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Effects of mirror therapy in recovering strength and function of the upper limbs in chronic stroke patients: A randomized controlled trial

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Background : *Stroke is one of the biggest healthcare problems in developing countries. Majority of the stroke patients have persistent upper limbs motor impairment. One of the promising methods to assist motor improvement is mirror therapy. However, the evidence supporting efficacy of this intervention in chronic stroke patients is limited, due to small sample size and non-RCTs in most currently available studies.*

Objective : *To investigate whether mirror therapy, as an adjunct program, can help chronic stroke survivors regain their upper limbs' motor functions, hand-related functions and reduce spasticity.*

Methods : *Forty-four chronic stroke patients were divided into 2 groups, who underwent clinical assessment for adjunct mirror therapy versus placebo. Clinical data of both the intervention and placebo were compared at baseline, 2, 4, 8 and 12 weeks. Brunnstrom stage of recovery, motor assessment scale of the upper extremity, modified Ashworth scale, and tip and lateral pinch gauges were assessed after the intervention at baseline, weeks: 2, 4, 8 and 12.*

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Results : *There were significant improvements within the intervention group when compared to the baseline levels for Brunnstrom hand and arm, Barthel activity as early as 2 weeks, and Motor Assessment Scale and lateral pinch strength as early as 8 weeks. This improvement also continued until the end of the study. Significant recovery between the groups was seen for the Brunnstrom hand at only 2nd week.*

Conclusion : *Mirror therapy with the conventional rehabilitation program may help to improve the Brunnstrom recovery stage for hand as early as 2nd week when compared with the sham therapy. The use of mirror therapy is simple, easy, cheap and can be done at the home.*

Keywords : *Mirror therapy, Brunnstrom stage of recovery, Motor assessment scale, chronic stroke, Activity of daily living.*

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จิรภา แจ่มไพบูลย์, วันเผด็จ สนธิ์ทิม, ราเมศ เรืองอยู่, กฤษณา พิรเวช. ผลการฝึกโดยใช้ภาพสะท้อนกระจกเงาต่อการฟื้นตัว และการใช้งานของแขนและมือในผู้ป่วยโรคหลอดเลือดสมองเรื้อรัง: การทดลองแบบสุ่มมีกลุ่มควบคุม. จุฬาลงกรณ์เวชสาร 2560 มี.ค. – เม.ย.; 61(2): 165 – 81

เหตุผลของการทำวิจัย : *ต้องการศึกษาผลของการใช้ภาพสะท้อนจากกระจกเงา (Mirror therapy) ร่วมการการฟื้นฟูแบบมาตรฐานต่อการฟื้นตัว และการใช้งานของแขนและมือข้างที่อ่อนแรงในผู้ป่วยโรคหลอดเลือดสมองเรื้อรัง เพื่อนำมาใช้เป็นแนวทางในการฟื้นฟูผู้ป่วยกลุ่มนี้*

วัตถุประสงค์ : *เพื่อศึกษาผลของการใช้ภาพสะท้อนจากกระจกเงาต่อการฟื้นตัวและการใช้งานของแขน และมือข้างที่อ่อนแรงในผู้ป่วยโรคหลอดเลือดสมองเรื้อรัง*

วิธีการศึกษา : *ผู้ป่วยโรคหลอดเลือดสมองที่มีภาวะอ่อนแรงครึ่งซีก และมีระยะเวลาเป็นโรคนานมากกว่า 3 เดือน ถูกสุ่มออกเป็น 2 กลุ่ม โดยในกลุ่มทดลองได้รับการฟื้นฟูแบบมาตรฐาน ร่วมกับการฝึกโดยภาพสะท้อนกระจกเงาโดยให้มองภาพในกระจกเงาขณะใช้มือทำกิจกรรมต่าง ๆ ใช้เวลาฝึกครั้งละ 30 นาที จำนวน 10 ครั้ง ส่วนในกลุ่มควบคุมได้รับการฝึกเช่นเดียวกันแต่กลับด้านกระจกเพื่อไม่ให้เห็นภาพสะท้อน การฟื้นตัว (Brunnstrom stage of recovery) ของมือและแขน การทำกิจวัตร ประจำวัน (Barthel ADL index) การใช้งานของมือและแขน (Motor assessment scale) แรงบีบนิ้ว (Lateral and tip pinch strength) ทำการประเมินเมื่อสิ้นสุดสัปดาห์ที่ 2, 4, 8 และ 12 หลังได้รับการทดลอง*

ผลการศึกษา : *ผู้ป่วยทั้งหมดจำนวน 44 ราย อายุเฉลี่ยของกลุ่มทดลอง 54.9 ± 11.9 ปี และกลุ่มควบคุม57.0 ± 10.0 ปี ค่ากลางของระยะเวลาเป็นโรคหลอดเลือดสมอง 4 - 4.5 เดือนเมื่อเปรียบเทียบระหว่าง 2 กลุ่ม พบว่าในกลุ่มทดลองมีการฟื้นตัวของมือ (Brunnstrom recovery stage hand) เพิ่มขึ้นอย่างมีนัยสำคัญ เมื่อสิ้นสุดสัปดาห์ที่ 2 ($P < 0.05$) ส่วนการฟื้นตัวของแขน (Brunnstrom recoverystage arm) การใช้งานของแขนและมือ (motor assessment scale) การทำกิจวัตรประจำวัน (Barthel ADL index) แรงบีบนิ้วมือ (Lateral and tip pinch strength) และการเกร็งของกล้ามเนื้อ (Modified Ashworth Scale) ไม่มีความแตกต่างทางสถิติเมื่อสิ้นสุดสัปดาห์ที่ 2, 4, 8 และ12*

