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EFFECT OF MIRROR VISUAL FEEDBACK ON HAND FUNCTIONS IN CHILDREN WITH HEMIPARESIS

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ABSTRACT

Background: Hemiparetic and hemiplegic cerebral palsy(CP) constitute at least a third of all people with CP. Children with hemiparesis are suffering from weak hand muscles and retarded hand use.Mirror therapy is a relatively new approach in rehabilitation used in different neurological disorders. In mirror therapy a mirror is positioned orthogonally in front of the center of the patient's body. The less-affected (healthy) extremity is moved and observed in the mirror. The purpose of this study was to determine the effect of mirror visual feedback on improving hand functions in children with hemiparesis.

Methods: Forty children with hemiparesis of both sexes, ranged in age from five to seven years old, participated in thisstudy. They were divided randomly into two groups of equal number (control and study). The control group received a specially designed physical therapy exercise program for four successive weeks while the study group received mirrorexercise program in addition to the same program of the control group. Hand functions assessments was done usinggrasping and object manipulation subtests of Peabody developmental motor scale (PDMS-2). Hand grip strength was performed using handheld dynamometer. Evaluation was performed pre and post treatment program.

Results:There was no significant difference between both groups in the pre-treatment mean values of all measured variables. Also, the results of this study revealed a significant improvement in the scores of the PDMS-2 andin grasp strength of the 2 groups. Post treatment results revealed more improvement in favor of the study group as compared with the control group.

Conclusion: Using the mirror visual feedback could help in improving hand functions in children with hemiparesis.

Keywords: Cerebral palsy, Mirror visual feedback, Hand functions, Hemiparesis.

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INTRODUCTION

Cerebral palsy (CP) is a group of permanent disorders of the development of movement and posture due to non progressive lesion that occurred in the developing fetal or infant brain [1]. The prevalence of CP is about 2 – 2.5 per 1,000 live births [2]. Spastic hemiplegia accounts for more than a third of all cases of CP, and the resulting impairments to extremities affect functional independence and quality of life [3].

Children with impaired function of one of their arms can have disabling symptoms that affect play, school, and self-care. Hand and arm function may be affected by abnormal muscle tone, flexion synergies, decreased strength, decreased active and passive range of motion, altered sensation, and neglection [4].

Children with hemiplegic CP rarely use their affected hand for unimanual tasks. The impaired hand is typically used when there is need for bimanual task performances. Bimanual tasks are more complicated than unimanual tasks as the movements of both arms and hands must be coordinated temporally and spatially to complete a task or achieve a desired goal, but many everyday tasks require coordinated use of both arms and hands [5].

Mirror visual feedback is a relatively new approach, used in rehabilitation of different neurological conditions including stroke patients [6]. In mirror therapy, patients sit in front of a mirror that is placed parallel to person's mid line preventing the view of the affected limb positioned behind the mirror. When the patient looks into the mirror he sees the reflection of his unaffected limb. This creates a visual illusion whereby movement or touch to the intact limb may be perceived as affecting the paretic or painful limb [7].

In spite of the encouraging clinical results, little is known about the underlying mechanisms of mirror therapy. Ramachandran [8]demonstrated that the "learned paralysis" in the brain could possibly be "unlearned" as a result of the mirror illusion. Other studies have attributed the positive effects of mirror therapy in stroke to motor imagery [7,9.10] or the mirror neuron system [11].

It is assumed that mirror illusion increases activity in precuneus and posterior cingulated cortex areas which in turn increase awareness of self and spatial attention [11]. It is suggested that mirror therapy stimulate the mirror neuron. Mirror neurons are specific types of neurons that modulate their activity both when a person performs a specific motor activity and when he observes the same or similar activity performed by another individual[12,7]. Several researchers have found that intense mirror therapy in stroke patients resulted in significant recovery of hand movement of paretic arm ,grip strength, steady and accuracy of arm movements [7] , increase in Fugl-Meyer assessments score, improvement in speed and hand dexterity [13] ,improvements in hand functions in sub-acute stroke patients with attention and sensory deficits, improvements in motor recovery in distal weak limb, [14] improvement in Ashworth scale, self-care items of the FIM instrument [7]. The purpose of this study was to determine the efficacy of mirror visual feedback on hand functions and grip strength in children with hemiparesis.

