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Effectiveness of Mirror Therapy to Improve Upper Extremity Motor Function in Neurological Deficit Patients

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Abstract:

Introduction: Mirror therapy is a novel clinical intervention to address neurological deficits like hemiplegia after stroke and postoperative procedures, aiming to enhance patients' neurological function and overall quality of life. It is a non-pharmacological and inexpensive method of treatment. The study is aimed to assess the effectiveness of mirror therapy to improve upper extremity motor function in neurological deficit patients and to implement it as a routine inpatient service. **Materials and Methods:** A quasi-experimental study was conducted in the Neurology /Neurosurgery Ward, Male/Female Medical Ward and Oncology Wards of a tertiary care centre. Non probability purposive sampling technique was used to select 52 study subjects with neurological deficits based on the inclusion and exclusion criteria. Sociodemographic and Clinical variables were collected. Fugl Meyer assessment scale was used to assess the pre and post interventional upper extremity motor function scores. Mirror therapy was administered for 30 minutes per day for 6days/week for two weeks for the intervention group. The comparison group received routine treatment only. Post assessment was done on 7th and 14thday of intervention for both the groups. **Results:** It was found that in the intragroup comparison, both groups showed statistically significant differences between assessments done pre and post interventions after two weeks of therapy($p<0.05$). In the intergroup comparison, the mirror therapy group did not show significant improvements compared with the routine treatment group. **Conclusion:** The study findings concluded that

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Mirror therapy is effective in improving upper extremity motor functions among patients with neurological deficits who are hemiplegic/hemiparetic without any adverse effects.

Keywords: Mirror therapy, Neurological deficit patients, Fugl Meyer Assessment

Introduction

V.S. Ramachandran introduced mirror therapy in 1996 as a remedy for phantom limb pain after amputation. It involves utilizing a mirror to provide visual input regarding the motor activity of the intact limb during different motions, promoting focused attention on the movement of the unaffected limb. This method harnesses visual cues to stimulate concentration on non-affected limb movements, fostering positive visual feedback and facilitating neuroplastic changes, ultimately enhancing the survivor's recovery speed.[1-3]

Neuroplasticity pertains to a cell's capacity for change. With each movement you make, the brain undergoes adjustments, akin to tricking its processes. Contrary to being a fixed network like an outdated electrical circuit, the brain continuously seeks improved methods for processing information by forming or dismantling neural connections. Mirror therapy employs the overlay of reflections from unaffected limb movements onto the affected limb, creating the illusion of movement in the latter.[4]

The brain serves as the central command center for the body, responsible for processing sensory input from all five senses. Among these senses, vision often holds a dominant role. Mirror neurons activate both when an individual executes an action and when they observe someone else performing the same action, but only if the action is within the observer's capability. For instance, mirror neurons remain inactive when observing actions like a bird flying. Remarkably, mirror neurons also engage when an individual imagines an action without physically performing it. This phenomenon explains how individuals can sometimes experience empathetic sensations, such as feeling another person's pain when witnessing them getting their fingers caught in a door, causing a reflexive wince.[5]

The brain isn't a fixed network of neurons, akin to an unchanging electrical board. Instead, it continuously seeks optimization in processing and managing information by forming or dismantling connections between neurons. This adaptive process is known as neuroplasticity. During infancy, as babies explore the world through their senses, their brains undergo significant development and restructuring. Similarly, as children acquire new skills like riding

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a bike, catching a ball, or playing a musical instrument, further remodelling occurs, enabling them to perform complex actions instinctively. Neuroplasticity persists throughout life, with ongoing effects influenced by individual experiences in various activities. For instance, consistent training in mental calculation enhances competency and speed over time.[6]

Merely observing and imitating actions during mirror therapy trigger motor neurons in both the cerebral cortex and spinal cord.[7] The mechanism at work is the mirror-neuron system, comprising specialized nerves known as mirror neurons. These mirror neurons, a subset of visuomotor neurons, activate when the brain engages in observing, imagining, or performing an action. They play a crucial role in learning new motor skills through observational learning.[8,9] Merely observing an action through the mirror-neuron system triggers activation in the primary motor cortex, responsible for executing actions during tasks.[10]