สรุป : *การฝึกด้วยภาพสะท้อนกระจกเงาร่วมกับการฟื้นฟูแบบมาตรฐานเป็นเวลา 2 สัปดาห์ สามารถเพิ่มการฟื้นตัวของมือในผู้ป่วยโรคหลอดเลือดสมองเรื้อรังได้ดี กว่ากลุ่มควบคุม*

คำสำคัญ : *โรคหลอดเลือดสมอง, ภาพสะท้อนกระจกเงา, การฟื้นตัว, การเกร็งของกล้ามเนื้อ, การทำกิจวัตรประจำวัน.*

Stroke burden, especially hemiplegia, continues to be one of the biggest healthcare problems in developing, resource-limited countries where in one-third of the stroke survivors end up with long-term, permanent, serious disability. [1–8] This type of post-stroke disabling sequelae usually has an enormous, catastrophic impact on the disability-adjusted life year (DALY) worldwide. [1, 6] Almost half of the survivors are chronic stroke patients and tend to have moderate to severe paralysis. Majority of these patients cannot fully recover their upper limb motor functions even with the standard, conventional stroke rehabilitation.[9]

Many studies[10–13] have shown the benefit of mirror therapy in improving the upper limb motor function in acute, and subacute stroke survivors. Even the range of motion (ROM), speed, and accuracy of the movement of the arm significantly improved post-therapy in chronic stroke patients. [10] Alschuler EL, *et al* showed that two weeks of intense mirror therapy can help improve the patient's grip strength and hand movement of the paretic arm in a chronic stroke patient, and suggested that the mechanism of this improvement may be due to the illusion of normal arm movement in the mirror that substitute the decrease proprioceptive input, by which helping to recruit the premotor cortex and facilitating motor rehabilitation through an intimate connection between premotor area amd visual input.[10] Likewise, mirror therapy for 3 to 4 weeks have been shown to increase the Fugl-Meyer assessment score, active ROM, movement speed, and hand dexterity among stroke survivors lasting even up to 6 months post-intervention. [12–14]

However, the small sample size and non-randomization of these trials have cautioned the authors to assess the efficacy of the intervention. In addition, mirror therapy has not been investigated in chronic stroke survivors with a wide variety of paralysis of the upper limb. Most of the patients in these studies were assigned the simple movements for the non-paretic hand during the mirror therapy. Therefore, the authors assessed the effect of mirror therapy comparing it to the sham therapy as an adjunct intervention with the standard, conventional stroke rehabilitation therapy among chronic stroke survivors with a mild, moderate and severe paralysis of the upper limb.Since majority of the survivors are chronic stroke patients, the outcomes of this study will be highly beneficial for countries with limited resources.

Methods

Type of study

This is a randomized, controlled, single-blind assessor clinical trial comparing the effects of mirror therapy to sham therapy.

Participants

Forty-four chronic stroke patients were recruited from the rehabilitation center of the Thai Red Cross Rehabilitation Center and the Department of Rehabilitation Medicine, King Chulalongkorn Memorial Hospital from August 2011 to September 2013. Patients with the following criteria were recruited into the study: 1) It was the first episode of stroke of the patient which was diagnosed by a neurologist and confirmed by the computed tomography or magnetic resonance imaging with hemiplegia / hemiparesis for more than

12 weeks; 2) age more than 18 years old;3) the patient can understand and follow two steps of command; 4) have a Brunnstrom score[15, 16] between stages I and IV for the arm and hand; 5) the patient can sit with / without support for more than 30 minutes; 6) the patient does not have any severe cognitive disorders (Thai Mental State Examination (TMSE) score > 24)[17]; 7) the patient does not have any other disorder of the paretic limb, and 8) the patient has signed the informed consent form (with or without relatives) to participate in the study. Those who were non-cooperative, having any medical problem(s), could not tolerate the rehabilitation program, having sensory / global aphasia, severe spasticity of the arm / hand (Modified Ashworth Scale (MAS) ≥ 3). [18] and/or severe neglect were excluded from the study.

Randomization

Patients were divided into two groups using blocked randomization technique: mirror therapy (intervention group) and the control group (sham therapy). Random numbers were generated by blocks of four. A research assistant performed the randomization process as follows: the blocks were numbered, then a random-number generator program was used to select the numbers to establish a sequence of blocks that were allocated to either the intervention or sham group.A medical doctor who was blinded to the research protocol and not involved in the trial operated the randomized number program.