METHODS

SUBJECTS

Forty children with hemiparesis of both sexes participated in this study. Patients were required to meet the following criteria for inclusion in the study:(1)Age 5 to 7 years, (2) The degree of spasticity was 1 to 1^{+} according to modified Ashworth scale [15] , (3)Ability to use the impaired upper limb , (4)Ability to understand and follow verbal commands and instructions included in evaluation and training, and(5)No fixed deformities of both upper limbs. Exclusion criteria:(1)Children with moderate and severe spasticity, (2)Fixed deformities of the upper limbs,(3)Mental retardation, (4)Excessive pain in the paretic extremity and (5)Visual and visual perceptual disorders. The faculty of physical therapy, Cairo University Ethics Committee approved the protocol and all patients provided their written informed consent. All children were divided randomly into two groups of equal number using closed envelops procedures.

MATERIALS

For evaluation

1-Peabody developmental motor scale

This scale is used to assess gross and fine motor skills. It is composed of six sub-tests: reflexes, stationary, locomotion, object manipulation, grasping, and visual motor integration. Fine motor unit includes object manipulation and grasping subtests.

2-Hand-held dynamometer

Isometric handgrip strength was also measured using a Jamar hand-held Dynamometer (Sammons Preston, Inc., Bolingbrook, IL) The Jamar has been reported to be a reliable and valid instrument for measuring handgrip strength [16].

For treatment

-Table with appropriate height, a sturdy chair, balls, cubes, drawing board, a pen, jar and cards.

-A solid stand-alone mirror: it consists of: (1) mirror piece (35 cm x 35 cm)and(2) wooden piece (35 cm x 40 cm)with hinge in between locking the two pieces together to make it stable.

PROCEDURES

For evaluation

Evaluation of each child in each group was conducted before and after 28 days of treatment application.

1-Assessment of fine motor skills:

PDMS-2 was used to evaluate fine motor skills including grasping and object manipulation. This scale provides a comprehensive sequence of gross and fine motor skills, by which the therapist can determine the relative develop-

mental skill level of a child, identify the skills that are not completely developed and plan an instructional program that can develop those skills [17].

2-Evaluation of hand grip strength:

Measurement of hand grip strength was carried out by the use of the hand-held dynamometer following the steps of Beenakker [18]. Each child was asked to sit on a chair with back supported. The head was maintained in mid-position ,the trunk was erect and fastened to the back of the chair. The hips and knees were flexed 90º with the feet fully supported on the ground in neutral position. Elbow joint flexed 90º, forearm was mid-way between supination and pronation and supported on a chair armrest with the wrist joint in neutral position and free from the chair armrest. Each child was then asked to hold the handle of the dynamometer and to squeeze it as much as possible, then release. After a familiarization trial ,the mean of three trials was recorded.

For treatment

Treatment for the Control group

Children in this group received daily physical therapy program to improve the gross motor functions. These exercises included :quadriped exercises group, kneeling and half kneeling, standing manually and standing momentarily. Physical therapy program for the affected upper limb to improve fine motor functions included the following tasks: turning cards, transfer cubes from one place to another, reaching to mouth (eating lollipop), squeezing ball (sponge ball), catching the ball, throwing the ball, transfer cubes from one hand to the other hand, opening and closing a jar and clapping with both hands. The treatment session was for 1hour.

Treatment for the study group:

Children in this group received the same physical therapy program of control group for 1hour followed by mirror visual feedback for half an hour.

First the child was asked to hide his affected hand behind the mirror and to put the unaffected hand in front of the mirror seeing its reflection in the mirror, then he was asked to perform the task with his unaffected hand while seeing its reflection in the mirror.

The exercises included the following:(1)Transfer cubes from one place to another while seeing his or her reflection in the mirror,(2)Squeezing a sponge ball:Each child was encouraged to hold a small sponge ball and try to squeeze it as much as he or she could while seeing his or her reflection in the mirror and(3)Drawing a circle: the subject was asked to draw a circle while seeing his or her reflection in the mirror.

Statistical analysis

Statistical Package for Social Sciences (SPSS) version 19 was used for data analysis. Non-parametric tests (the Wilcoxon signed-rank test and the Mann–Whitney test) were used to analyze the pre- and post-treatment values of PBDMS and grip strength within and between the groups.

RESULTS

Basic demographic data as well as the clinical characteristics of the 40 hemiparetic CP participants are presented in table 1.There was no significant difference between both groups in age (p>0.05).There was also no significant difference between both groups in gender, degree of spasticity.Comparison between right and left leg in both groups revealed that there was no significant difference between both sides.