Materials and methods

A Quasi experimental pre-test and post-test design was adopted to conduct the study among patients with neurological deficits. It was conducted in a 1000 bedded tertiary care hospital after obtaining the permission from the hospital authority. The researcher explained about the study and obtained the informed consent from the participants. Fifty two samples who met the inclusion criteria were selected using purposive sampling technique and were allocated into intervention group(n=26) and comparison group(n=26).The inclusion criteria were patients with first episode of stroke ,patients with stroke related and tumor related postoperative hemiplegia/hemiparesis, patients who had upper extremity motor impairment, patients who are able to understand and obeys commands, patients who are in Stage II, III and IV in Brunnstrom motor recovery .The exclusion criteria for the present study were patient who had poor cognitive function ,patients with visual deficit and perceptual deficit, Contracture in the affected limb and patients who had fracture on stroke affected extremities. The demographic and clinical variables were collected by interview technique and from medical records. The pre-test assessment was done using Fugl-Meyer assessment. The mirror therapy containing functional tasks was administered for 30 minutes per day and 6days/ week for two weeks for the intervention group. The comparison group received routine care only. At the end of 7th day and 14th day of intervention, a post-assessment was done using Fugl-Meyer Assessment for both the intervention group and comparison groups.

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Mirror apparatus

Articles Required

1. Mirror box
2. Chair
3. Bed Side table
4. Percussion hammer
5. Pencil
6. Sponge ball
7. Small ball
8. Circular Fidget
9. Wipe clothes
10. Bottle/Basket/steel glass
11. Container with coins
12. Cards

S.No	Mirror Therapy Exercises	Sets and Repetitions
1	Arm extension and palm up and down	3 sets with 10 reps
2	Elbow bend, palm up and down	3 sets with 10 reps
3	Moving of elbow inward and outward swiping-like movement	3 sets with 10 reps
4	Moving wrist backward, forward, and sideways	3 sets with 10 reps
5	Fisting and unfisting of hand	3 sets with 10 reps
6	Touching the thumb with each finger	3 sets with 10 reps
7	Using a small ball open and close your hand	3 sets with 10 reps
8	Moving hands up and down holding a pencil	3 sets with 10 reps
9	Using fidget for hand exercise	3 sets with 10 reps
10	Squeezing a sponge ball	3 sets with 10 reps
11	Moving a basket /steel glass up and down	3 sets with 10 reps
12	Putting coins/clips in the basket	3 sets with 10 reps
13	Using a washcloth for swiping movements	3 sets with 10 reps
14	Flipping of cards	3 sets with 10 reps
15	Crawl your fingers up, down and diagonally in the mirror	3 sets with 10 reps

