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A Comparative study on effectiveness of graded motor imagery technique and functional stregnth training on upper limb motor activity and functional performance among post stroke patients

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Abstract

Background: Stroke is a leading cause of disability that affects upper limb motor function and daily activities. This study aimed to compare the effectiveness of graded motor imagery (GMI) and functional strength training (FST) on upper limb motor activity and functional performance among post-stroke patients.

Methodology: The study was conducted at RVS College of Physiotherapy with ethical approval and informed consent. Forty post-stroke patients meeting the inclusion criteria were divided into two groups: Group A received graded motor imagery, and Group B received functional strength training. Both groups were treated for two weeks. Upper limb motor activity and functional performance were assessed using the Fugl-Meyer Assessment for Upper Extremity (FMA-UE) and the Action Research Arm Test (ARAT).

Results: Unpaired t values for upper limb motor activity (7.75) and functional performance (12.8) exceeded the critical value (2.763, $p<0.005$), indicating significant differences between the two interventions.

Conclusion: Graded motor imagery was more effective than functional strength training in improving upper limb motor activity and functional performance among post-stroke patients.

Keywords: Stroke, Graded motor imagery, Functional strength training, Upper limb motor activity, Functional performance.

Introduction

Stroke has been defined as an "rapidly developing clinical signs of focal and global disturbance of cerebral blood function with symptoms lasting 24 hours or longer or leading to death with no apparent cause other than vascular origin".[1]

Atherosclerosis, cerebral thrombus, cardiac embolism, intracranial haemorrhage, subarachnoid haemorrhage, and intracranial small vessel disease are among the primary causes of stroke. Hypertension, diabetes, heart disease, obesity, abnormal blood lipids, cigarette smoking, alcohol and drug use, and physical activity are risk factors for stroke.[2]

One of stroke's most prevalent and incapacitating aftereffects is motor dysfunction. Upper extremity (UE) motor dysfunction following a stroke impairs everyday living, recreational, and occupational activities, increasing reliance and decreasing social engagement. Patients prioritize functional independence, quality of life, and effective upper extremity rehabilitation that optimizes recovery.[3]

Compared to anterior cerebral artery stroke, middle cerebral artery stroke is more frequent. The temporal lobe and two thirds of the lateral surface of the hemisphere are supplied by the cortical branches of the middle cerebral artery.[4]

Impaired upper extremity motor function is the main issue with hemiplegia. Due to upper extremity weakness, hemi paretic patients have difficulty performing daily tasks like clothing, bathing, writing, and self-care. Strokes frequently result in decreased manual dexterity and hand function, which restricts activities.[1]

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Graded Motor Imagery Technique

Graded motor imagery is a therapeutic strategy targeting the activation of different networks in a graded manner. Brain is a target organ of graded motor imagery. Graded motor imagery progressively engages the cortical neural networks in order to improve cortical reorganization through neuroplasticity. Graded motor imagery is a three-stage process compromising of left /right discrimination training (implicit motor imagery), Explicit motor imagery motor imagery (imagined movements) and mirror therapy. The cognitive technique of visualizing a movement of our own body without actually moving it is known as motor imagery.[6]

Laterality training, motor imagery, and mirror therapy are all steps in the sequential process of graded motor imagery. In general, "graded" refers to a series of procedures that include motor imagery, mirror treatment, laterality reconstruction, and the requirement that the brain be exposed to body representations in a graded manner rather than bodily tissue. Restoring accuracy and speed in determining whether a visual or real body part represents the right or left side of the body, or whether the body is oriented to the right or left, is known as laterality training. Technique for motor imagery is a modern method that works better for treating people who have had a left middle cerebral artery stroke in terms of wrist and hand function. Motor imagery is a technique for practicing motor skills that involves seeing or imagining the task being performed without explicit physical practice. The cognitive rehearsing of task components has positive consequences. Similar brain regions that are activated during real movement are likewise activated during imagined movement, according to brain mapping techniques. It has been repeatedly demonstrated that motor imagery helps people learn motor abilities. For individuals who get tired easily and can't keep up with physical activity, it should be taken into consideration.[7]

In mirror therapy, patients move their unaffected limb while observing their movements in a mirror. This causes the brain to receive a visual stimulation that encourages movement in the affected limb.[6]

Functional Strength Training

Functional strength training is a form of exercise that focuses on improving strength and neuromuscular control through movement patterns that mimic activities of daily living, work, or sport, emphasizing multi-joint, multiplanar movements, core stability, balance and coordination to enhance functional performance and reduce injury risk.[8]

Functional strength training is a repetitive progressive resistive exercise during goal -directed activity with the therapist providing verbal prompting and feedback.[8]

Methodology

The review board of RVS College of Physiotherapy, Coimbatore, has approved this Two-group pre-and post-test experimental study and a written consent was obtained from all the participants after giving clear instructions regarding the treatment procedure and its implications. The study was conducted in RVS College of physiotherapy, Coimbatore, Tamil Nadu, India.

