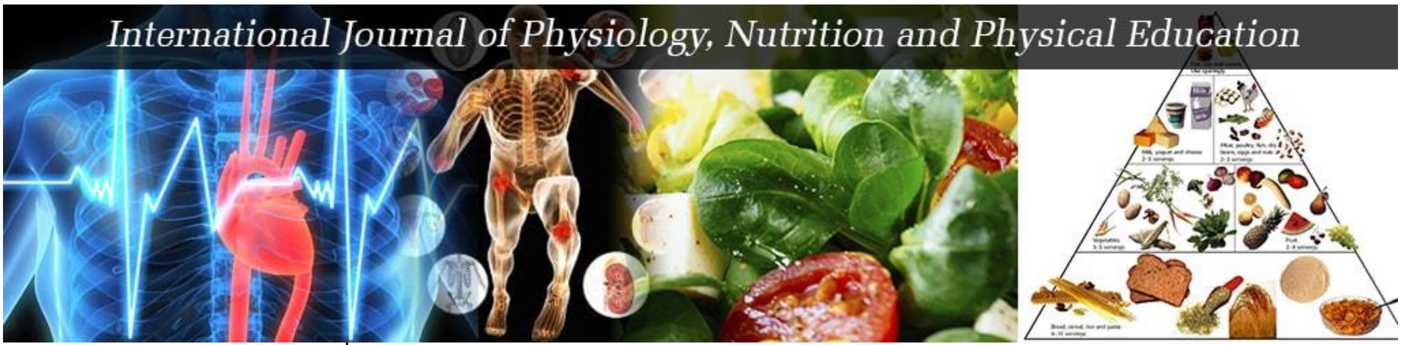
International Journal of Physiology, Nutrition and Physical Education 2018; 3(2): 329-334



ISSN: 2456-0057
IJPNPE 2018; 3(2): 329-334
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www.journalofsports.com
Received: 17-05-2018
Accepted: 18-06-2018

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Mental practice with motor imagery to improve upper limb motor function in sub-acute stroke: A comparative study

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Abstract
Background: Upper extremity function impairment is the most common and challenging sequelae of a stroke patients. Motor imagery and mental practice has been used in patients with sub – acute stroke.
Objectives: To find out the effectiveness of mental practice with motor imagery in improving upper limb motor function and to compare the effectiveness of mental practice with imagery to the conventional techniques in improving upper limb motor function.
Procedure: 30 stroke patients were included in this study and divided equally in two groups. Group A received mental practice with motor imagery session whereas group B received conventional exercise sessions. ARAT and TMD scores were taken before and after treatment.
Results: Paired't' test has been used to find the significance of study parameters within each group. Unpaired't' test has been used to find the significance of study parameters between the groups. The results of the study showed that there is a significant improvement in the upper limb function of stroke patients from both experimental and control group.
Conclusion: Mental practice with motor imagery improves upper limb motor function in stroke. However, mental practice with motor imagery cannot be considered as a better therapy option than physical practice**.** Hence, motor Imagery can be used as valuable supplementary approach in stroke rehabilitation.

Keywords: Action research arm test (ARAT) timed manual dexterity performance (TMD)

Introduction

Stroke is defined by the World Health Organization as a clinical syndrome consisting of 'rapidly developing clinical signs of focal (at times global) disturbance of cerebral function, lasting more than 24 h or leading to death with no apparent cause other than that of vascular origin [1]. Stroke is a global health problem. It is the second commonest cause of death and fourth leading cause of disability worldwide [2]. Approximately 20 million people each year will suffer from stroke and of these 5 million will not survive [3]. In developed countries, stroke is the first leading cause for disability, second leading cause of dementia and third leading cause of death. Stroke is also a predisposing factor for epilepsy, falls and depression in developed countries and is a leading cause of functional impairments, with 20% of survivors requiring institutional care after 3 months and 15% - 30% being permanently disabled [4]. Stroke prevalence among the elderly in rural India was 1.1% and urban India was 1.9%.There are two types of strokes: (1) Ischemic stroke (2) Hemorrhagic stroke. Upper extremity function impairment is the most common and challenging sequelae of a stroke patients. Many Therapists, while attempting to apply neurophysiologic principles to treatment, have limited their use to more passive techniques such as brushing, icing and neuro-developmental treatment-based handling techniques performed separately from functional tasks. With the most current research on motor control supports the use of tasks performed in content specific situations such as upper extremity weight bearing for postural support, reaching, carrying, lifting, grasping and manipulating of common objects. These types of activities clearly carry over into daily life tasks and are comprehensive enough to treat a variety of problem areas [5, 6]. Approaches used in conjunction with task-oriented approach are Constraint-induced therapy, Electromyographic biofeedback, Upper extremity weight bearing tasks, task oriented approaches etc. Another recent advancement in the field of stroke rehabilitation is mental practice or imagery. The use of imagery has received increasing amount of literature in support.