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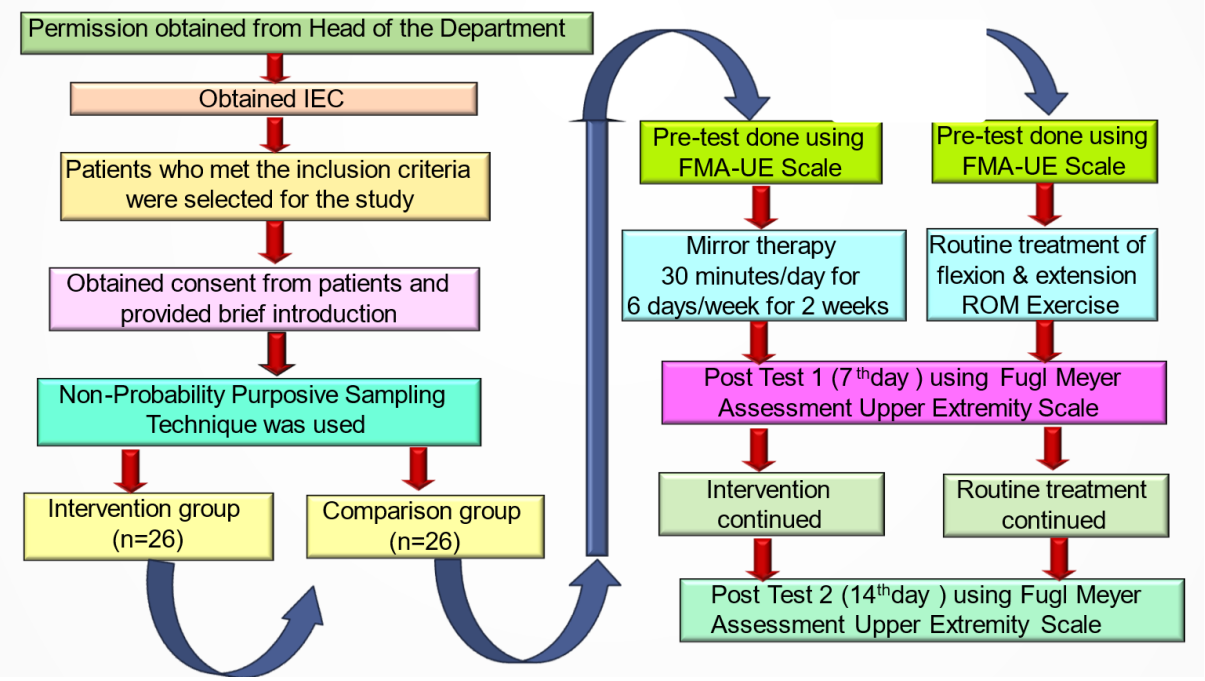
Table.1: Mirror therapy Protocol



RESULT

Motor performance Score was significantly improved after post-test1 and post- test 2 as $p<0.05$ and $p<0.001$, i.e.1.88% and 18.24% respectively. Sensation scores was improved in post-test 1 but not statistically significant at $p<0.05$ (i.e. 1.14%) and significantly improved after post-test 2 as $p<0.05$ (i.e. 15.69%) respectively. Passive Joint Motion Score was improved after post-test1 but no statistically significant as $p>0.05$ (1.04%) and significantly improved after post-test 2 as $p<0.005$(20.3%) respectively. Joint pain scores were increased after post-test 1 but not statistically significant as $p>0.05$(0.18%) and statistically not significant after post-test 2 as $p>0.05$(1.56%) respectively.

Motor performance Score was significantly improved after post-test 1 and post-test 2 as $p<0.05$, i.e.0.45% and 5.67% respectively. Sensation scores was improved in post-test 1 but not statistically significant at $p<0.05$ (i.e. 2.03%) and significantly improved after post-test2 as $p<0.05$ (i.e. 5.28%) respectively. Passive Joint Motion Score was improved after post-test 1 but not statistically significant as $p>0.05$ (3.93%) and significantly improved after post-test2 as $p<0.005$(15.93%) respectively. Joint pain scores were increased after post-test1 but not

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statistically significant as p>0.05(2.38%) and statistically significant after post-test2 as p<0.05(12.08%) respectively.

There is no significant difference of motor performance score, sensation score, passive joint motion score at pre-test, post -test1, post-test 2 between intervention and comparison group as p>0.05, i.e., intervention group had less motor performance, sensation and passive joint motion score than the comparison group.

There is a significant difference of joint pain score at pre-test and post-test 1 between intervention and comparison group as p<0.05 and not significant difference of joint pain score at post-test 2 between intervention and comparison group as p>0.05.

There is no significant association between the selected sociodemographic and clinical variables and the pre-test motor performance scores, sensation score, passive joint motion score and joint pain score among sample population.

