summary of the demographic and clinical features of the patients (n = 30) is shown in Table I, There were no significant differences between the two groups in age, gender, sex, time since stroke, side of hemiplegia and stroke type, baseline PROM of ankle dorsiflexion, Modified Ashworth Scale score of ankle plantarflexor muscles, Brunnstrom stages of lower extremity and walking velocity ($P > 0.05$).

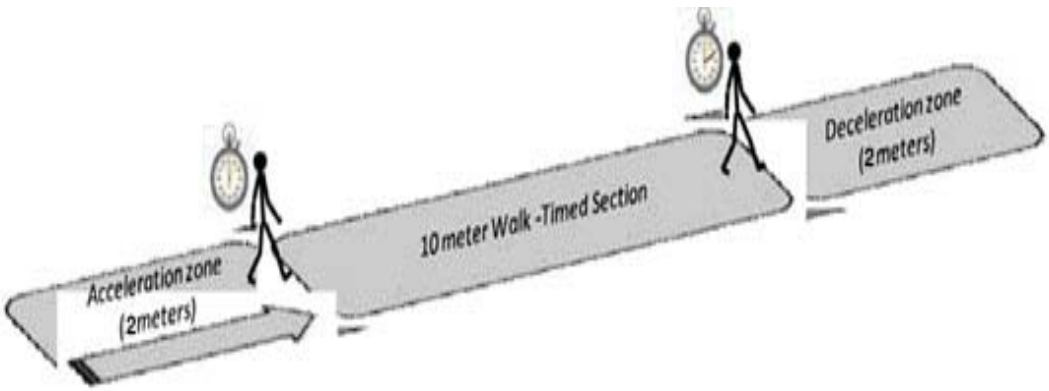

Fig.1 10-Metre Walk-Test

TABLE I
SUBJECT CHARACTERISTICS

	Experimental group	Control group
Sex (male/female)	8 /7	7/8
Age (year)	60 ± 8.97	59.1 ± 9.1
Time since stroke(Months, Mean ± SD)	14.9 ± 1.83	15.4 ± 1.28
Stroke Type(hemorrhage/ infarction)	5/1 0	4/11
Side of Rigidity(R/L)	9/6	8/7
Height (cm)	161 ± 4.03	164 ± 3.94
Weight (kg)	60.3 ± 4	63 ± 4.61

Note: Values are mean± SD, or n.

TABLE II
MEASURED PARAMETERS BEFORE AND AFTER INTERVENTION IN BOTH EXPERIMENTAL GROUPS

Measured parameters	Pretreatment			Pos treatment	
	Experimental group	Control group		Experimental group	Control group
	Mean (SD	Mean (SD)	P -value	Mean (SD) Within-group P -value	Mean (SD) Within-group P -value
Ankle joint dorsiflexion PROM	15.9±2.33	15 ±1.49	0.132	19.9 ±2.46 0.0001	16.95±2.14 0.0002
Modified Ashworth Scale of ankle planterflexor	2.75±0.72	2.9±0.79	0.533	2.47± 4.03 0.104	2.68±0.75 0.187
Lower extremity BS	3.1±1.21	2.8±1.15	0.427	3.79±1.23 0.0001	3.16±1.21 0.0034
10 m walk test	0.641±0.34	0.609±0.318	0.22	0.724±0.34 0.0001	0.584±0.28 0.76

The ages of the patient ranged between 28 and 73 years. Experimental group comprised of 8 (53%) male patients and 7(47%) female patients, and the control group comprised of 7 (47%) male and 8 (53%) female patients. Experimental group comprised of 9 right (60%) and 6 left (40%) hemiplegic patients, and the control group comprised of 8 right (53%) and 7 left (47%) hemiplegic patients. The demographic characteristics of the patients are shown in Table I

Table II presents the measured parameters before and after intervention in both groups. The assessed outcome parameters of Brunnstrom stages of lower extremity and PROM of ankle dorsiflexion improved significantly in both the groups after treatment($p < 0.05$).Only the members of the experimental group showed a significantly greater amount and percentage increase in gait velocity ($p < 0.0001$). There was no significant improvement in MAS in experimental and control group ($p < 0.104$ and $p < 0.187$, respectively).

