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Effect of Rhythmic Auditory Stimulation against Mirror Therapy on Hand Function in Stroke Patients

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Abstract

Objective: Stroke affects the upper limb function keeping the patient dependent for daily activities. Rhythmic auditory stimulation is proved to be beneficial in upper limb functions, although Mirror therapy and Conventional therapy has their own beneficial effects in stroke. The study aimed at comparing the effect of rhythmic auditory stimulation against mirror therapy and conventional therapy. **Method:** Sixty participants were taken for the study divided into three groups, 20 in each. Interventions were planned with Group A for Conventional therapy, Group B for Rhythmic Auditory Stimulation and Group C as Mirror therapy. Hand grip was measured by Hand held Dynamometer and Hand function by using Action Research Arm Test. Treatment was given for 20 minutes in a day, for 5 sessions a week extending for 4 weeks. **Findings:** The results obtained after the analysis showed a significant difference in ARAT scores among three groups: Control (34.80 ± 8.27), RAS (40.60 ± 7.12) and Mirror therapy (33.50 ± 7.86) with mean post-test scores ($F=4.7400$, $p=0.0120$) and change from pre-test to post-test ($F=67.2790$, $p=0.0001$). A significant difference was observed among three groups: Control (21.28 ± 6.82), RAS (27.61 ± 6.94) and Mirror therapy (23.39 ± 5.47) with mean post-test scores ($F=5.0040$, $P=0.0100$) and pretest post-test score for hand grip ($F=59.6750$, $P=0.0001$). **Novelty:** Mirror therapy and rhythmic auditory stimulation influences the visual and the auditory system respectively. The novelty of this study is being exhibited in identifying the effective intervention that can influence the neuroplasticity of the brain in the learning process. **Conclusion:** Both RAS and mirror therapy programme have been found to improve hand functions and grip in paretic arms; hence they can be used as an add-on intervention alongside convention therapy to help hemiparetic patients regain upper extremity function.

Keywords: Rhythmic Auditory stimulation; Mirror box; Paretic arm; Hand function and Hand grip

1 Introduction

Hemiplegia caused by a stroke involves huge complications that impact cognitive function, perceptual issues, and motor skills. Individuals may not use their damaged upper limb after a stroke at first, which can develop learned non-use⁽¹⁾. As the upper limb deficits persist for 6 months in more than 50% of hemiplegics, a necessity arises to focus on upper limb recovery⁽²⁾. Functional improvement is the result of Plasticity of neural systems, additionally, physiological and psychological adaptation adds up for the recovery⁽³⁾.

Stretching and exercise therapy procedures, which depend on the therapist according to the needs, are some of the popular conventional therapeutic interventions, while there is a wide range of therapies accessible⁽⁴⁾. The most effective intervention in using systems to affect the motor learning process is still unknown. In mirror therapy, a mirror is positioned between arms such that the paretic arm's vision is blocked and patient can observe movements of the intact arm in the mirror. The patient is urged to follow the unaffected arm movement at the same time as the mirror's reflection⁽⁵⁾. A recent year study had shown the positive benefits of enhancing the task-oriented movements of hemiplegics⁽⁶⁾. Mirror therapy works by stimulating the somatosensory cortex, premotor cortex and the mirror neuron system in the fronto-temporal region and superior temporal gyrus. This cortical incitement could bring up the motor output in hemi paretic subjects⁽⁷⁾.

Rhythmic auditory stimulation influences the temporal lobe through the auditory system. Auditory rhythm is a powerful sensory cue that can regulate motor timing and coordination in the presence of a deficient internal timing system in the brain⁽⁸⁾. Interestingly, music training when merged with motor training neuroplastic changes happen in the adult brain⁽⁹⁾.

In a recent study they have proved that combined effect of visual and auditory incitement has advantageous impact on strength and functions of hemi paretic arm⁽¹⁰⁾. Although both the interventions are favorable being cost-effective and easy to administer in the neurological rehabilitation for upper limb functions no studies had compared the effectiveness in their physiological recovery. So, the novelty of the study was to compare the effectiveness of rhythmic auditory stimulation against mirror box therapy on paretic arm of stroke patients, also to identify which intervention is significantly effective in the motor learning.

2 Methodology

Study design was made as three group pre-test, post-test experimental study where random sampling technique was used for sampling. Study was explained to all 60 patients and obtained the consent as well. After obtaining the approval from the Ethical Committee patients were allocated into three groups of 20 in each group. The study was conducted at OPD of Krupanidhi College of Physiotherapy and hospitals in and around Bangalore and the duration of the study was one year. The inclusion criteria were thrombotic or embolic type of stroke in which the anterior cerebral artery or Middle cerebral artery was involved. Both genders were taken for the study. Criteria for inclusion were considered with the age limit 35 to 60 years. Patients under the category of Brunnstrom recovery stage 3 and 4 hand component was included. The duration of the condition was from onset to within six months with intact hearing limits.