Table.2: Distribution of Sociodemographic variables in both intervention and comparison group

S No	Sociodemographic Variables	Intervention Group (n=26)	Comparison Group (n=26)	Chi-square P Value
		f (%)	f (%)	
1	**Age (yrs)**			
	15 – 25	2 (7.69)	0 (0)	5.94 P=0.20
	26 – 35	5 (19.23)	1 (3.85)	
	36 – 45	7 (26.92)	8 (30.77)	
	46 – 55	5 (19.23)	9 (34.62)	
	56 & above	7 (26.92)	8 (30.77)	
2	**Gender**			0 P=1
	Male	19 (73.08)	19 (73.08)	
	Female	7 (26.92)	7 (26.92)	
3	**Educational status**			
	No formal education	1 (3.85)	0 (0)	6.59 P=0.086
	Primary	2 (7.69)	9 (34.62)	
	Secondary	4 (15.38)	2 (7.69)	
	Graduate	19 (73.08)	15 (57.69)	

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4	**Occupation**			
	Housewife	6 (23.08)	3 (11.54)	12.61 P=0.006
	Labourer	1 (3.85)	3 (11.54)	
	Business	8 (30.77)	0	
	Government	11 (42.31)	20(76.92)	
5	**Support system**			0
	Yes	26 (100)	26 (100)	P=1
	No	0	0	

n=52

Table.3: Distribution of Clinical variables in both intervention and comparison group

S No	Clinical Variables	Intervention Group (n=26)	Comparison Group (n=26)	Chi-square P Value
		f (%)	f (%)	
1	**Type of neurological deficits**			
	Stroke related hemiplegia	20 (76.92)	22 (84.62)	0.12 P=0.73
	Tumour related hemiplegia	6 (23.08)	4 (15.38)	
2	**Duration of neurological deficits**			
	< 10 Days	0 (0)	0 (0)	8.80 P=0.012
	10 days – 6 mths	12 (46.15)	8 (30.77)	
	6mths – 1 year	9 (34.62)	18 (69.23)	
	>1year	5 (19.23)	0	
3	**Side of hemiplegia**			
	Right	13 (50)	15 (57.69)	0.31 P=0.58
	Left	13 (50)	11 (42.31)	
4	**Pre stroke dominant side**			
	Right	23 (88.46)	24 (92.31)	FET; P=1
	Left	3 (11.54)	2 (7.69)	
5	**Hand dominance**			
	Right	23 (88.46)	24 (92.31)	FET;

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	Left	3 (11.54)	2 (7.69)	P=1
6	**Duration of hospital stay (Days)**			
	10 – 15	2 (7.69)	13 (50)	11.34 P=0.001
	>15	24 (92.31)	13 (50)	

Table.4: Frequency and Percentage Distribution of upper extremity motor function in both intervention and comparison group

S No	Variables	Intervention Group (n=26)			Comparison Group (n=26)		
		Pre-test	Post test1	Post-test 2	Pre-test	Post test1	Post-test 2
1	**Motor performance score**	**f (%)**	**f (%)**	**f (%)**	**f (%)**	**f (%)**	**f (%)**
	>63 (Normal)	0 (0)	0 (0)	1 (3.85)	0 (0)	0 (0)	0 (0)
	55 – 62 (Mild)	1 (3.85)	1 (3.85)	1 (3.85)	1 (3.85)	1 (3.85)	1 (3.85)
	33 – 54 (Moderate)	5 (19.23)	5 (19.23)	4 (15.38)	4 (15.38)	4 (15.38)	5 (19.23)
	<32 (Severe)	20 (76.92)	20 (76.92)	20 (76.92)	21 (80.77)	21 (80.77)	20 (76.92)
2	**Sensation score**						
	>10 (Normal)	4 (15.38)	4 (15.38)	5 (19.23)	2 (7.69)	1 (3.85)	2 (7.69)
	7 – 9 (Mild)	7 (26.92)	7 (26.92)	14 (53.85)	20 (76.92)	20 (76.92)	22 (84.62)
	4 – 6 (Moderate)	11 (42.31)	11 (42.31)	7 (26.92)	2 (7.69)	0(0)	1 (3.85)
	<3 (Severe)	4 (15.38)	4 (15.38)	0(0)	2 (7.69)	5 (19.23)	1 (3.85)
3	**Passive joint motion score**						
	>19 (Normal)	2 (7.69)	2 (7.69)	3 (11.54)	0(0)	0(0)	0(0)
	13 – 18 (Hypo mobility)	1 (3.85)	2 (7.69)	6 (23.08)	4 (15.38)	3 (11.54)	5 (19.23)
	<12 (No movement)	23 (88.46)	22 (84.62)	17 (65.38)	22 (84.62)	23 (88.46)	21 (80.77)
4	**Joint pain score**						