Graded Motor Imagery (GMI)

The graded motor imagery program (GMI) consists of a program of laterality reconstruction, motor imagery and mirror work and it appears to work best if carried out in that order [7]. Mental imagery can be defined as a Dynamic state during which an individual simulates a given action [8]. A motor imagery is the mental representation of a previously executed movement, while motor imagery based mental practice is a process whereby a motor image is evoked repeatedly to improve motor behaviour [9].

Active Motor Imagery includes: 1) Laterality reconstruction 2) Mirror therapy.

1) Laterality reconstruction is the restoration of the brain's concept of left and right. Two tools can be used to assess and treat laterality deficits; these are flash cards and recognize programme [9].
2) Mirror therapy uses a mirror box, where the brain is tricked into thinking that the limb is actually better than the brain think it is. If the affected limb is "hidden" inside a box with a mirror on one side, use of good limb in front of the mirror will inform the brain, via the reverse image, that the painful and disabled limb can be moved. When individuals actually perform an action (moving their fingers) and when they mentally imagine moving their fingers, activation is similarly detected in the supplymentary motor area (SMA) and primary cortex (M1) [9]. Activation in the motor cortex during motor imagery amounts about 30% of the level observed during actual performance [9].

The purpose of this study is to fine the combined therapeutic effects mental practice with motor imagery (Mirror box and laterality reconstruction) in improving hand function following stroke. Aim of this study is to evaluate the therapeutic benefit of mental practice with motor imagery in improving upper limb motor function in stroke.

Materials and methodology

The proposed study was Quasi Experimental Study Design. It was pretest, posttest experimental study. 30 subjects were selected by means of convenient sampling procedure. This study was conducted at Shree B. G. Patel College of Physiotherapy, Anand. Subjects with age group of 40 to 75 years, both male and female subjects, patients had an episode of stroke in recent 6 months before the study, ARAT score between 3 and 51 and Mental state questionnaire score should be 7 or more were included in this study. If patient have any lethal diseases, altered vitals and unstable cardiac condition, having any previous history of neurological or orthopaedic conditions involving both the upper extremities, having comprehension and perceptual deficit were excluded in this study. Measurements of study taken by action research arm test (ARAT) and timed manual dexterity performance scale (TMD). Thirty subjects with age group of 40 to 75 years having the stroke were selected according to the baseline inclusion & exclusion criteria. Patients consent was obtained and were allocated into two equal groups. Group A (Experimental group) received mental practice with motor imagery session whereas group B (Control group) received normal care which included conventional exercise sessions. Patients in both the groups underwent therapy for 45 minutes, five sessions a week for 4 weeks. Pretest measurement were taken for hand function by action research arm test (ARAT) and timed manual dexterity performance scale (TMD) scale. By the end of the 4th week post test were taken as similar to the pretest measurement. Measurement of parameters were taken with action research arm test (ARAT) and timed manual dexterity performance scale (TMD).

Action research arm test (ARAT)

It was developed by Ronald Lyle in 1981. It is scored on a four-level ordinal scale (0-3).[65] The Total score on the ARAT ranges from 0 to 57, with the lowest score indicating that no movements can be performed, and the upper score indicating normal performance. ARAT is highly reliable scale with Coefficient of reproducibility of 0.98 and coefficient of scalability of 0.97 [10, 11, 12].

Fig 1: ARAT tools

Table 1

subscales on the ARAT	Number of items subscale	Score ranges per subscale
Grasp subscale	6 items	Scores 0-18
Grip subscale	4 items	Scores 0-12
Pinch subscale	6 items	Scores 0-18
Gross movement subscale	3 items	Scores 0-9

Timed Manual Dexterity Performance

The secondary outcome measure used to assess the hand function was manual dexterity performance test. It can be performed either by assessing the number wooden blocks/pegs the patient is able to pick up over a time period of one minute or the total time taken for the patient to pickup or reinsert 16 wooden pegs. Intra rater reliability of 0.91and established construct validity [13].