Forty patients aged between 40 to 60 years were selected for the study and randomly assigned into one of two groups. Group A: Twenty Patients received graded motor imagery technique and Group B: Twenty Patients received functional strength training with each 10 to 15 repetitions per session per day, five sessions per week for a total duration of 12 weeks. Upper limb motor activity and functional performance were assessed before and after 12 weeks of intervention by Fugl Meyer Assessment upper extremity scale and Action research arm rest. Post stroke patients of age group between 40 to 60-year-old were included in the study and all the confounding variables were clearly identified and controlled.

Measurement Procedure

Fugl Meyer Assessment Upper Extremity Scale

The Fugl Meyer assessment consists of two sections namely upper arm movements and wrist and hand movements which assess the upper limb motor function of the patients. Totally there are 38 functional tasks, each patient was made to perform 3 tries of each task and the best score was recorded for analysis.

Action Research Arm Test

The action research arm test is an observational test to determine upper limb function. The test consists of 19 items grouped in subtest and performance of each item is rated on four-point scale ranging from 0-3.

Performance of each item rated on 4-point scale ranging from

3- performance test normally
2-completes test, but takes abnormally long or has great difficulty
1- Performs test partially
0-can perform no part of test

Treatment Procedure

Group A- Graded motor imagery technique

Graded motor imagery consisted of three progressive stages:

1. Laterality Training



Figure 1: Laterality training.

Patients identified whether hand images displayed on a computer were left or right hands. 60 images were shown in each session. Goal: ≥80% accuracy with a response time of about 2 seconds.

2. Mental Imagery (Introduced during the last 2 sessions of laterality training)

Patients imagined performing upper-limb movements without actually moving the affected arm. Task progressed from simple isolated movements to functional activities such as holding a cup and combing hair. Accuracy of imagined movements was emphasized.



Figure 2: Elbow flexion and extension



Figure 3: Holding a cup (functional task).

3. Mirror Therapy (Introduced during the last 2 sessions of mental imagery)

A mirror was placed vertically, hiding the affected hand. Patients performed wrist, finger, and forearm movements with the unaffected hand while attempting the same movements with the affected hand. Exercise speed was gradually increased according to patient progress.



Figure 4: Open and closing of hands.

Group B - Functional Strength Training (FST)

Patients performed task-oriented strengthening exercises for the affected upper limb

1. Sitting and Reaching Exercise

The patient sits and reaches sideways with the affected arm toward the therapist's hand. The elbow is kept extended and the shoulder abducted to 90°.

2. Quadruped Reaching Exercise

The patient assumes a quadruped position and reaches forward with the unaffected hand while supporting weight through the affected upper limb. This improves shoulder stability and weight-bearing.

3. Grasp Exercise

The patient grasps a cylindrical object using the affected hand, wrapping the fingers and thumb around it. The grip is held for 5-10 seconds to improve hand strength.

4. Pronation and Supination Exercise

The patient holds a cylindrical object and rotates the forearm alternately into pronation and supination. Each position is held for 3-5 seconds to improve forearm control and mobility.



Figure 5: Sitting and Reaching Activities.



Figure 6: Quadruped Reaching



Figure 7: Grasp Activities of hand.



Figure 8: Supination and Pronation.

DATA ANALYSIS

Table 1: Mean value, mean difference, standard deviation and paired 't' values of upper limb motor activity among group A

Measurement	Mean	Mean difference	Standard deviation	Paired 't' value
Pre-test	37.6	12.3	3.01	18.27
Post-test	49.9			

*0.005 level of significance.

In group A for upper limb motor activity the calculated paired 't' value is 18.27 and the 't' table value is 2.861 at 0.005 level of significance. Since the calculated 't' value is more than the 't' table value, there is significant difference in upper limb motor activity following graded motor imagery technique among post stroke patients.

Table 2: Mean value, mean difference, standard deviation and paired 't' values of upper limb motor activity among group B

Measurement	Mean	Mean difference	Standard deviation	Paired 't' value
Pre-test	35.9	6.8	1.01	30.25
Post-test	42.7			

*0.005 level of significance.