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	0 (No)	0(0)	0(0)	0(0)	1 (3.85)	1 (3.85)	0(0)
	1 – 8 (Mild)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
	9 – 15 (Moderate)	3 (11.54)	3 (11.54)	2 (7.69)	9 (34.62)	9 (34.62)	5 (19.23)
	>15 (Severe)	23 (88.46)	23 (88.46)	24 (92.31)	16 (61.54)	16 (61.54)	21 (80.77)

Table.5: Effectiveness of mirror therapy on upper extremity motor performance sensation, passive joint motion and joint pain scores in intervention group

S No	Variables	Mean ± SD	M_e(IQR)	Wilcoxon Z Value	P Value	Significance
1	**Motor performance score**					
	Pre test	22.31 ± 14.94	19 (11-29.5)	-	-	-
	Post-test 1	22.73 ± 14.7	19 (12-29.5)	2.06	**0.039**	**Significant**
	Post-test 2	26.38 ± 14.18	23.5 (15-31)	4.12	**<0.0001**	**Highly Significant**
2	**Sensation score**					
	Pre test	6.12 ± 3.49	6 (4 - 8)	-	-	-
	Post-test 1	6.19 ± 3.46	6 (4 - 8)	1	0.32	**Significant**
	Post-test 2	7.08 ± 3.21	8 (8 - 8)	2.55	**0.011**	**Significant**
3	**Passive joint motion score**					
	Pre test	7.69 ± 6.94	10 (0-12)	-	-	-
	Post-test 1	7.77 ± 7	10 (0-12)	1	0.32	**Significant**
	Post-test 2	9.23 ± 7.14	12 (10-12)	2.83	**0.005**	**Significant**
4	**Joint pain score**					
	Pre test	22.5 ± 3.95	24(24-24)	-	-	-

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	Post-test 1	22.46 ± 3.93	24(24-24)	1	0.32	Nonsignificant
	Post-test 2	22.85 ± 3.4	20(12-24)	0.37	0.72	Nonsignificant

Table.6 : Effectiveness of routine treatment on upper extremity motor performance, sensation, passive joint motion and joint pain scores in comparison group

n=26

S No	Variables	Mean ± SD	M_e(IQR)	Wilcoxon Z Value	P Value	Significance
1	**Motor performance score**					
	Pre test	24.53 ± 11.05	25 (19.7-29.5)	-	-	-
	Post-test1	24.42 ± 10.81	24 (19-29.5)	0.67	0.5	Nonsignificant
	Post-test 2	25.92 ± 9.96	26 (19.7 - 30)	2.28	0.023	**Significant**
2	**Sensation score**					
	Pre test	7.38 ± 2.25	8 (8 - 8)	-	-	-
	Post-test 1	7.23 ± 2.34	8 (4 - 8)	1	0.32	Nonsignificant
	Post-test 2	7.77 ± 2.29	8 (8 - 8)	1.63	0.1	Nonsignificant
3	**Passive joint motion score**					
	Pre test	9.92 ± 4.98	12 (11-12)	-	-	-
	Post-test 1	10.31 ± 4.37	12 (3.5-14)	1.07	0.29	Nonsignificant