Group- A (Experimental group)

Received by mental practice (MP) with motor imagery (MI) intervention

Mental and motor imagery session included following components:

The first 5 minutes were dedicated for laterality reconstruction. In this the patients were shown pictures representing hand in various positions. Patients were asked to identify between left and right hand, in other words judging handedness through mentally simulated action.

The next 30 minutes was dedicated for mental practice. Patients were given a detailed instruction about the movement /activities in the form of scripts, to have a better visual imagination. Imagery was further maximized through action observation of the therapist making the actions. The activities for mental practice were: (Table 2)

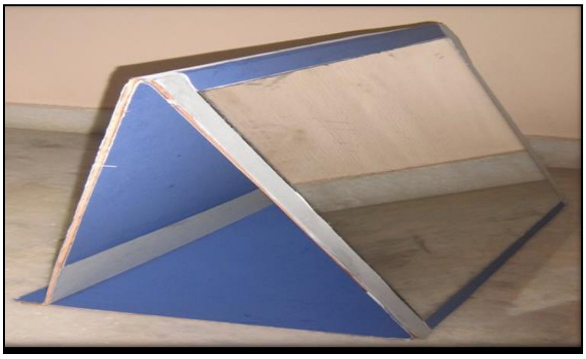

Fig 2: Mirror box

Fig 3: Play Cards/Pictures

Table 2: Experimental group intervention protocol (mental practice).

Protocol	Activities	Duration
1. Imagining of elementary Movement	Opening and closing of hand, wrist rotation and arm elevation	5 minutes
2. Imagining of goal-directed Movements.	Reaching, grasping, lifting Of house hold objects	10 minutes
3. Imagining of ADLs	Dressing, bathing and eating	15 minutes

Verbal facilitation and action observation were emphasized during motor imagery of elementary movements. Training of goal-directed movements were further facilitated by the presence of graspable objects. Training of ADLs made use of the presence of objects involved in the movement.

The last 10 minutes were dedicated for active motor imagery using mirror box. In this session, the patients were asked to look at the mirror and perform activities like grasp and release, thumb to finger movements and rotation of forearm with the unaffected hand in front of the mirror while the affected hand was kept inside the mirror box. Patients were asked to imagine that the hand moving in the impaired hand. This evoked the illusion of impaired hand moving. This has been shown to improve recovery of hand weakness in stroke [14, 15, 16].

Group B (control group)

Received intervention by normal care which included conventional exercise sessions:

Patients in this group were given normal care control for the affected upper extremity. The treatment duration was similar to that of experimental group. Following activities were given to the normal care control.

Table 3: Control group Intervention protocol

Protocol	Activities	Duration
1. Active or active assisted movements of shoulder, elbow, forearm, wrist and fingers.	shoulder flexion, xtension,	5 minutes
	abduction, adduction, rotation	
	elbow flexion, extension.	
	Forearm-pronation, supination.	
	Wristflexion, extension, deviation	
	finger (MCP, IPand DIP movements)	
2. Stretching	biceps, trapezius, triceps, forearm pronators,long finger flexors.	10 minutes
3. Weight bearing activities.	sitting and weight bearing on affected hand.	10 minutes
	prone-on-elbows	
4. Strengthening	triceps, biceps, deltoids, long wrist and finger flexors, wrist extensors, finger opponens	10 minutes

The post-intervention ARAT and timed manual dexterity scores were recorded for both the groups.