Table 1: Demographic data of participants

Subjects characteristics	Control group	Study group	T value or Pearson chi -square	P value	Significance
Age in years (Mean±SD)	5.7 ± 0.5	5.7 ± 0.4	0.26	0.798	NS
Gender: Male, n(%) Female,n(%)	60% 40%	65% 35%	0.107	0.744	NS
Affected side:Rt,n(%) Lt,n(%)	20% 80%	25% 75%	0.143	0.705	NS
Modified Ashwarth scale(1/1⁺)	13/7 (65% / 35%)	12/8 (60% / 40%)	0.107	0.743	NS

NS:non significant

Grasping subtest standard scores

Comparing pre and post-treatment values of grasping subtest standard scores within both groups:

As shown in table (2) and illustrated in fig. (1)a statistically significant difference was revealed between the pre and post-treatment grasping subtest values for both groups (p<0.05).

Table 2: Pre and post-treatment values of grasping subtest standard scores within both groups

Grasping subtest standard scores	Control Group		Study Group	
	Pre	Post	Pre	Post
Median	3	4	3	6
Negative and positive rank	0 – 14		0-20	
Z-value	-3.345		-3.97	
P-value	0.004		0.001	
Significance	S		S	

P: Probability, S: Significant

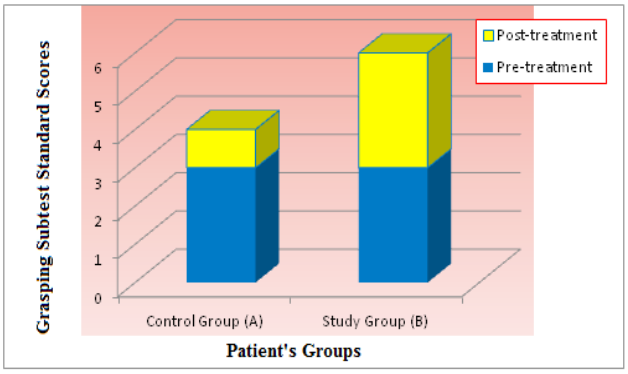

Fig. 1: Pre and post-treatment values of grasping subtest standard scores within groups.

Comparing the post-treatment values of grasping subtest standard scores between groups:

A statistically significant difference was revealed between the two groups after the suggested period of treatment ($p<0.05$), as the post-treatment median values for control and study groups were 4 and 6 respectively, U-value = 95.500, thesignificant improvement was in favor of the study group(table 3).

Table 3: Post-treatment values of grasping subtest standard scores between groups.

Post-treatment	Grasping subtest standard scores	
	Control Group (A)	Study Group (B)
Median	4	6
U-value	95.5	
P-value	0.001	
Significance	S	

U-value: Un-Paired Mann-Whitney value, P: Probability, S: Significant.

Object manipulation

Comparing pre and post-treatment values of object manipulation subtest standard scores within both groups:

As shown in table (4) and illustrated in fig. (2), a statistically significant difference was revealed between the pre and post-treatment object manipulation subtest values for both groups ($p< 0.05$).

Table 4: Pre and post-treatment values of object manipulation subtest standard scores within both groups.

Object manipulation	Control Group		Study Group	
	Pre	Post	Pre	Post
Median	7	7.5	7.5	9.5
Negative and positive rank	0 – 13		0-19	
Z-value	-3.286		-3.977	
P-value	0.001		0.001	
Significance	S		S	

P: Probability, S: Significant

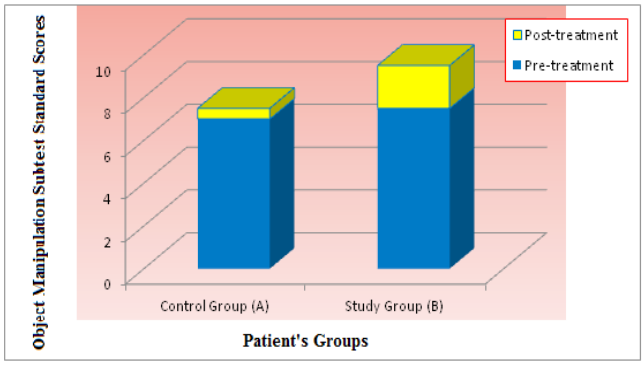

Figure 2: Pre and post-treatment values of object manipulation subtest standard scores within groups.