Intervention

Standard Stroke Rehabilitation Program

All participants were in the standard stroke rehabilitation program, 5 days a week, 6 hours a day, for 8 weeks. The standard program was patient-specific and consisted of neurodevelopmental facilitation techniques, physiotherapy, occupational therapy, and speech therapy (if needed).

Mirror Therapy

Patients in the intervention group received an additional 30 minutes /session of mirror therapy program, 5 days a week for 2 weeks under an occupational therapist. During the mirror practices, the patient was seated close to a table which had a mirror sized40 × 60 cm on top of it. The paretic hand was placed behind the mirror and the non-paretic hand in front of the mirror. The practice consisted of non-paretic side movements such as: wrist and finger flexion and extension, picking up the tennis ball and putting it in the basket, picking up various sizes of pins, holding the glass and putting it down while the patient looked at the mirror, watching the image of his / her non-paretic hand, thus seeing the reflection of the hand movement projected over the paretic hand.The patients could only see the non-paretic hand in the mirror. During the session, the patients were asked to try to do the same movements with the paretic hand. Two occupational therapists were assigned to deliver the mirror therapy.

Sham treatment

The control group performs the same exercises for the same duration but uses the nonreflecting side of the mirror in such a way that the paretic hand was hidden from sight. Two occupational therapists from above also provided sham treatment.

Sample size calculation

The sample size was calculated by using the data from Yavuzer G, *et al*.[13] based on the prevalence of the Brunnstrom stage, this study would require 25 subjects per group.

Outcome measurements

The following measurement tools were used in this study: Brunnstrom stage of recovery.[15, 16], MAS[18], Barthel Activity of Daily Living (ADL) Index[19], Motor Assessment Scale (Thai version)[20], and the lateral pinch strength, and tip pinch strength. The Brunnstrom stage of recovery was used to measure the recovery of the arm and hand.[15, 16] The motor assessment score was used to evaluate the function of the upper extremities.[20] After the completion of the treatment sessions, patients in both the mirror and control groups were re-assessed with the Brunnstrom stage of recovery, MAS, motor assessment scale (Thai version), Barthel ADL Index, and lateral pinch strength and tip pinch strength 3 times by using B & L Engineering pinch gauge at 2, 4, 8 and 12 weeks. At each visit, the measurements were done by the assessor who was blinded to treatment allocation.

The following information were collected and captured for analysis: 1. General geographic data; 2. General health characteristics, TMSE, Brunnstrom stage of recovery, MAS; and 3. Functional assessment data such as Barthel ADL Index, motor assessment scale (Thai version) and lateral pinch strength and tip pinch strength.

Detailed information and rationale of the study were provided to all of the participants before the screening process. Written informed consents were obtained from all participants and/or relatives prior to any procedures being performed. This study has been approved by the Institution Review Board of the Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand, registered in the Thai Clinical Trials Registry (TCTR20140903002), and was conducted according to the ICH8 and good clinical practice (GCP).

Statistical analysis

SPSS version 16 for Windows (SPSS Inc., Chicago, IL, USA) was used. The patients' baseline data were qualitatively analyzed and demonstrated by using the mean, standard deviation, number and percentages. Repeated measures ANOVA, post-hoc analysis with a Bonferroni correction was used to compare the results of the therapy, pre- and post-treatment, within the groups. A *P*-value of < 0.05 was considered statistically significant. Mann-Whitney U test was used to compare the results of the therapy between the groups with Bonferroni-adjusted *P* values of < 0.0125 was considered statistically significant ($\alpha = 0.05/4$). Chi-square test were used to analyze number of patients with Brunnstrom change from baseline to 2, 4, 8, and 12 weeks between groups. A *P*-value of< 0.05 was considered statistically significant.

Results

A total of 44 patients from the Thai Red Cross Society and the Department of Rehabilitation Medicine of King Chulalongkorn Memorial Hospital were recruited into the study from August 2011 to September 2013. One patient in the mirror group withdrew and one was lost to follow-up. Two patients in the control group were also lost to follow-up. Therefore, there were 40 patients who finished the study.The study flow chart is shown in Figure 1.