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	Post-test 2	11.5 ± 2.85	12 (12-12)	1.69	0.092	Nonsignificant
4	**Joint pain score**					
	Pre test	18.03 ± 6.75	24(12-24)	-	-	-
	Post-test1	18.46 ± 6.82	24(24-24)	1.6	0.11	Nonsignificant
	Post-test 2	20.69 ± 4.96	24(16-24)	2.41	0.016	**Significant**

Table.7 : Comparison of effectiveness of mirror therapy on upper extremity motor performance, sensation, passive joint motion and joint pain scores in intervention group with comparison group

n=52

S No	**Variables**	**INTERVENTION GROUP (n=26)**		**COMPARISON GROUP (n=26)**		**MW test Z Value**	**P Value**	**Significance**
		Mean ± SD	**M_e(IQR)**	**Mean ± SD**	**M_e(IQR)**			
1	**Motor performance score**							
	Pre test	22.31 ± 14.94	19 (11-29.5)	24.53 ± 11.05	25 (19.7-29.5)	1.05	0.29	Nonsignificant
	Post-test1	22.73 ± 14.7	19 (12-29.5)	24.42 ± 10.81	24 (19-29.5)	0.91	0.36	Nonsignificant
	Post-test 2	26.38 ± 14.18	23.5 (15-31)	25.92 ± 9.96	26 (19.7 - 30)	0.5	0.62	Nonsignificant

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2	**Sensation score**							
	Pre test	6.12 ± 3.49	6 (4 - 8)	7.38 ± 2.25	8 (8 - 8)	1.99	0.05	Nonsignificant
	Post-test1	6.19 ± 3.46	6 (4 - 8)	7.23 ± 2.34	8 (4 - 8)	1.72	0.085	Nonsignificant
	Post-test 2	7.08 ± 3.21	8 (8 - 8)	7.77 ± 2.29	8 (8 - 8)	1.53	0.13	Nonsignificant
3	**Passive joint motion score**							
	Pre test	7.69 ± 6.94	10 (0-12)	9.92 ± 4.98	12 (11-12)	1.63	0.1	Nonsignificant
	Post-test 1	7.77 ± 7	10 (0-12)	10.31 ± 4.37	12 (3.5-14)	1.54	0.12	Nonsignificant
	Post-test 2	9.23 ± 7.14	12 (10-12)	11.5 ± 2.85	12 (12-12)	0.86	0.39	Nonsignificant
4	**Joint pain score**							
	Pre test	22.5 ± 3.95	24(24-24)	18.03 ± 6.75	24(12-24)	2.48	0.013	**Significant**
	Post-test 1	22.46 ± 3.93	24(24-24)	18.46 ± 6.82	24(24-24)	2.12	0.034	**Significant**
	Post-test 2	22.85 ± 3.4	20(12-24)	20.69 ± 4.96	24(16-24)	1.91	0.056	Nonsignificant