Comparing the post-treatment values of object manipulation subtest standard scores between groups:

A statistically significant difference was revealed between the two groups after the suggested period of treatment ($p<0.05$), as the post-treatment median values for control and study groups were 7.5 and 9.5 respectively, U-value = 115.000, the significant improvement was in favor of the study group, table (5) and fig. (3).

Table 5: Post-treatment values of object manipulation subtest standard scores between groups.

Post-treatment	Object Manipulation subtest standard scores	
	Control Group (A)	Study Group (B)
Median	7.5	9.5
U-value	115.00	
P-value	0.022	
Significance	S	

U-value: Un-Paired Mann-Whitney value, P: Probability, S: Significant.

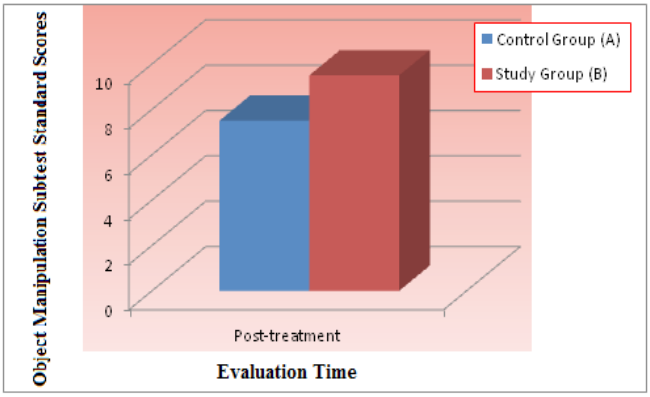

Figure 3: Post-treatment values of object manipulation subtest standard scores between groups.

Grip strength

Comparing pre and post-treatment values of grip strength (kg) within both groups:

As shown in table (6) and illustrated in fig. (4), a statistically significant difference was revealed between the pre and post-treatment grip strength values for both groups ($p<0.05$).

Table 6: Pre and post-treatment values of grip strength within groups.

Grip strength	Control Group		Study Group	
	Pre	Post	Pre	Post
Median	2.3	2.8	2.5	3.3
Negative and positive rank	0 – 20		0 – 20	
Z-value	-4.234		-4.038	
P-value	0.001		0.001	
Significance	S		S	

P: Probability, S: Significant

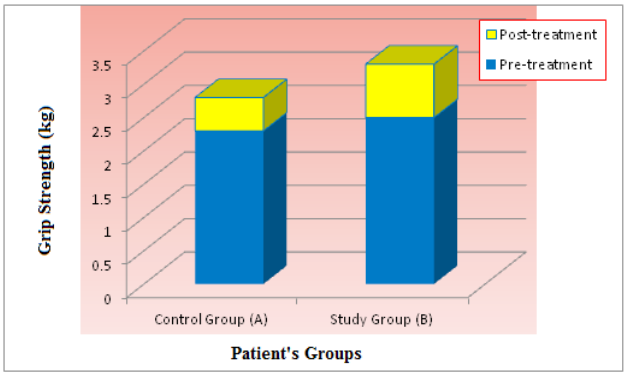

Figure 4: Pre and post-treatment values of grip strength within groups.

Comparing the post-treatment values of grip strength (kg) between groups:

A statistically significant difference was revealed between the two groups after the suggested period of treatment ($p< 0.05$), as the post-treatment median values for control and study groups were 2.8 and 3.3 respectively, U-value = 114.500, thesignificant improvement was in favor of the study group (table7).

Table 7: Post-treatment values of grip strength between groups.

Post-treatment	Grip strength (kg)	
	Control Group (A)	Study Group (B)
Median	2.8	3.3
U-value	114.500	
P-value	0.020	
Significance	S	

U-value: Un-Paired Mann-Whitney value, P: Probability, S: Significant.

Comparing the percentage of improvement of all measured variables in the two groups:

As presented in table (8),and illustrated in fig. (5),an improvement was revealed in the two groups in all measured variables when comparing the pre and post-treatment values but there was more improvement in favor of the study group. As the percentage of improvement of the grasping subtest standard scores , object manipulation subtest standard scores and grip strength (kg) for the control group were 20.96%,12.5 %and 14.28% respectively, and for the study group they were 37.87% ,23 %and 16.67% respectively.

Table 8: Percentage of improvement of all measured variables in the two groups .