In group B for upper limb motor activity the calculated paired 't' value is 30.25 and the 't' table value is 2.861 at 0.005 level of significance. Since the calculated 't' value is more than the 't' table value, there is significant difference in upper limb motor activity following functional strength training among post stroke patients.

Table 3: Mean value, mean difference, standard deviation and unpaired 't' values of upper limb motor activity among group A & group B.

Measurement	Mean	Mean difference	Standard deviation	Unpaired 't' value
Group A Group B	12.3 6.8	5.5	2.26	7.75

*0.005 level of significance.

In group A & B for upper limb motor activity the calculated unpaired 't' value is 7.7 and the 't' table value is 2.704 at 0.005 level of significance. Since the calculated 't' value is more than the 't' table value, there is significant difference in upper limb motor activity between Graded motor imagery technique and functional strength training among post stroke patients.

Table 4: Mean value, mean difference, standard deviation and paired 't' values of functional performance among group A.

Measurement	Mean	Mean difference	Standard deviation	Paired 't' value
Pre-test Post-test	36.4 48.7	12.3	1.7	22.8

*0.005 level of significance.

In group A for functional performance the calculated paired 't' value is 22.8 and the 't' table value is 2.861 at 0.005 level of significance. Since the calculated 't' value is more than the 't' table value, there is significant difference in functional performance following graded motor imagery technique among post stroke patients.

Table 5: Mean value, mean difference, standard deviation and paired 't' values of functional performance among group B.

Measurement	Mean	Mean difference	Standard deviation	Paired 't' value
Pre-test Post-test	43.1 46.6	3.5	1.35	8.17

*0.005 level of significance.

In group B for functional performance the calculated paired 't' value is 8.17 and the 't' table value is 2.861 at 0.005 level of significance. Since the calculated 't' value is more than the 't' table value, there is significant difference in functional performance following functional strength training among post stroke patients.

Table 6: Mean value, mean difference, standard deviation and Unpaired 't' values of functional performance among group A & group B

Measurement	Mean	Mean difference	Standard deviation	Unpaired 't' value
Group A Group B	12 3 3.5	8.8	1.5	12.8

*0.005 level of significance.

In group A & B for functional performance the calculated unpaired 't' value is 12.8 and the 't' table value is 2.704 at 0.005 level of significance. Since the calculated 't' value is more than the 't' table value, there is significant difference in functional performance between Graded motor imagery technique and functional strength training among post stroke patients.

Results

Forty Post stroke patients who fulfilled the inclusion and exclusion criteria were selected for the study and consecutively divided into two equal groups A and B.

Group A - Treated with Graded motor imagery technique Group B - Treated with Functional strength training

The statistical findings suggested that both graded motor imagery technique and functional strength training produced significant positive outcomes in post stroke patients. A marked increase in upper limb motor activity was observed with a subjects treated with both group A and B, with a paired and unpaired t-value of 18.27,30.25 and 7.75. Similarly, functional performance showed a significant improvement, reflected by a paired t-value of 22.8,8.17 and 12.8. Overall, the critical t value results exceeded the t-table value at the 0.005 significance level, indicating a statistically significant difference between the two groups.

Discussion

This study compared the effectiveness of graded motor imagery (GMI) and functional strength training (FST) over 12 weeks among post-stroke patients, assessing upper limb motor activity and functional performance using the Fugl-Meyer Assessment Upper Extremity (FMA-UE) and Action Research Arm Test (ARAT). The findings demonstrated that graded motor imagery produced greater improvements in both upper limb motor recovery and functional performance than functional strength training.[11]

Supporting literature suggests that Graded motor imagery enhances cortical reorganization, motor planning, and neuroplasticity, leading to improved motor recovery after stroke. Previous studies have consistently reported superior outcomes with Graded motor imagery compared to conventional rehabilitation and strength-based interventions, supporting the findings of the present study.[12]

Conclusion

This study employed a pre-test and post-test experimental design to compare the effectiveness of graded motor imagery and functional strength training on upper limb motor activity and functional performance in post-stroke patients. Twenty participants were allocated into two groups and underwent 12 weeks of intervention, with outcomes assessed using the FMA-UE and ARAT. The results showed that graded motor imagery produced significantly greater improvements, confirming its superior effectiveness in enhancing upper limb motor recovery and functional performance among post-stroke patients.

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