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Effectiveness of Scapular Stabilizing Exercises Equipped with Smartphone Based Movement Sensor in Improving Upper-Limb Functions among Hemiparetic Patients

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Abstract: ***Stage of recovery starts with upper limb rehabilitation from day one. Scapula setting with proper alignment are the most efficient position of the rotator cuff muscle to function. Scapular stabilizing exercise will help to improve shoulder ROM, firing rate, and synchrony at level of motor neuron by neural adaptation. Recently, more and more attentions are focused on wearable equipment to recognize the activity and help patients to train their movements. Objective: To find out the effectiveness of scapular stabilizing exercises with smartphone sensor to improve motor performance, functional activities in hemi paretic patients. Methodology: 50 MCA stroke patients were assessed and selected on the basis of inclusion and exclusion criteria and divide equally into two groups, Group A and Group B. Each group consists of 25 subjects. The subjects in group A trained with scapular stabilizing exercise by mounting the smartphone on upper limb followed by task specific training. Group B trained with conventional exercise followed by task specific training. Outcome measures: Stroke rehabilitation assessment of movement (STREAM) and Chedoke arm and hand inventory (CAHAI). Results: statistical analyses were made using SPSS software. Baseline assessment measured with Shapiro wilk test. Pre-test values showed that there are no significant differences between both groups. After the intervention, both the groups (Group A – STREAM =11.92; CAHAI = 33.45; Group B – STREAM = 9.02, CAHAI =38.37 <0.001) showed improvement in motor performance and functional activities. Conclusion: Scapular stabilizing exercises with smartphone sensor improved motor performance and functional activities in hemi paretic patients, but not merely greater effective than conventional treatment.***

Keywords: smartphone sensors, scapular stabilizing exercises, upper limb movements, hemiparesis

1. Introduction

Worldwide, stroke is the common cause of mortality after CAD. The burden of stroke is increasing in India [(1)]. Stroke is a global health problem and major cause of mortality and morbidity in developed countries [(2)]. Characterization of motor deficits is paralysis or weakness, mainly on the side of the body opposite to the side of the lesion [(4)].Repetitive, intensive, goal oriented therapy is mandatory for stroke rehabilitation. Attention seems to be targeted more on walking and activities of daily living (ADL) in order to optimize the opportunity for patients to be discharged home soon [(5)]. Therefore, priority is not given to the affected arm early and intensive upper extremity training[(6)]. Based on the prioritization recovery and regaining the lost function in the upper extremities may be more difficult to achieve than returning the normal function of ambulation to the lower limb[(7)]. In such case, not only the primary impairment but also "learned non-use theory" defines the probability of recovery [(8)]. Early implementation of upper limb treatment is very important in order to keep the upper limb in the body scheme involving learning based therapy for reorganization of the brain maps[(9)]. The requirement for recovery of voluntary selective movements of the upper limb in patients with post stroke based on the adaptation of trunk automatically anticipating upper limb movement by setting Anticipatory Postural Adjustments (APA) achieved by good core stability, correct scapula setting, efficient scapula humeral rhythm, good somatosensory function of shoulder muscles[(11).]

The shoulder joint is mainly affected by scapular stability during movement in cardinal planes. Previous studies of recovery of upper extremity function have investigated the effects of active, repetitive, and functional activities in post-stroke patients. The studies used constraint induced movement therapy, robot-assisted movement, and electromyography- trigged neuromuscular electrical stimulation. These therapeutic approaches mainly focus on fine motor skills in distal extremities, not gross motor skills in proximal extremities, even they have been reported to provide benefits for chronic stroke patients. Proper initiation and recruitment are the necessary elements for correct scapular movement in impaired stroke patients. A paretic arm can change scapular orientation because of the impaired scapular stabilizers which cannot overcome arm weight and maintain anatomical characteristics. Hence it increases motor impairment of upper extremities and consequently many stroke survivors independent daily living. Postural control of the trunk is also a critical component of independent ADLs. Hsieh et al. investigated the relationship between trunk control and comprehensive ADLs. Stoykov et al. examined

the effect of postural control training on the fine motor function of the paretic upper limb. They suggested that the recovery of upper extremity function is contributed by postural control training. Even though there is lack of research between postural control and upper limb functional correlations.