Variable	Percentage of Improvement %	
	Control Group (A)	Study Group (B)
Grasping subtest standard scores	20.96 %	37.87 %
Object Manipulation subtest standard scores	12.5 %	23 %
Grip strength(kg)	14.28 %	16.67 %

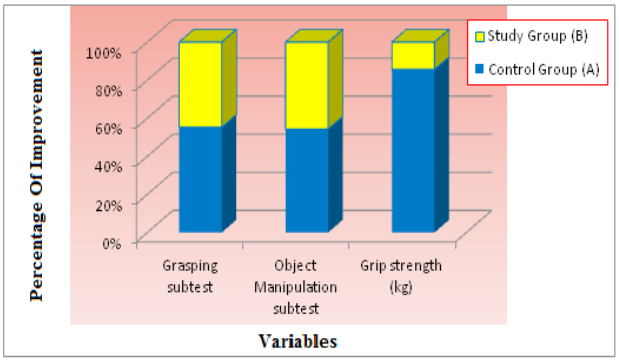

Figure 5: Percentage of improvement of all measured variables in the two groups at the end of the treatment.

DISCUSSION

This study demonstrated that there is statistically and clinically significant improvement in hand functions in subjects who received mirror therapy with conventional therapy than the subjects who received conventional therapy for a period of 4 weeks.

Choosing the age of the children of the present study to be ranging from five to seven years comes in agreement with Berk [19] and Schneck [20] who revealed that, by the age of six years; the grasp patterns become fully matured. Case-Smith [21] confirmed that by the age ranging between five and seven years, the child can assume hand grip with regular force either to grasp or to lift the object without letting it slipping through the fingers.

During mirror therapy trainings subjects practice consisted of non-paretic side movements while subjects looked into the mirror watching the image of their noninvolved hand. Several underlying mechanisms for the effect of mirror therapy on motor recovery after stroke have been proposed. Altschuler et al [22]. suggested that the mirror illusion of a normal movement of the affected hand may substitute for decreased proprioceptive information, thereby helping to recruit the premotor cortex and assisting rehabilitation through an intimate connection between visual input and premotor areas. Stevens and Stoykov [9] suggested that mirror therapy related to motor imagery and that the mirror creates visual feedback of successful

performance of the imagined action with the impaired limb. Motor imagery itself, the mental performance of a movement without overt execution of this movement, has proven to be potentially beneficial in the rehabilitation of hemiparesis.

In mirror therapy, the effect of mirror visual illusions on brain activity has been investigated in a number of studies. Garry et. al [13]. Performed transcranial magnetic stimulation during mirror illusion in healthy subjects and showed increased excitability of primary motor cortex (M1) of the hand behind the mirror. Mirror neurons are bimodal visuomotor neurons that are active during action observation, mental stimulation (imagery), and action execution. It has been shown that passive observation of an action facilitates M1 excitability of the muscles used in that specific action. Mirror neurons are now generally understood to be the system underlying the learning of new skills by visual inspection of the skill.

Our results come in agreement with Dohle et al.[14] Who had done comparative study on mirror therapy to promote recovery from severe hemiparesis. They included 36 patients with severe hemiparesis. They randomly assigned patient either mirror therapy or equivalent control therapy. The main outcome measure used was the Fugl- Meyer sub scores for upper extremity. They concluded that mirror therapy is promising method to improve sensory and attention deficits and to enhance motor recovery in distal plegia.

Also, Our results come in agreement withYauzer et al.[7] who studied the effect of mirror therapy on improving hand function in sub-acute stroke patients. forty inpatients, within 12 months of post stroke were selected & they randomly assigned in two groups; one group did mirror therapy to upper limb along with conventional therapy &other group did sham mirror therapy along with conventional therapy. They used Modified Ashworth scale, self-care items of the FIM instrument. They concluded that hand function improved more after mirror therapy program.

This study is with several limitations: Improvements were found based on 4 weeks of intervention, follow-up was not done therefore long term effects were not found.

According to the finding of this study the following recommendations are advised: Evaluate the effect of mirror therapy program on children with age above 7 years, evaluate and comparing the effect of mirror therapy program between the children with dominant affection and children with non-dominant affection.

CONCLUSION

Mirror therapy is an effective additional tool to the rehabilitation program for children with hemiparesis, to gain more hand strength, improve hand functions, prevent from hemineglect, improve ADL capacity, and in conclusion to improve the functional and health outcome of these children.

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