Patients who have dementia, major depression or productive psychosis were excluded from the study. Participants with visual impairments that would limit them from mirror therapy and visuospatial neglect, which was evaluated by therapist asking patients to turn their head toward the examiner on their contralateral side also excluded. Patient with pain or joint contractures in the upper limb that prevented movement were excluded.

The treatment was given one session a day, five days a week for a month. The study duration was for one year, Group A, B and C received conventional therapy, rhythmic auditory stimulation and mirror box therapy respectively.

2.1 Procedure

2.1.1 Conventional Physiotherapy

The Group A was given conventional therapy which include Tone normalization, free movements for the arm, sensory reeducation also encouraging voluntary movements such as grooming and dressing. In tone normalization sustained pressure over the agonist muscle was given. Free movements of arm and hand, guiding for voluntary control, Sensory re-education includes stroking through the thenar and hypothenar eminences 5-10 times for intentional muscular activity. Patients were allowed to feel objects of various size, shapes and materials for localization of touch. Treatment was given for 20 min.

2.1.2 Rhythmic Auditory Stimulation

Group B was given Rhythmic Auditory Stimulation (RAS) in which subjects were positioned in sitting in the chair, with paretic arm on the table. RAS was given using a smart-phone supported digital metronome placed over the table. The treatment

duration was 20 mins. The participants were asked to perform movements like grasping and releasing of ball, rolling the ball within fingers and palm, squeezing a ball and coin stacking. This was performed in sequence with the metronome beats.

2.1.3 Mirror Therapy

Group C was given 20-minute mirror box training session in which the patient was asked to place nonparetic hand in front of the mirror and their paretic hand behind the mirror. The patients were instructed to perform movements of hand and fingers in all degrees, including fists on the affected side, sponge squeezing, Table swiping with a towel, using a peg board, and beans transfer using a spoon, while gazing into a mirror to observe the reflection of intact hand. Subjects were instructed to perform the same movements with affected hand parallelly.

2.2 Measurement Tool and Method

Action Research Arm Test (ARAT) was taken to evaluate the upper limb functioning. The hand grip strength was measured by a hand-held dynamometer.

2.3 Statistical Analysis

Statistical analysis was done using paired t test for within the groups. One way ANOVA was used for between three groups to measure hand grip. The data was analyzed using the SPSS version 29.0.

3 Results and Discussion

After analyzing the data, the results obtained showed that there were no significant differences between 3 groups in pretest ARAT scores: Control (30.55 ± 8.04), RAS (27.70 ± 8.67) and Mirror therapy (26.70 ± 8.25) ($F=1.1520$, $p=0.3230$). But significant difference was observed between three groups in post-test ARAT scores: Control (34.80 ± 8.27), RAS (40.60 ± 7.12) and Mirror therapy (33.50 ± 7.86) ($F=4.7400$, $p=0.0120$). These difference between pretest and posttest score was ($F=67.2790$, $P=0.0001$). A Significant improvement were observed in all the 3 groups, control group (13.91%) (Table 1), in RAS group (46.57%) (Table 2) and in Mirror therapy group (25.47%) (Table 3), the RAS group had shown further enhancement in ARAT scores (Table 4). Similarly, there was no significant difference in pretest grip scores between three groups; Control (18.74 ± 5.73), RAS (17.76 ± 5.12) and Mirror therapy (19.03 ± 4.91) ($F=0.3170$, $p=0.7290$). But significant difference was noted in post test scores: Control (21.28 ± 6.82), RAS (27.61 ± 6.94) and Mirror therapy (23.39 ± 5.47) ($F=5.0040$, $P=0.0100$). The difference between pretest and post-test score was ($F=59.6750$, $p=0.0001$). While comparing the pre and post-test significant improvement was observed in control group (13.55%) (Table 1), in RAS group (55.46%) (Table 2) and in Mirror therapy group (22.92%) (Table 3) and the RAS group is showing better progress in hand grip (Table 5).

Table 1. Pretest and posttest Action Research Arm Test and Handgrip scores in Group A (conventional therapy)

Variables	Pretest mean values	Posttest mean values	SD	P-value	Significance
ARAT	30.55	34.80	1.41	0.0001*	Highly significant
HAND GRIP	18.74	21.28	1.63	0.0001*	Highly significant

From the table 1, it is inferred that Group A showed good improvement in Hand function and grip strength

Table 2. Pretest and posttest Action Research Arm Test and grip strength scores in Group B (Rhythmic auditory stimulation)

Variables	Pretest mean values	Posttest mean values	SD	P-value	Significance
ARAT	27.70	40.60	3.67	0.0001*	Highly significant
HAND GRIP	17.76	27.61	2.98	0.0001*	Highly significant

From the table 2, it is inferred that Group B showed good improvement in Hand function and grip strength