V. DISCUSSION

This study reveals that MT of the paretic leg in addition to a conventional rehabilitation program provide additional benefit in terms of lower-extremity motor recovery and gait speed in chronic stroke patients. However, we found no effect on spasticity. Thieme et al. carried out a systematic review to summarize the effectiveness of MT for improving motor function, activities of daily living, pain, and visuospatial neglect in patients after stroke. They reported that MT may have a positive effect on motor function, ADL, and pain but they found limited evidence for improving visuospatial neglect [15]. In a randomized controlled study with subacute stroke patients, Sutbeyaz et al. reported that MT improved lower extremity motor and function recovery more than sham therapy [8]. In the present study, lower extremity motor recovery was measured with 6 grades Brunnstrom stages for the lower extremity range from 1 (flaccidity) to 6 (isolated joint movement). This study has shown improvement in BS stages of the lower extremity by 80% in the experimental group and 45% in the control group. To our knowledge, ours is the first study to investigate the effects of mirror therapy on gait speed of stroke patients. Gait speed was shown to be a very important prognostic factor for lower limb recovery after stroke [16]. Burridge et al. reported that a 10% improvement in gait velocity was considered to be functionally relevant [17]. In the present study, only the experimental group (20%) showed significant improvement in gait speed. These results showed significant beneficial effects of mirror therapy on motor recovery and gait speed after stroke, although these effects were only assessed immediately after the intervention and no long-term effect of the mirror therapy modality was assessed by the study. However, other studies showed that the effects of mirror therapy may last for up to six months in stroke patients [8], [18]. Sütbeyaz et al. conducted a study in which 40 stroke patients were randomly assigned to either the mirror group or control group; there was a significant change in the FAC score of both groups, but no significant difference between groups [18]. Previous studies reported that the treatment only using mirror therapy have no significant effect in reducing muscle tone in stroke patients [18], [19]. The results of the present study also showed there was no significant improvement in MAS in experimental and control group. Although the mechanism of MBT remains unclear, the mechanism of the effect of mirror therapy on motor recovery after stroke has been investigated in a number of studies. There are several theories, which can be classified into two common mechanisms: a primary motor cortex mechanism and a mirror neuron system mechanism [20]. Another possible mechanism for the effectiveness of the mirror therapy might

be bilateral limb movements [18]. Summers et al. reported that bilateral training intervention was more effective than unilateral training in facilitating upper-limb motor function in chronic stroke patients [21]. In the present study we asked patients to move the paretic ankle as much as they could while moving the non-paretic ankle and watching the reflection in the mirror. The limitations of the present study are the number of participants was small and we did not use imaging techniques that might have demonstrated the primary motor cortex mechanism and the mirror neuron system mechanism of the mirror therapy. Further studies are needed to investigate the long-term effects of mirror therapy on spasticity and also on the functional activity of spastic patients.

VI. Conclusion

Rehabilitation programme combining function electrical stimulation and mirror therapy is safe, feasible and acceptable to stroke patients. This study shows that the clinical implementation of the mirror therapy together with conventional rehabilitation program may increase PROM of ankle dorsiflexion, improve BS stages of lower limb and also provides greater amount and percentage increase in gait velocity.