Wearable sensor is an electronic device attached to the body or it may embedded in a clothes and it has the ablility to record information about the user's body movements by analyzing the signals produced by the device transducers [(15)]. In recent decades, wearable sensors have governed much attention for their ability to remote access and monitor physical movement[(16)]. More attentions are focused on rehabilitation training with wearable sensors[(17)]. Researchers use wearable equipment for monitoring human activity and help patients to train their motion[(18)]. Physical activity recognition using wearable sensors has enabled the scientific community to develop novel applications, especially in the area of healthcare and assisted living [(14)]. Physics toolbox, vieyra software is a complete toolbox for measuring and testing all devices, their mission provide free and low cost data analysis tools to enhance science education. This app allows to turn the mobile device into a research tool. Background accelerometer and gyroscope motions indicated as arrow used for feedback.

The multidimensional framework, WHO International Classification of Functioning, Disability and Health provides classification of outcome instruments. Outcomes may be measured at any of these levels -Body functions/structure, activities and participation. The Stroke Rehabilitation Assessment of Movement (STREAM) is an assessment tool that was developed to provide a quick and simple way to evaluate motor functioning in post stroke patients. [(20).] It was originally designed for the clinical assessment conducted by physiotherapists. The Chedoke Arm and Hand Activity Inventory (CAHAI) is a new measure for assessing functional upper-limb recovery in stroke survivors. The measure was developed by Barreca et al. (2004) to provide a valid, clinically relevant means of assessment for the recovery of paretic limb [(19).]

2. Methodology

The study determined the effectiveness of scapular stabilizing exercise training equipped with smartphone based movement sensor in improving motor performance, functional activities in hemi paretic patients. Ethical approval was obtained from the Ethical committee of kovai medical centre and hospital, Coimbatore. 50 subjects who fulfilled the selection criteria were recruited for the study. The independent variables were scapular stabilizing exercises and task specific training. The dependent variables were Motor performance and functional activities.

Study Design: Non randomized pre test post test control group design.

Sample Size: Sample of 50 subjects were selected
Group – A 25 (control group)
Group – B 25 (experimental group).

Sampling Technique: Purposive sampling

Study Duration: 1 year

Treatment Duration: 1 hour/day, 3 days/week for 2 months.

Study Setting: Physiotherapy department, Kovai Medical Center and Hospital, Coimbatore**.**

Inclusion Criteria	Exclusion Criteria
Ischemic stroke involving MCA Patients with first time stroke in hyper acute stage (7days to 3 months) Both male and female Age 50 – 65 years Cognition level MMSE 24 or more Right or left upper limb involvement Patients who are able to sit on a stable surface independently for 30 seconds. Patients possess smart gadgets like smartphone and able to operate by themselves or by caregivers Medically stable patients to participate in active rehabilitation	Patient with spasticity (Modified Ashworth scale) grade 3 and 4 Disabling orthopaedic conditions including fibromyalgia, severe arthritis, shoulder dislocation Other neurological manifestations such as cerebellar stroke and parkinsonism Visual deficits (spectacles can be included)

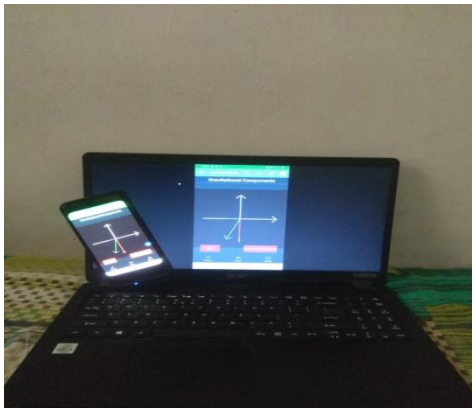
Study Schema

Within Group Analysis

Test	Group	Mean	Standard Deviation	Calculated T Value	P Value 0.05
Pre Test Stream	A	8.13	5.12	.619	.542
	B	7.2	5.02		
Pre Test Cahai	A	27.64	15.18	.280	.782
	B	27.08	12.19		