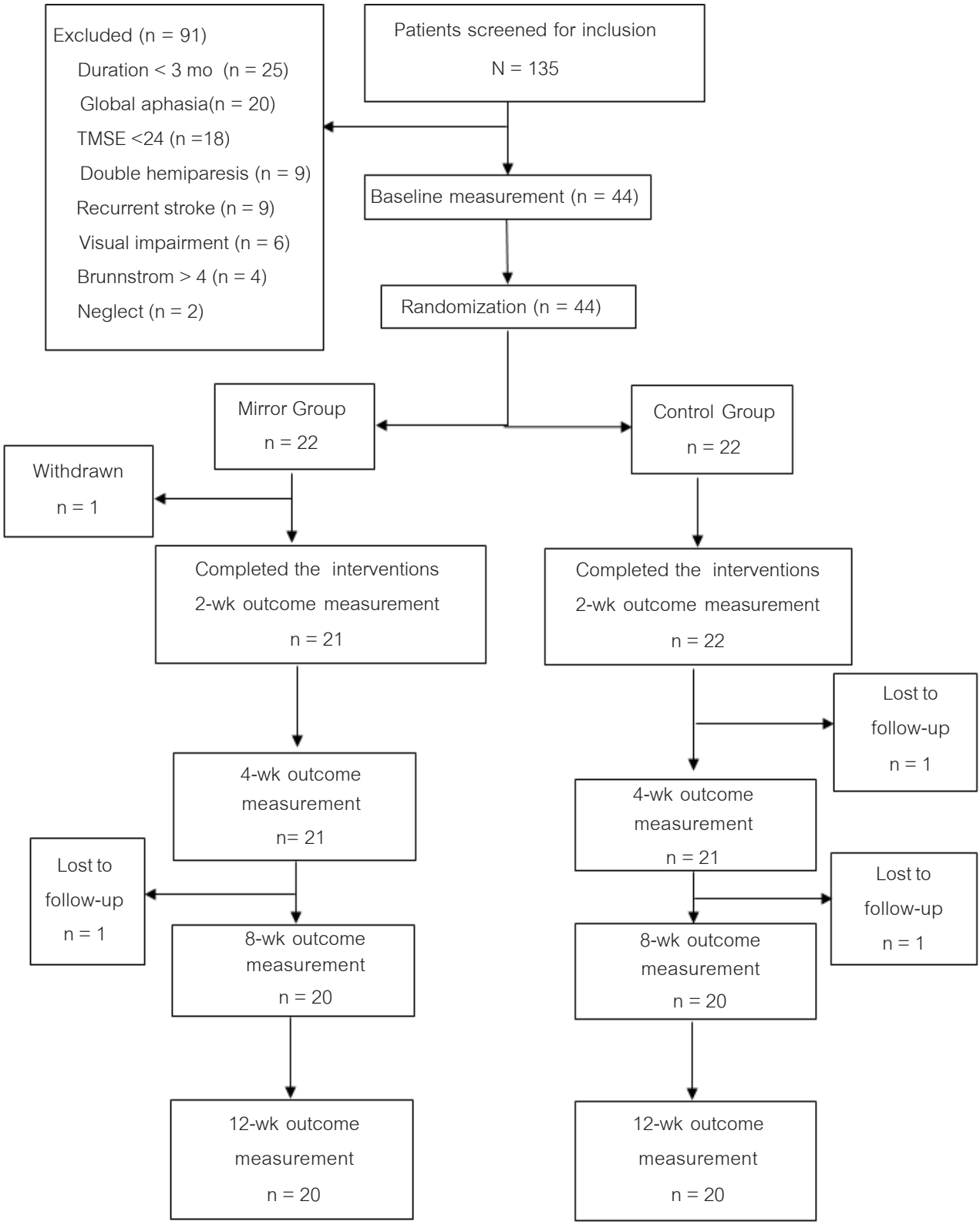

Figure 1. Study flow chart.

The general demographic data and general health data were shown in Table 1. The demographic and baseline characteristics between both groups were comparable. There were similar number of males and females in both groups. The mean age for the intervention and control groups was 54.9 ± 11.9 years and 57 ± 10.0 years respectively.

The results of the Brunnstrom staging of recovery for the hand and arm within groups from baseline to 12 weeks are shown in Table 2. The results of the motor assessment scale, lateral pinch strength, tip pinch strength, Barthel activity index and MAS within groups from baseline to 12 weeks are shown in Table 3. Comparisons between the groups for the motor assessment scale, lateral pinch strength, tip pinch strength, Barthel activity index and MAS from baseline to12 weeks are shown in Table 4. Comparisons between groups for the Brunnstrom staging of recovery for the hand and arm from baseline to 12 weeks are shown in Table 5.

Table 1. Comparisons of the demographic data and basic stroke characteristics of the patients from the intervention and sham groups by the Man Whitney U test. (*P <.05)

Characteristics		**Mirror group**	**Control group**	***P*-value**
No. of subject		20	20	
Age (year)		54.9 ± 11.9	57.0 ± 10.0	.551
Sex (male/female)		9/11	12/8	.355
Time since stroke (mo)		9.7 ± 16.3 (3 - 72)	4.7 ± 1.8 (3 - 10)	.177
		Median = 4.5	Median = 4	
Lesion (Ischemic/hemorrhagic)		13/7	14/6	.744
Paretic side (left/right)		11/9	14/6	.340
Dominant hand (left/right)		4/16	2/18	.422
JPS** (Intact/Loss)		15/5	17/3	.422
TMSE**		26.2 ± 2.1	26.8 ± 3.4	.542
Barthel ADL** Index		65.8 ± 11.7	58.3 ± 18.1	.130
	Stage 1	3	6	.485
Brunnstrom stage	Stage 2	16	8	
(Hand)	Stage 3	1	2	
	Stage 4	0	4	
	Stage 1	4	4	.213
Brunnstrom stage	Stage 2	14	9	
(Arm)	Stage 3	2	6	
	Stage 4	0	1	
MAS**		0.9 ± 0.6	0.9 ± 0.6	.783
Motor assessment scale		0.4 ± 0.5	0.5 ± 0.7	.432
Lateral pinch strength (lbs.)		0.6 ± 1.5	0.9 ± 1.3	.500
Tip pinch strength (lbs.)		0.3 ± 0.9	0.3 ± 0.6	.989