Result & Statistical analysis

Group-A: mental practice (MP) with motor imagery (MI) intervention

Group-B: only conventional therapy

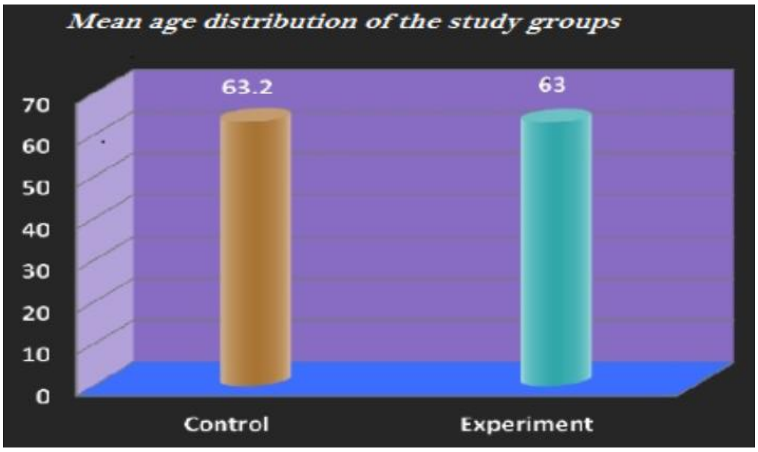

Fig 4: Mean age distribution between Group A & B

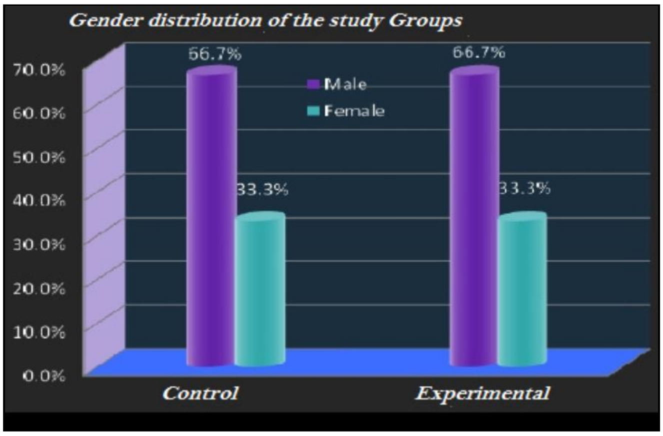

Fig 5: Mean gender distribution between Group A & B

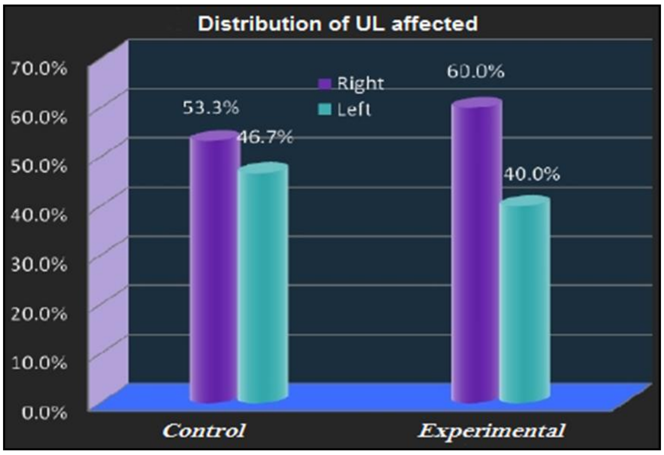

Fig 6: Distribution of UL affected in the study groups

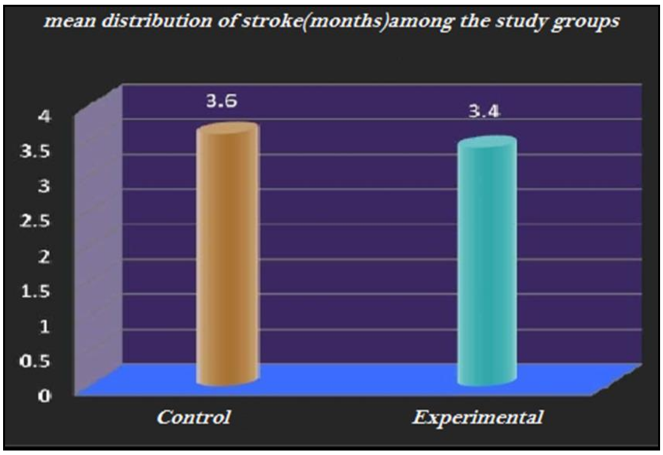

Fig 7: Mean Duration of stroke (months) among the study groups.

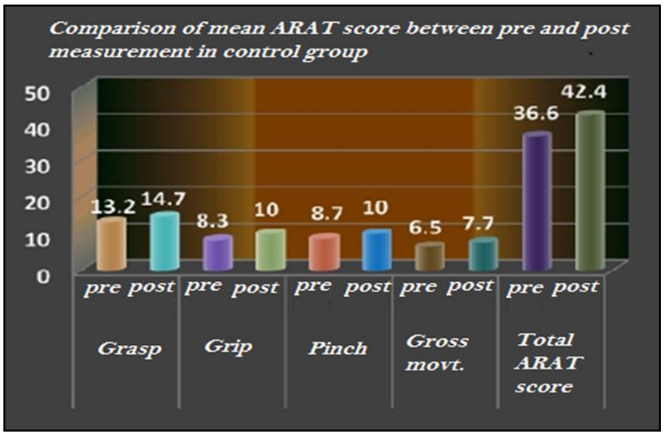

Fig 8: Comparison of Mean ARAT Score between Pre and Post measurement in control group