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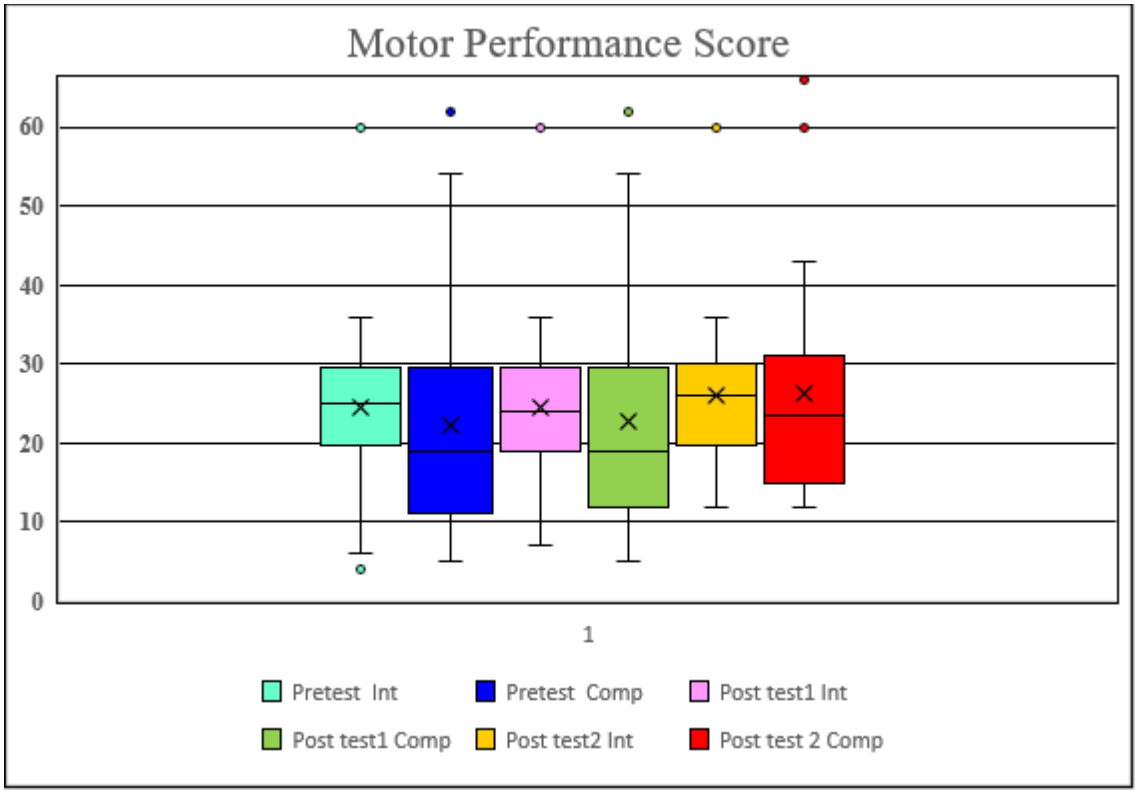
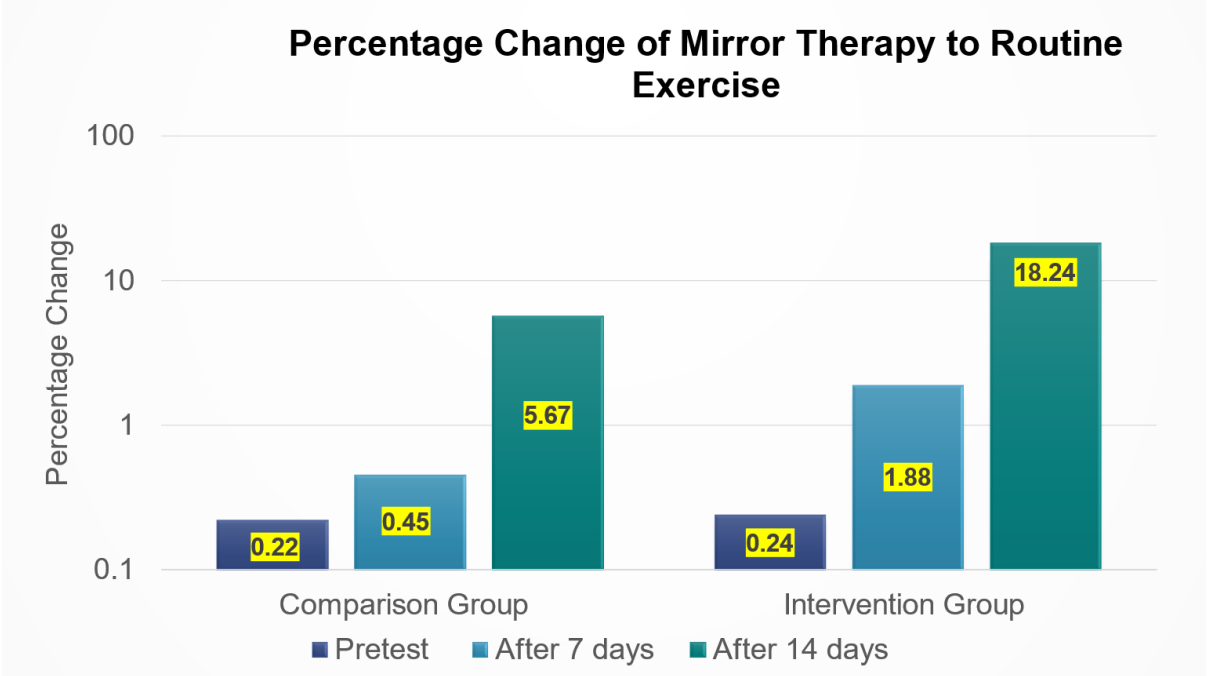