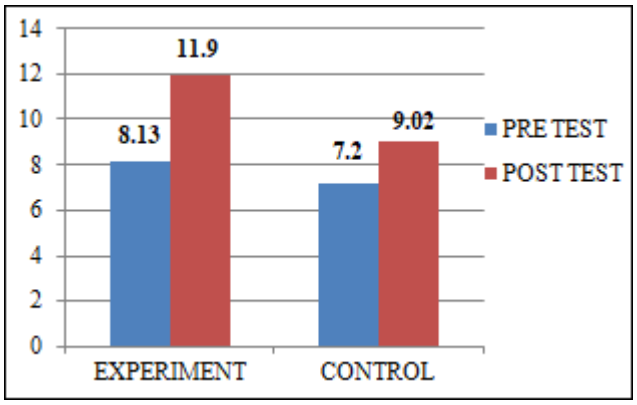
Between Group Analysis

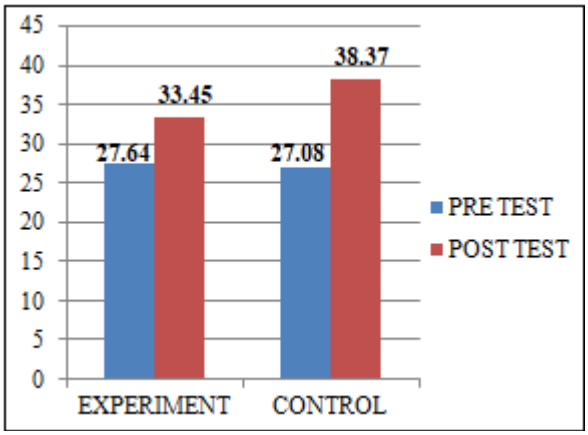
Group	Test	Mean	Standard Deviation	Calculated T Value	P Value
A STREAM	Pre Test	8.13	5.01	10.34	.001
	Post Test	11.92	3.85		
A CAHAI	Pre Test	27.64	15.17	25.76	.001
	Post Test	33.45	15.26		
B STREAM	Pre Test	7.2	5.02	8.90	.001
	Post Test	9.02	3.80		
B CAHAI	Pre Test	27.08	12.91	27.92	.001
	Post Test	38.37	14.95		



Graphical Representation
Stream: Mean Difference of Pre and Post Test - between Exp and Control Group

Smartphone Sensor Feedback





CAHAI: Mean Difference of Pre and Post Test - Between Exp and Control Group

3. Data Analysis and Results

The difference within the groups was analyzed using paired 't-tests and the difference between the groups using independent 't-tests.

Between-Group Analysis of Group A and Group B:
The pre-mean and standard deviation values of STREAM in Group A and Group B were 8.13 and 7.2 respectively. The t-value and p-value were .619 and .542. The calculated 't' value = 1.717 was less than the table 't' value, there was no statistical significant differences exist between the groups.

The pre-mean and standard deviation values of CAHAI in Group A and Group B were 27.64 and 27.08 respectively. The t-value and p-value were .280 and .782. the calculated 't' value = 1.717 was less than the table 't' value, there was no statistical significant differences exist between the groups.

Within Group Analysis of Group A and Group B
The post-mean and standard deviation values of STREAM in Group A and Group B were 11.92, 9.02 respectively. the table 't' value was 1.717 and the calculated 't' value was 10.34. Since the calculated 't' value was greater than the table 't' value, the null hypothesis was rejected. Hence there was a significant difference exist in scapular stabilizing and tasks specific exercise training with smartphone based movement sensor in improving upper limb functions in hemi paretic patients.

The post-mean and standard deviation values of CAHAI in Group A and Group B were 33.45, 38.37respectively the table 't' value was 1.717 and the calculated 't' value was 25.76. Since the calculated 't' value was greater than the table 't' value, the null hypothesis was rejected. Hence there was a significant difference exist in scapular stabilizing and tasks specific exercise training with smartphone based movement sensor in improving upper limb functions in hemi paretic patients.

4. Discussion

The main purpose of this study was to examine the efficacy of scapular stabilization and task specific training on the motor performance and function of the upper extremities with wearing mobile sensors by patients with hemiparetic stroke. Mobility of the upper limb is vital for daily activities. upper limb paresis following stroke is the most common chronic impairment related to limitations of daily activities, functional activities, and social roles. Upper limb paresis in individuals with hemi paretic stroke may compromise many essential and meaningful functions of daily living. Therefore, relearning motor skills and restoring function of the paretic upper limb are the major goals of rehabilitation exercise in clinical settings. Strengthening the scapular stabilizers is especially important. Previous studies have suggested that strength training for the glenohumeral and scapulothoracic regions improves the functionality of the paretic upper extremities. They reported that these muscles play an important role in the stability of the shoulder complex and that stability is necessary to achieve an appropriate range of motion in the shoulder joint during arm elevation, as well as in the distal joints such as the wrist and fingers.

Mandalidis and O'Brien reported that the efficient movement and proper range of motion of the muscles that act on a distal joint are only possible when the proximal joints are efficiently stabilized by the surrounding musculatures. Because the scapula plays a critical role in controlling the shoulder joint position and joining it with the humeral head, but evaluations of scapular stabilizers have been commonly neglected in rehabilitation, despite previous studies indicating that strong scapular muscles are among the major factors contributing to functional restoration of the upper extremities.