Comparision within group by using paired‘t’ test. At 95% confidence interval = "-2.964 to 3.46" In this test‘t’ calculated value > ‘t’ tabulated value. So, null hypothesis is rejected and this study is significant

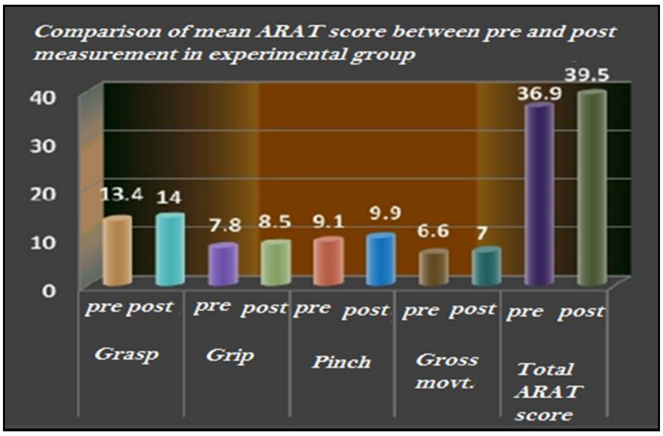

Fig 9: Comparison of Mean ARAT Score between Pre and Post measurement in experimental group

Comparision within group by using paired‘t’ test. At 95% confidence interval = "1.264 to 1.6.46"

In this test ‘t’ calculated value > ‘t’ tabulated value. So, null hypothesis is rejected and this study is significant

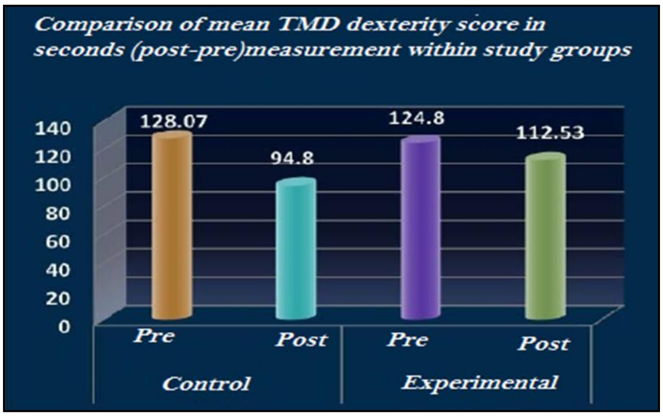

Fig 10: Comparison of Mean Timed Manual Dexterity (TMD) Score (in seconds) Within Pre and Post measurement in Study Groups.

Comparison within group by using paired‘t’ test. And between groups by using unpaired‘t’ test. At 95% confidence interval = "2.64 to 3.646" In this test‘t’ calculated value > ‘t’ tabulated value.

So, null hypothesis is rejected and this study is significant.

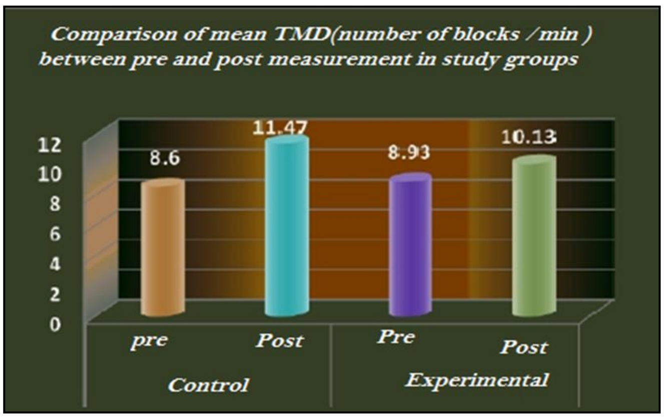

Fig 11: Comparison of Mean Timed manual Dexterity (TMD) score (Number of Blocks per Minute) between the study groups.

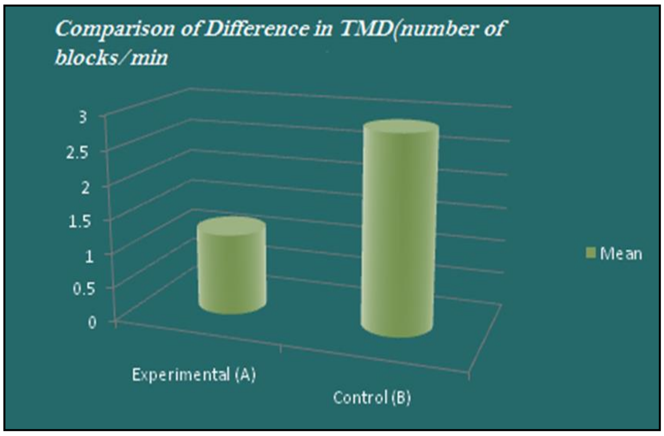

Fig 12: Comparison of difference in TMD (number of blocks/min)