Fig.1: Comparison of effectiveness of mirror therapy on upper extremity motor performance scores in intervention group with comparison group



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Discussion:

In the present study the motor function impairment was assessed in terms of motor function ,sensation, passive joint motion and joint pain . The results of the study are in line **Steven and Stoykov** reported a 33%improvement in upper extremity function, based on FMA in two chronic stroke patients receiving combined treatment involving imagination, movement training and mirror therapy. In this study, the upper extremity function of stroke patients improved by an average of 21%in patients receiving simple mirror therapy and 31%in patients receiving task-oriented mirror therapy.[11]

The results of the study are in line with **Lee et.al.** who have used FMA upper extremity assessments to evaluate the effects of 10 mirror therapy exercises on different parts of the affected upper extremity and determined that, with the exception of upper extremity coordination, the functions of the shoulder, elbow, forearm, wrist and hand were improved.[12]

The results of the study are in line with the study conducted by **Gandhi et al** which suggested that mirror therapy increases activity in primary and secondary visual and somatosensory areas, thus enhancing attention, conscious awareness of sensory feedback and avoidance of learned non-use of the affected limb.[13]

In a similar study, **Dohle et.al** also found that there was a significant improvement in superficial touch sensation in the mirror group compared to the control group.[14]

In the present study, it was found that in the intragroup comparison, both groups showed statistically significant differences between assessments done pre and post interventions after two weeks of therapy($p<0.05$). In the intergroup comparison, the mirror therapy group did not show significant improvements compared with the routine treatment group.

The results of the study are in line with **Gurbuz. et.al.** there was a statistically significant improvement in both groups in FMA after the treatment compared to the pre-treatment value ($p=0.001$ for both groups). The post-treatment FMA upper extremity score was statistically significantly higher in the mirror group than in the comparison grou($p=0.047$).[15]

In a similar study by **Peninga Langhu et.al.** found that pre-test and post-test values were compared and observed statistically significant ($p<0.001$) improvement in motor function, sensation, passive joint motion and joint pain scores of the upper extremity and also found significant ($p<0.001$) difference between the experimental and control group.[16]

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In a similar study by **Selvaraj et.al.** found that after 3 weeks of mirror therapy, mean change scores were significantly greater in the mirror therapy group than in the control group for Fugl -Meyer assessment (p=0.008).[17]

In a similar study by **Kim.et.al.** found that in the intragroup comparison, both groups showed significant differences between measurements taken before and after the four weeks of therapy($p<0.05$).In the intergroup comparison ,the mirror therapy group showed significant improvements compared with the conventional therapy group.[18]

CONCLUSION

The study findings concluded that Mirror therapy is effective in improving upper extremity motor functions among patients with neurological deficits who are hemiplegic/hemiparetic without any adverse effects and it can be practiced at home also and is a cost-effective nonpharmacological method which is patient friendly to practice.

ACKNOWLEDGEMENT

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CONSENT AND ETHICAL APPROVAL

- Permission from Institutional ethical committee is obtained vide Letter No. IEC S No: IEC/2023/239 Date: 24 Mar 2023
- Written informed consent taken from participants.
- Information collected will be kept confidential.

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