**Joint Position Sense: JPS; Thai Mental State Examination: TMSE; Barthel Activity of Daily Living Index: Barthel ADL index; Modified Ashworth Scale: MAS

Table 2. Comparisons of the improvement of the Brunnstrom stages for the hand and arm from baseline to weeks 2, 4, 8 and 12 within groups by repeated-measure ANOVA test. (**P <0.05)*

Change of Parameter		Baseline - wk 2		*P*	Baseline – Wk 4		*P*	Baseline – Wk 8		*P*	Baseline – Wk 12		*P*
		None (%)	≥1Stage (%)	value	None (%)	≥1Stage (%)	value	None (%)	≥1Stage (%)	value	None (%)	≥1Stage (%)	value
Brunnstorm Hand	Mirror	11 (55)	9 (45)	*.045**	9 (45)	11(55)	*.010**	8 (40)	12 (60)	*.000**	8 (40)	12 (60)	*.000**
	Sham	16 (80)	4 (20)	.092	15 (75)	5 (25)	.090	12 (60)	8 (40)	.421	12 (60)	8 (40)	.075
Brunnstorm Arm	Mirror	12 (60)	8 (40)	*.035**	8 (40)	12 (60)	*.004**	6 (30)	14 (70)	*.000**	6 (30)	14 (70)	*.000**
	Sham	15 (75)	5 (25)	*.047**	12 (60)	8 (40)	*.021**	12 (60)	8 (40)	*.021**	12 (60)	8 (40)	*.021**

Table 3. Comparisons of the Motor Assessment Scale, lateral pinch strength, tip pinch strength, Barthel activity index and the Modified Ashworth Scale from baseline to weeks 2, 4, 8 and 12 within groups by repeated-measure ANOVA test. *(*P <0.05*)

Parameter	Group	Baseline	Wk 2	*P* value Wk 0 - 2	Wk 4	*P* value Wk 0 - 4	Wk 8	*P value* Wk 0 - 8	Wk 12	*P* value Wk 0 -12
Motor Assessment	Mirror	0.4 ± 0.5	0.6 ± 0.9	.056	0.8 ± 0.9	.075	1.0 ± 0.7	*.019**	1.0 ± 0.7	*.021**
Scale	Control	0.5 ± 0.7	0.7 ± 0.7	.092	0.8 ± 0.7	.210	0.8 ± 0.7	.235	0.9 ± 0.7	.102
Lateral pinch	Mirror	0.6 ± 1.5	1.0 ± 1.9	.395	1.2 ± 2.0	.115	1.3 ± 2.0	.082	1.3 ± 2.0	.096
strength (lbs.)	Control	0.9 ± 0.6	1.1 ± 1.5	.090	1.2 ± 1.8	.161	1.2 ± 1.6	.110	1.2 ± 1.5	.085
Tip pinch	Mirror	0.3 ± 0.1	0.4 ± 1.6	1.0	0.4 ± 1.4	1.0	0.4 ± 2.0	1.0	0.4 ± 1.4	1.0
Strength (lbs.)	Control	0.3 ± 0.6	0.5 ± 0.6	1.0	0.5 ± 1.3.6	1.0	0.5 ± 1.0	1.0	0.5 ± 1.0	1.0
Barthel activity	Mirror	65.8 ± 11.7	77.3 ± 12.6	*.000**	82.8 ± 11.0	*.000**	84.5 ± 10.4	*.000**	84.5 ± 10.0	*.000**
index	Control	58.3 ± 18.1	68.8 ± 12.6	*.002**	73.3 ± 11.8	*.000**	75.0 ± 12.0	*.000**	76.0 ± 11.9	*.000**
MAS**	Mirror	0.9 ± 0.6	1.0 ± 0.6	1.0	1.2 ± 0.7	.493	1.2 ± 0.6	.692	1.2 ± 0.6	.596
	Control	0.9 ± 0.6	1.2 ± 0.6	1.0	1.3 ± 0.6	.961	1.1 ± 0.6	1.0	0.9 ± 0.7	.289

**MAS: Modified Ashworth Scale

Table 4. Comparisons of the changes (post- minus pre-treatment) in Motor Assessment Scale, lateral pinch strength, tip pinch strength, Barthel activity index and the Modified Ashworth Scale from baseline to weeks 2, 4, 8 and 12 between groups by the Man Whitney U test. (*P <.0125)