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References

[1] L. Liu, D. Wang, K. S. L. Wong, and Y. Wang, "Stroke and stroke care in China," Stroke, vol. 42, 2011, pp. 3651–3654.
[2] S. C. Johnston, S. Mendis, and CD. Mathers, "Global variation in stroke burden and mortality: estimates from monitoring, surveillance, and modeling. Lancet Neurol," vol.8, 2009, pp. 345–354.
[3] American Heart Association, "Heart disease and stroke statistics," Dallas, TX, American Heart Association, 2005.
[4] V. S. Ramachandran, D. Rogers-Ramachandran and S. Cobb, "Touching the phantom limb," Nature, vol. 377, 1995, pp. 489-490.
[5] E. L. Altschuler, S. B. Wisdom SB, L. Stone L, et al., "Rehabilitation of hemiparesis after stroke with a mirror," Lancet, vol. 353, 1999, pp. 2035-2036.
[6] H. Thieme H, J. Mehrholz, M. Pohl, J. Behrens, and C. Dohle, "Mirror therapy for improving motor function after stroke," Cochrane Database Syst Rev, vol. 3, 2012, CD008449.
[7] C. S. McCabe, R. C. Haigh, E. F. Ring, P. W. Halligan, P. D. Wall, and D. R. Blake, "A controlled pilot study of the utility of mirror visual feed-back in the treatment of complex regional pain syndrome (type 1)," Rheumatology, vol. 42, 2003, pp. 97-101.
[8] S. Sutbeyaz, G. Yavuzer, N. Sezer, and B.F. Koseoglu, "Mirror therapy enhances lower-extremity motor recovery and motor functioning after stroke: arandomizedcontrolled trial," Archives of Physical Medicine and Rehabilitation, vol. 88. No. 5, 2007, pp. 555 –559.
[9] A. H. Bakhtiary, and E. Fatemy, "Does electrical stimulation reduce spasticity after stroke? A randomized controlled study." Clinical Rehabilitation 22, no. 5 (2008): 418-425.
[10] R. W. Bohannon and M. B. Smith MB, "Internal reliability of a modified Ashworth scale of muscle spasticity," J PhysTher 1987; 67:206–208.
[11] K. S. G. Chua, K. H Kong, and Y. C. Lui, "Botulinum toxin A in the treatment of hemiplegic spastic foot drop: clinical and functional outcomes," Singapore Med J 2000; 41: 209–213.
[12] J. W. Lance, and J. G. McLeod, A Physiological Approach to Clinical Neurology. London: Butterworth.1981.
[13] C. L. Chen, H. C. Chen, S. F. Tang, C. Y. Wu, P. T. Cheng, and W. H. Hong, "Gait performance with compensatory adaptations in stroke patients with different degrees of motor recovery, " Am J Phys Med Rehabil 2003; 82:925-35.
[14] D. T. Wade DT. Measurement in neurological. Oxford: Oxford University Press, 1992.
[15] H. Thieme, J. Mehrholz, M. Pohl, J. Behrens, and C. Dohle, "Mirror therapy for improving motor function after stroke," Stroke, Cochrane Data base Syst Rev 3, vol. 44, 2013, CD008449.
[16] Wade DT, Wood VA, Heller A, Maggs J, Langton Hewer R. Walking after stroke. Measurement and recovery over the .rst 3 months. Scand J Rehabil Med 1987; 19: 25–30.
[17] J. H. Burridge, I. D. Swain, and P. N. Taylor, "Functional electric stimulation: a review of the literature published on common peroneal nerve stimulation for the correction of dropped foot," Rev ClinGerontol vol. 8, 1998, pp.155-61.
[18] G. Yavuzer, R. Selles, N. Sezer, S. Sütbeyaz, J. B. Bussmann, F. Köseoğlu, M. B. Atay, and H. J. Stam, "Mirror therapy improves hand function in subacute stroke: a randomizedcontr- olled trial," Arch Phys Med Rehabil. Vol. 89, no. 3, 2008, pp. 393-8.
[19] M. F.Michielsen, R. W. Selles, J. N. Van Der Geest, M. Eckhardt, G. Yavuzer, H. J. Stam, M. Smits, G. M. Ribbers, J. B. and Bussmann, "Motor recovery and cortical reorganization after mirror therapy in chronic stroke patients: a phase II randomized controlled trial,"Neurorehabil Neural Repair. 2011, 25(3):223-33.
[20] K. Lamont, M. Chin, and M. Kogan, "Mirror box therapy: seeing is believing," Explore (New York, N.Y.), vol. 7, no. 6, 2011, pp. 369 e 372.
[21] J. J. Summers, F. A. Kagerer, M. I. Garry, C. Y. Hiraga, and A. Loftus, and J. H. Cauraugh JH, "Bilateral and unilateral movement training on upper limb function in chronic stroke patients: a TMS study," J NeurolSci 2007; 252:76-82.