ISSN: 2690- 909X

Research Article

Advances in Neurology and Neuroscience

Effect of Bilateral Repetitive Protraction in Antispastic Position Of Suspended Upper Extremity on Motor Performance and Scapular Position in Stroke

Bharti Kirar[1*], MonalisaPattnaik[2] and PatitapabanMohanty[3]

[1]*Swami Vivekanand National Institute of Rehabilitation Training and Research, Olatpur, Bairoi, Cuttack, India*

[2]*MPT, Asst. Prof. (PT), Swami Vivekanand National Institute of Rehabilitation Training and Research, Olatpur, Bairoi, Cuttack, India*

[3]*Ph. D., Assoc. Prof. (PT), Swami Vivekanand National Institute of Rehabilitation Training and Research, Olatpur, Bairoi, Cuttack, India*

[*]Corresponding author

Bharti Kirar, Swami Vivekanand National Institute of Rehabilitation Training and Research (SVNIRTAR), Olatpur, Bairoi, Cuttack - 754010 India

Submitted: 20 July 2020; **Accepted:** 15 July 2021; **Published:** 20 July 2021

Citation: *Bharti Kirar, MonalisaPattnaik and PatitapabanMohanty (2021). Effect of Bilateral Repetitive Protraction in Antispastic Position Of Suspended Upper Extremity on Motor Performance and Scapular Position in Stroke. Adv Neur Neur Sci, 4(3): 19- 25.*

Abstract

Purpose: *To find out the effect of bilateral repetitive protraction of suspended upper extremity in anti-spastic position with conventional therapy in patients with hemiplegia due to stroke.*

Methodology: *A total of 36 subjects of hemiplegia due to stroke (post stroke duration more than 3 months) were recruited and distributed in two groups. Group 1 received bilateral repetitive scapular protraction in anti-spastic position of suspended upper extremity along with scapular mobilization in addition to conventional therapeutic exercises. Group 2 received Conventional therapeutic exercises consisted of task specific activity such as bilateral activity on pegboard, ball throwing activity and reaching activities, bilateral active range of motion exercises and weight bearing exercises for upper extremity.*

Outcome Measures: *Universal Goniometer measurements and Fugl-Meyer upper extremity scale were taken prior to the beginning of treatment and after the completion of 4 weeks treatment protocol.*

Results: *Overall results of the study showed significant improvement in active range of motion of the affected upper extremity for shoulder and elbow except wrist in experimental group only. Scapular spine distance improved in both the groups but more significantly in the experimental group. Fugl-Meyer assessment of upper extremity showed more significant improvement in experimental group post 4 week of intervention.*

Conclusion: *Bilateral repetitive protraction in anti-spastic position of suspended upper extremity along with conventional therapeutic exercises for 4 weeks is more effective in improving scapular position and upper extremity motor performance as compared to conventional therapeutic exercise alone.*

Keywords: Bilateral movement, Protraction, Scapula, Stroke, Suspension

Introduction

Stroke describes a variety of disorders characterized by the sudden onset of neurological deficits caused by vascular injury to the brain, resulting in many neurological deficits. One of the major problems of stroke patients is motor deficit, especially in upper extremity movements and many patients still do not regain full movement of the upper extremities.

The shoulder joint is particularly 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. These

studies focused 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, the necessary elements for correct scapular movement, which is often linked to proper initiation and recruitment, are impaired in stroke patients. A paretic arm can change scapular orientation, because scapular stabilizers are often so impaired by muscle weakness that they cannot overcome arm weight and maintain anatomical characteristics. Weakness of scapular stabilizers has been shown to increase motor impairment of upper extremities and consequently many stroke survivors of independent daily livings [1].

The scapula provides dynamic stability with controlled mobility at the glenohumeral joint [2]. It plays a significant role in facilitating shoulder joint function, as anatomy and biomechanics of the scapula allow for controlled movement of shoulder joints. Given its significance, recent studies have focused on the need to design upper extremity exercises. Scapular stabilization exercises may be effective in increasing muscle strength, and decreasing scapular dyskinesis [3].

The serratus anterior stabilizes the scapula during elevation and pulls the scapula forward. Weakness in the serratus anterior can impair scapular orientation and stability, thereby contributing to pathologic kinematics [4]. In stroke, scapula rotates downward and adducts or retracts [5].

Bilateral exercise is a training method that utilizes the non-paretic limb in order to promote functional recovery of the damaged limb through the inter-limb coupling effect. In order to obtain the inter-limb coupling effect in the upper limbs, both the paretic side and the non-paretic side should be repetitively and intensively trained in a simultaneous manner. In this way, the paretic arm will couple with the movement pattern of the non-paretic arm and, accordingly, the function of the paretic arm will improve [6].

When movement occurs in only one of the upper limbs, inhibition of activation in the same-sided hemisphere takes place; however, while performing symmetric bilateral movement tasks, both the left and the right cerebral hemispheres are activated, reducing inhibition between the hemispheres and thereby promoting recovery of the paretic limb [7].

Studies have shown that bilateral movement increases the function of the paretic arm in patients with chronic stroke, suggesting the potential role of bilateral movement in recovering upper limb function after stroke [8].

Suspension therapy is among most promising approach due to its low-cost, efficiency, and easiness. In particular, sling exercise therapy (SET) is based on slings attached to a particular part of human body using ropes and pulleys inside a sling system aiding to treat the impairments [9].

Therefore, in order to help clarify the effect of bilateral repetitive movement through suspension, the subjects of this study performed bilateral repetitive protraction of upper extremity in suspension.
Aim of the Study

To find out the effect of bilateral repetitive protraction in anti-spastic position of suspended upper extremity, to improve the scapular position and upper extremity motor performance in patient with stroke.