Parameter	Group	Wk 0 to Wk 2	*P* value	Wk 0 to Wk 4	*P* value	Wk 0 to Wk 8	*P* value	Wk 0 to Wk 12	*P* value
Δ Motor Assessment Scale	Mirror	0.3 ± 0.6	.278	0.5 ± 0.4	.446	0.6 ± 0.8	.155	0.6 ± 0.8	.163
	Control	0.2 ± 0.4		0.3 ± 0.2		0.3 ± 0.5		0.3 ± 0.5	
Δ Lateral pinch strength (lbs.)	Mirror	0.4 ± 0.6	.045	0.5 ± 0.7	.118	0.7 ± 1.0	.085	0.7 ± 1.0	.462
	Control	0.2 ± 0.4		0.3 ± 0.6		0.4 ± 0.5		0.4 ± 0.4	
Δ Tip pinch Strength (lbs.)	Mirror	0.1 ± 0.5	.361	0.1 ± 0.4	.433	0.2 ± 0.4	.554	0.2 ± 0.5	.317
	Control	0.2 ± 0.6		0.2 ± 0.2		0.2 ± 0.7		0.2 ± 0.7	
Δ Barthel activity index	Mirror	11.5 ± 10.0	.681	17.5 ± 6.0	.516	18.5 ± 2.9	.785	18.6 ± 10.6	.967
	Control	10.5 ± 10.4		14.5 ± 5.8		17.3 ± 4.1		18.3 ± 13.2	
Δ MAS**	Mirror	0.2 ± 0.5	.212	0.4 ± 0.4	.719	0.4 ± 0.3	.323	0.5 ± 05	.174
	Control	0.2 ± 0.7		0.3 ± 0.4		0.2 ± 0.3		0.5 ± 0.5	

**MAS: Modified Ashworth Scale

Table 5. Comparisons of the improvement of Brunnstrom stage for the hand and arm from baseline to weeks 2, 4, 8 and 12 between groups by the Chi-square test.(*P <.05)

Parameter	Group	Wk 0 to Wk 2 N (%)	*P* value	Wk 0 to Wk 4 N (%)	*P* value	Wk 0 to Wk 8 N (%)	*P* value	Wk 0 to Wk 12 N (%)	*P* value
Brunnstom Hand	Mirror	9 (45)	*.047	11 (55)	.053	12 (60)	.113	12 (60)	.113
	Sham	4 (20)		5 (25)		8 (40)		8 (40)	
Brunnstom Arm	Mirror	8 (40)	.311	11 (60)	.228	13 (70)	.150	13 (70)	.150
	Sham	5 (25)		8 (40)		8 (40)		8 (40)	

A significant improvement of the hand (P = 0.045) and arm (P = 0.035) were seen as early as 2 weeks in the intervention groups when compared to the baseline levels. According to the Brunnstrom staging of recovery for the hand in the intervention group, this improvement continued from the baseline levels to 4 (P = 0.01), 8 (P = 0.01) and 12 (P = 0.001) weeks. The Brunnstrom stage of recovery for the arm in the intervention group continued to improve at weeks 4 (P = 0.004), 8 (P = 0.01) and 12 (P = 0.01). As for the sham group, there were no significant changes in the Brunnstrom stage of recovery for the hand from the baseline level to weeks 2, 4, 8, and 12 compared to the baseline levels. However, the Brunnstrom staging of recovery for the arm in the sham group significantly improved as early as 2 weeks (P = 0.047) and continued to improve at weeks 4 (P = 0.021), 8 (P = 0.021) and 12 (P = 0.021).

The assessment of other parameters within groups showed significant improvement in the Barthel activity index as early as 2 weeks (P = 0.001) in the intervention group. This improvement continued at 4 (P = 0.001), 8 (P = 0.001) and 12 (P = 0.001) weeks. Likewise, the sham group also showed similar recovery of the Barthel activity index at 2 (P = 0.002), 4 (P = 0.001), 8 (P = 0.001) and 12 (P = 0.001) weeks. The other significant improvements seen within the intervention group were the motor assessment scale (P = 0.003) as early as 8 weeks. The improvement continued at week 12. There were no significant improvements seen in the lateral pinch strength, tip pinch strength and MAS for the intervention group. Whereas in the sham group, there were no significant improvement for the motor assessment scale, lateral pinch strength, tip pinch strength and the MAS.

However, when the comparisons were made between groups, only the Brunnstrom recovery stage for the hand showed significant improvement at 2 weeks (P <.045) but this improvement did not continue beyond that time point. As for the other parameters assessed such as the Brunnstorm recovery stage of arm, Motor Assessment Scale, lateral pinch strength, tip pinch strength, Barthel activity index and the MAS, the improvements between both groups were comparable at 2, 4, 8 and 12 weeks.