Weakness or paralysis is the most typical stroke impairment that leads to dysfunction most frequently. To restore functional abilities in the paretic arm, stroke therapy recommendations prescribe a few months of high-quality, high-quantity functional task practice⁽¹¹⁾. The study focused on comparing the effect of mirror therapy against rhythmic auditory stimulation on functions of hemi-paretic arm. The obtained results after the treatment showed significant improvement in group A

Table 3. Pretest and posttest Action Research Arm Test and grip strength scores in Group C (Mirror Therapy)

Variables	Pretest values	mean	Posttest values	mean	SD	P-value	significance
ARAT	26.70		33.50		6.80	0.0001*	Highly significant
HAND GRIP	19.03		23.39		1.74	0.0001*	Highly significant

From the table 3, it is inferred that Group C showed good improvement in Hand function and Grip strength

Table 4. Comparison of pretest and posttest ARAT scores in three groups (Control, RAS and Mirror therapy)

Groups	Time	Mean	SD	Mean Diff.	SD Diff.	% of effect	t-value	p-value
Control group	Pretest	30.55	8.04	4.25	1.41	13.91	13.4841	0.0001*
	Posttest	34.80	8.27					
RAS group	Pretest	27.70	8.67	12.90	3.67	46.57	15.7228	0.0001*
	Posttest	40.60	7.12					
Mirror therapy group	Pretest	26.70	8.25	6.80	1.47	25.47	20.6515	0.0001*

The table 4 indicates the significant difference in hand functions using ARAT in all three groups

Table 5. Comparison of three groups (Control, RAS and Mirror therapy) with mean pretest and posttest grip strength scores by one-way ANOVA

Time points	Sources of variation	df	Sum of Squares	Mean Square	F-value	P-value
Pretest	Between groups	2	17.61	8.81	0.3170	0.7290
	Within groups	57	1581.63	27.75		
	Total	59	1599.25			
Posttest	Between groups	2	415.67	207.84	5.0040	0.0100*
	Within groups	57	2367.36	41.53		
	Total	59	2783.03			
Difference	Between groups	2	579.26	289.63	59.6750	0.0001*
	Within groups	57	276.65	4.85		
	Total	59	855.90			

The table 5 shows the differences within the group and between group comparisons for grip strength

(Conventional therapy), group B (Rhythmic auditory stimulation), and group C (Mirror therapy). A higher score was in the rhythmic auditory stimulation group (group B) as compared with the other groups in hand grip, action research arm test (ARAT), and hand function.

A recent study by Rujin Tian et.al, on 30 stroke patients, in two groups of 15, significant improvements in motor functions were observed in the RAS group from 50.40 to 59.73 mean SD in Fugl-Meyer assessment of upper extremity scale and 38.27 to 49.53 mean SD in Wolf Motor Function Test. The Barthel index score also improved from 60.67 to 80.33 mean SD⁽⁶⁾. According to Shinil Kang, range of motion got improved $P=0.0019$, minimum euler angle $p=0.0057$, Duration $p=0.0002$, and RMSE $p=0.0063$ in hemi-paretic stroke patients after receiving auditory cuing during upper limb movement. The study results signify the positive impact of music on various motor patterns and muscular endurance⁽¹²⁾. Dorcas BC Gandhi et.al, in a recent review, concluded that Mirror box therapy has advantageous effects on motor and sensory impairments⁽¹³⁾. The study results were also favored by Shafqatullah Jan in which mirror box therapy showed improvements in hand function when compared with motor learning programme⁽¹⁴⁾. Hussein Shaker had proven the positive effects of mirror therapy in wrist extensors and grip strength of the paretic arm⁽¹⁵⁾.

During mirror therapy, mirror neurons that are already present in brain cells get stimulated. The presence of a mirror neuron system in the fronto-temporal region and superior temporal gyrus gets activated in response to a goal-directed hand movement or when someone else performs a similar movement⁽¹⁶⁾. Training with rhythmic auditory stimulation helps the cerebellum, supplementary motor region, premotor cortex, and basal ganglia to activate. At the perceptual level, auditory stimuli reach the brain faster than visual and tactile stimuli⁽¹⁷⁾. As per the above discussions based on analysis, it is understood that Mirror Therapy, Rhythmic Auditory Stimulation and conventional therapy is effective in hand functions. Interestingly Rhythmic

Auditory Stimulation is highly beneficial as compared to Mirror therapy and Conventional therapy.

4 Conclusion

The study findings suggest that both RAS and Mirror Therapy have advantageous effects on hand functions and strength of the hemiparetic arm. However, on comparison the study results indicates that RAS is more effective than mirror therapy and conventional physiotherapy in promoting recovery of the hand functions. Therefore, it is suggested that RAS could be an additive with ongoing physiotherapy or other treatment interventions to promote the rehabilitation of hand functions in hemiparetic patients.

5 Limitation and Suggestions

The study lacks the follow up; long term benefits of the intervention can be checked. It was conducted in 60 subjects so the findings would not be appropriate for all stroke patients. Programs tailored to patients with different levels of functioning and Brunnstrom stages should be developed.

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