Both interventions produced significant differences in the outcomes of upper limb motor performance, range and functional activities. These findings are consistent with the studies that found benefits of mobile sensor based stroke rehabilitation. It has been reported that the repetitive training of isolated movements can have a greater effect on stroke-related motor impairments than increased therapy time alone. A benefit of mobile sensor based intervention is in the fact that once the therapist has set up the mobile, the patient can be left alone with the mobile and thereby reduces the need for one-on-one skilled persons need continuously and it provides visual feedback to the participant while the exercise is performed. It can be performed in the patient's room while the patient is supine in bed or sitting in a chair. The high intensity of sensorimotor exercises, in which the stroke patient repeatedly performs a well-defined motor task, is hypothesized to produce plastic changes in the cerebral cortex, which provides repetitive movement of the hand, may also be beneficial in reorganizing the somatosensory and motor cortex.

The study by yu- wei et al estimates the minimal clinically important difference of the stroke rehabilitation assessment of movement (STREAM) change scores were measured for 3 subscales. The change score of upper limb STREAM sub scale is 2.2 perceives as clinically important. The experiment group change score MCID is 3.79 for STREAM sub scale. For clinical decision making purpose the interventional changes exceeds the standard errors in measurement. Homogenicity persists in the study with small size sample but the generasibility lacks due to the sampling methods. Being the scale of motor performance it doesn't measured individual range rather it focuses on the upperlimb voluntary movement pattern through which the stroke recovery occurs. The study by Daley et al (1999) reports that the STREAM provides an assessment of voluntary movement that includes the testing of amplitude, gross quality and independence in mobility, while maintaining simplicity and objectivity. The simple scoring systems and standardized testing instructions and the progression of assessment items from supine to standing and from low to high level in terms of ability contribute to the reliability and rapidity of the assessment.

The MCID value of chedoke arm and hand inventory (CAHAI) is not yet established in Indian population. The CAHAI has demonstrated responsiveness to change over time and a value for minimal detectable change has been reported in Canadian people. CAHAI test items were specifically selected to be meaningful and relevant to a stroke population. The scale is well-constructed test that was designed to be compatible with World Health Organization (WHO) guidelines as well as the CMSA. These include personal care, dressing, feeding, mobility, communication and recreation (Barreca et al. 2004). Items for the CAHAI were purposefully generated to meet these criteria. The CAHAI covers a wide range of functions not assessed by other measures of paretic-upper limb dysfunction. These include normative upper-limb movements of manipulation, reach and grasp, non gender-specific tasks, degree of motor recovery, and bilateral tasks. Additionally, the test was designed to be applicable across different settings and may be used in the hospital, at home, or in an outpatient unit. The items which lacks accuracy for Indian setup is cutting putty may not be applied as daily task for Indian men. Climbing stairs by carring bag increases the task complexity which may not be done by the stroke people who needs more attention while doing single task as this task requires dual attention (climbing stairs with hemiparetic limb and conscious holding of bag by maintaining cylindrical grip)

The mean change score for CAHAI in this interventional study is 5.81. No relevant clinical change observed in this scale. Reason for this clinical outcome may due to lack of interaction in between the individual, task and environment much important for motor learning may due to distractions or care takers under or over influences. Being significant change observed in motor performance, this performance lack to carry over in functional activites. The consistent monotonus time frame and repetitions may not be applicable for every individuals. Customized and self structured treatment parameters is necessary as one individual learning and physical ability change from one individual to other.

5. Limitations

Follow up period was not long and future studies are needed with a long follow up time.

The dose and length of training time are undefined.

Incorporation of OT and PT into the treatment makes it difficult to quantify the sole effect of the outcomes. However, it is often common standard practice for stroke patients to receive more than 1 session of therapy during the acute phase of stroke rehabilitation. Perhaps the same findings would have occurred whether or not the additional intervention was performed.

Further randomized controlled studies implementing this therapy in a large number of patients and extending the duration of the study are needed to confirm these results and the long term benefits of the intervention.

6. Suggestions

Further qualitative, with more samples - randomized controlled studies of such techniques to demonstrate their validity could be done subjects with various levels of upper limb impairment may be necessary to better control for confounding factors and enhance the generalizability of the present findings to the entire stroke population.

7. Conclusion

These results provide further support to the therapeutic impact of scapular stabilizing exercise training equipped with smartphone based movement sensor on upper limb recovery functions in individuals with acute stroke. Mobile sensor based exercise training may contribute toward the recovery of upper limb function in acute stroke patients. The positive results obtained through the safe and reliable mobile sensor based scapular stabilizing exercise reinforce the recommendation to extend it to a larger clinical practice as traditional rehabilitation.

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