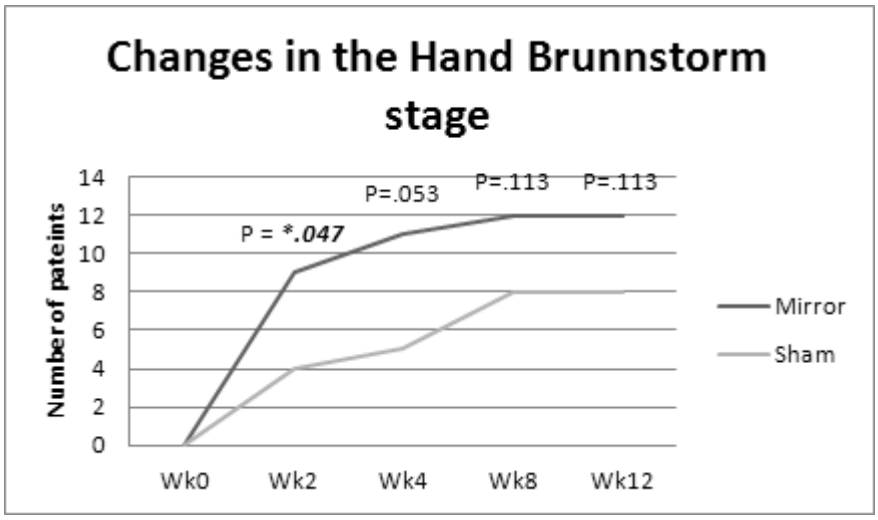

Figure 2. Comparisons of the changes in the hand Brunnstrom stage between the intervention and sham groups at 0, 2, 4, 8 and 12 weeks by Chi-square test. (*P <.05)

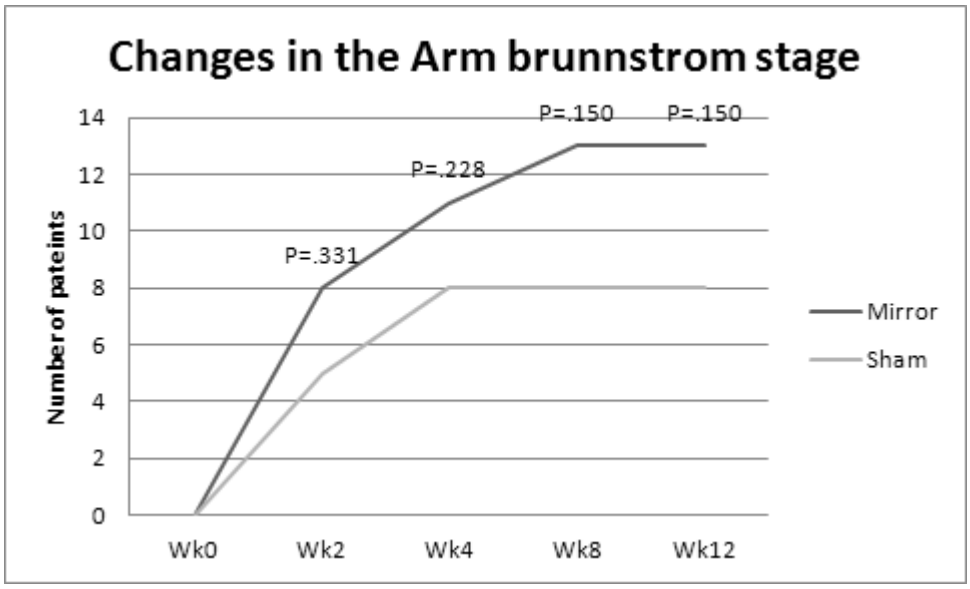

Figure 3. Comparisons of the changes in the arm Brunnstrom stage between the intervention and sham groups at 0, 2, 4, 8 and 12 weeks by Chi-square test. (*P <.05)

Discussion

There was no randomized clinical trials (RCT) with adequate sample size that have investigated the use of mirror therapy as an adjunct therapy to the conventional, standard stroke rehabilitation program in chronic stroke survivors with various stages of hemiparesis in a resource-limited setting. This study was the first to report that in a resource-limited setting, a total of 10 sessions of mirror therapy, 30 minutes per session, was sufficient to improve the Brunnstrom recovery stage for the hand and arm, and Barthel activity index as early as 2 weeks and motor assessment scale at 8 weeks. Likewise, the sham group also showed significant recovery of the Brunnstrom arm and the Barthel activity index as early as 2 weeks and at 4, 8 and 12 weeks. This indicated that the conventional stroke rehabilitation was sufficient to help the patients recover their Brunnstrom arm function and Barthel Activity index. But the conventional stroke rehabilitation alone could not improve the Brunnstrom hand function, motor assessment scale in the patients from the Sham group.

The results correspond to the previously published data that mirror therapy can improve the upper limb motor function.[21] This study confirmed that mirror therapy can be used as an adjunct therapy for chronic stroke survivors with mild, moderate, and severe upper paretic limb.This adjunct therapy was feasible, cost-effective in resource-limited setting and could be easily incorporated into the national and WHO guidelines for the treatment post-stroke. Additional infrastructures are not necessary for the mirror therapy which the patient can do at home in front of a mirror that costs at about 20 baht (around US$ 0.61). Professional mirror boxes can also be bought online for around 1,500 baht (US$ 47).