Discussion

The results of the study showed that there is a significant improvement in the upper limb function of stroke patients from both experimental and control group. The rationale for the efficacy of mental practice in stroke as a useful rehabilitation method is that activation of motor areas through imagery will enhance brain plasticity. In order to provide a more direct evaluation of the plasticity account, mental practice was not included in physical therapy group. This was done to find a more direct indication that mental practice works through processes of brain plasticity independent of the effects of physical therapy. Since, from previous researches it was clear that combined mental and physical practice gave improvement on trained task [17]. So it was necessary to evaluate the benefit of mental practice when not combined with physical practice of the movements. The upper limb functions especially grasp, grip, pinch, gross movement, ADLs are seriously affected by stroke. In this study, the results suggests that both control and experimental group significantly showed improvements in grasp, grip, pinch and manual dexterity with p value <0.05.

There are various evidences that shows mental practice and motor imagery improves upper extremity function in stroke. Studies have provided converging evidence that imagining a motor act is a cognitive task that engages parts of the executive motor system: in particular the supplementary motor area, the cerebellum, as well as the premotor, cingulated, superior, inferior parietal, sensorimotor and primary motor cortices. Drawing on these findings, investigators have suggested that training with motor imagery (mental practice) could be effective in learning new motor skills or in promoting motor recovery after damage to the central nervous system. Using imagery and mental practice has been shown to do the following: activate the cortical representation and musculature, correlates with the imagined movements, improves learning and performance, enhance the rate of motor skill acquisition and accuracy. It may well suit hemi paretic stroke patients also because it requires low energy consumption, cost-effective, and no special facilities or equipments required [18]. According to Page SJ, kinesthetic “sensations” of movement, could be highly effective in activating the non-conscious processes involved in motor training. Mental practice is also reported to enhance self confidence as well because subjects can easily apply mental practice techniques prior to performance of any task, which helps their confidence in taking control of task performances [19]. Some studies have demonstrated the effectiveness of mental practice in therapeutic settings in improving motor performance when it is combined with physical practice [20, 21]. According to Jackson PL, mental practice when combined with physical practice improves the performance of a sequential motor skill in stroke [22]. Several studies have shown improvement in strength, function, and use of both upper and lower extremities in chronic stroke. Converging empirical evidence indicates a functional equivalence between action execution and motor imagery. For instance, in an experiment participants were instructed to walk mentally through gates of a given apparent width positioned at different apparent distances. The gates were presented to the participants with a 3-D visual display (a virtual reality helmet) which involved no calibration with external cues and no possibility for the subject to refer to a known environment. Participants were asked to indicate the time they started walking and the time they passed through the gate. Mental walking time was found to increase with increasing gate distance and decreasing gate width. Thus, it took the participant longer to walk mentally through the gate than to walk through a larger gate placed at the same distance [23, 24]. This finding led neurophysiologists to propose that there is a similarity in mental states between action simulation and execution [25, 26]. Studies have shown that mental practice with motor imagery promote recovery of hand function through motor imagery by recruiting areas of brain that could stimulate functional redistribution of brain activity [27, 28, 29]. Parsons *et al* have shown Laterality reconstruction i.e. mental rotation of hands recruits motor imagery and activates motor area [30]. In an another study, Jackson and his colleagues demonstrated that kinesthetic imagery is more effective than purely visual imagery. According to their model, mental practice with motor imagery can be conceptualized as a means to access the otherwise non-conscious learning processes involved in a task. They recognize, however, that the absence of direct feedback from physical execution makes mental practice on its own a less effective training method than physical practice. He concluded in his study that MP should not be considered as a substitute to physical practice [31].

Conclusion

From the findings of this study, it can be concluded that mental practice with motor imagery improves upper limb motor function in stroke. However, MP should be considered only as a complementary technique to physical rehabilitation and not a substitute for physical practice.

Limitation of study

(1) Sample size is small.
(2) Since both males and females were included in this study, comparison based on gender is not attributed.
(3) Follow-up evaluations were not done in this study, hence the long term effect of MP is not known.
(4) Stroke patients with less ARAT score (less than 3) were not included. So this study could establish efficacy of MP with MI only for patients with some motor function.

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