The results of our study agree with the findings from several studies. Yavuzer G, *et al*.'s randomized, controlled trial with sufficient sample size conducted

in subacute stroke survivors detected a significant improvement of the hand function when the mirror therapy was used in conjunction with the standard, conventional stroke rehabilitation.[13] A study conducted in Korea clearly showed that there were neurophysiological changes in the corticospinal excitability among stroke patients during the mirror therapy sessions when viewing the mirror image of the ipsilateral hand in motion.[21] The benefits of the mirror therapy as an adjunct therapy were irrefutable even though Thieme H, *et al*.'s randomized, controlled trial conducted in subacute stroke patients with severe paresis of the arm showed that there was no significant improvement in the sensory-motor function of the arm, activities of daily living and quality of life when the mirror therapy was administered in conjunction with the patients' regular therapy individually or in a group for 30 minutes with a total of 20 sessions for five weeks compared to the standard, conventional stroke rehabilitation. [21] The reason why the results were different because most of the patients from Thieme H's study had severe weaknesses whereas 80% of the patients from our study did not have any severe weaknesses.

The lateral pinch strength, tip pinch strength, Barthel activity index and MAS were comparable between both groups at weeks 0, 2, 4, 8, and 12.Interestingly, the motor assessment scale between both groups was also comparable which contrasted to the results seen within groups. This indicated that the effects of the mirror therapy or the recovery of the motor function was not large enough to be detected between the groups but could significantly impact within group comparisons.

Another discrepancy detected between the groups was the changes in the Brunnstrom recovery stage for the hand. Significant improvement in the Brunnstrom recovery stage for the hand was detected in the mirror group as early as 2 weeks whereas beyond that time point, it became comparable between groups. This indicated that there was an advantage of using the mirror therapy as an adjunct program to the conventional stroke rehabilitation program because the results of the recovery in the Brunnstorm stage for the hand could be seen as early as 2 weeks. However, after that, the recovery between both groups became comparable as the effects of the conventional stroke rehabilitation program have finally caught up with the effects of the mirror therapy. As for the Brunnstrom staging for the arm between groups, the recovery scores were comparable at weeks 0, 2, 4, 8 and 12. This indicated that the conventional stroke rehabilitation was good enough in recovering the Brunnstrom stages for the hand and the arm but the adjunct mirror therapy may have an added advantage in accelerating this recovery for the hand as early as 2 weeks. On the other hand, the results between the groups and within the groups yielded different outcomes. The outcomes between the groups indicated that the conventional stroke rehabilitation program with or without the mirror therapy had comparable effects on the recovery of the Brunnstrom for the hand and the arm, even though the hand showed a faster recovery as early as 2 weeks with the adjunct therapy. Furthermore, when the outcomes were compared within the groups, this also showed that both groups had significant recovery for the Brunnstrom for the hand and the arm. This finding was consistent with the data from between groups that the conventional stroke rehabilitation program is necessary for the recovery of the upper limb function. These data support previous reports[14, 23 – 26] and the

importance of the conventional stroke rehabilitation among post-stroke patients.

One of its weaknesses of this study was the severity of the paretic upper limb which was heterogeneous. As a result of this, it was difficult to ascertain the benefits of the mirror therapy among those with severe paralysis. Additional studies should examine different adjunct programs conducted over a long period and have a longer follow-up period. It would also be interesting to combine various adjunct programs together and assess its effects. The authors also recommended assessment of the improvement of the motor function when the recovery has plateaued. In this study, the improvement did not reach its plateau and might require a longer duration of therapy and follow-up period.

Nevertheless, there were many strong points taken in this study. Firstly, the study's randomization design provided better clinical evidence and recommendation for treatment guidelines worldwide. Secondly, there was only one assessor who was used throughout the study to maintain consistency in grading the motor function of the patients. Thirdly, this assessor was also blinded to the assignment of the patients. Fourthly, two therapists were used throughout the study and were assigned equal number of patients from both arms to ensure unbiased preference to work harder with one group of patients compared to the other. Fifthly, all of the therapy sessions were conducted on-site to avoid confounding factors such as poor lighting, too cold/ hot environment, too noisy, too many distractions, etc.The patients were not blinded to the treatment because it was obvious which group received the mirror therapy from the beginning. Sixthly, there was only one mirror box and this box was used for all patients for consistency. Seventhly, the mirror box was open at both ends of the box so the paretic arm could be inserted into the box and the therapist can watch the paretic arm during the sessions at the other end of the box. Eighthly, the sample size was sufficient enough to detect significant differences between the groups as well as any differences from the baseline levels. The reason for this was because the authors used the calculation for the highest power of detection for the sample size. Thus when the actual sample size fell a little short compared to the targeted number, the study still had sufficient power to detect for 80% significant difference between groups and time points. Lasty, the inclusion criteria were extremely stringent to ensure the targeted population was chronic stroke survivors. However, this also became an obstacle in reaching the targeted number of patients per group but as with any clinical trials, population selection bias or the population selected is highly specific and cannot be generalized to the general population. The study population did not have many other health problems as seen in real life such as not understanding simple commands, inability to sit still for more than 30 minutes, and so on so forth to ensure the completion of the study. Thus the population from this study was the ideal chronic stroke patients without any other health and neurocognitive complications that may influence the results of the study.

Conclusion

Mirror therapy with the conventional rehabilitation program may improve the Brunnstrom hand and arm, Barthel activity, motor assessment scale. These improvements can be seen as early as

2 - 8 weeks of continuous therapy. Mirror therapy is simple, practical, cheap and can be easily done at home by the caregiver.

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