Methodology

Design: Two group, pre-test post-test structured, experimental study design.

Research Setting: Study was conducted in Department of Physiotherapy, Swami Vivekananda National Institute of Rehabilitation Training and Research (SVNIRTAR), Olatpur, Cuttack, Odisha.
Inclusion Criteria: Persons with hemiplegia due to stroke who were medically stable, duration more than 3 months, age between 30 to 60 years, able to understand and follow simple verbal instructions, had no cognitive disorder, able to perform at least 30 degree of active shoulder abduction, elbow flexion not more than 30 degree, able to sit independently in the suspension frame, both the genders were included in the study.

Exclusion Criteria:- Any cognitive deficit, inability to understand and follow simple verbal command, heart disease, uncontrolled hypertension, contracture in the upper limb etc.

Procedure

36 subjects with mean age 51 years were included as per inclusion and exclusion criteria. After meeting the inclusion and exclusion criteria subjects were assessed using assessment Performa, and informed consent were taken from the participants, and randomly allocated to either of the two groups:- Group 1: Experimental group and Group 2: Conventional group.

All participants underwent an initial baseline assessment of AROM of affected upper extremity by Universal Goniometer, Scapular spine distance was measured from the inferior angle of scapula to the T7 spinous process by the measuring tape and motor function & joint pain was measured by FUGL-MEYER UPPER EXTRIMITY SCALE (FMA-UE).

FUGL MEYER UPPER EXTRIMITY SCALE- The Fugl-Meyer Assessment (FMA) upper extremity score was used to evaluate the various dimensions of motor weakness. FMA is a quantitative assessment tool that measures motor recovery after stroke in the shoulder, elbow, forearm, wrist, and hand. Points from 0 to 2 are given to each item according to the performance on the motor function evaluation (0: Unable to perform, 1: Performs partially, 2: Performs completely). The maximum motor performance score for the upper extremity is 66 points. Joint pain is also the component of FMA. The maximum score for joint pain in upper extremity is 24. (0: pronounced pain during movement or very marked pain at the end of the movement, 1: some pain, 2: no pain) The scale has high intra-rater reliability (r=0.99), inter-rater reliability (r=0.94), and construct validity.

Both groups received conventional physiotherapy. The experimental group in addition, received bilateral repetitive scapular protraction in suspension along with scapular mobilization

Conventional group was treated with task specific activity such as bilateral activity on pegboard, ball throwing activity, and reaching activities, bilateral active range of motion exercises and weight bearing exercises for upper extremity. Repetition was increased for

progression.

Experimental group was treated with bilateral repetitive scapular protraction in suspension along with scapular mobilization in addition to conventional therapy. The subject in sitting position, bilaterally shoulders were suspended in 90 degree of flexion, elbows in extension and forearm in supination wearing elbow gutter in the affected side to prevent the elbow flexion during movements. Patient held a stick by both the hands. Patient performed repeated scapular protraction bilaterally in rhythmic and coordinated manner, 3 minute of 2 sets, with a 5 minute rest time between sets. Time period was increased for progression.

Treatment was given for 5 days in a week for 4 weeks.

Data Collection

Measurements were taken prior to the beginning of treatment and were repeated finally after the completion of 4 week treatment protocol.

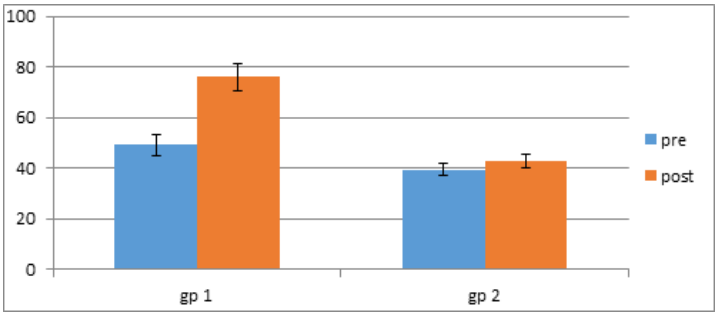
Data Analysis

Statistical analysis was performed using SPSS version 23.0 package.

The AROM of shoulder, elbow and wrist and Scapular spine distance were analysed using a **(GLM) General Linear Model ANOVA, 2×2**with 2 as time factor and 2 as group factor. There was one between factor (group) with two levels (Group 1 and 2) and one within factor (time) with two levels (time: Pre and Post). All pair wise post-hoc comparisons were analysed using a 0.05 level of significance. Data was analyzed using non parametric, **Mann- Whitney U** Test to test difference between pre to post change scores of control group with that of the experimental group.

Results

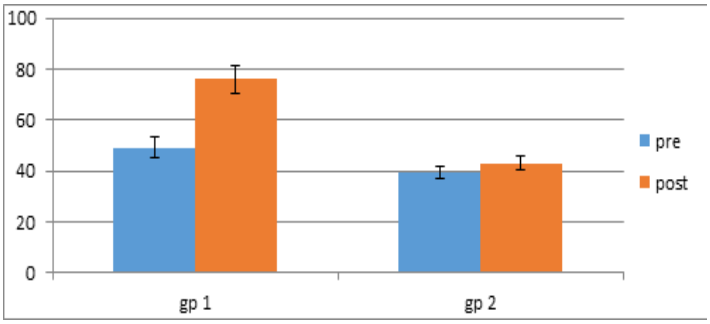
Scapular Spine Distance in Both the Groups



Graph 1: Scapular spine distance in both the groups

As illustrated in graph 1, there was improvement scapular spine distance in both the groups following treatment for 4 weeks. However, the experimental group showed greater improvement in the post treatment measurements as compare to conventional group.

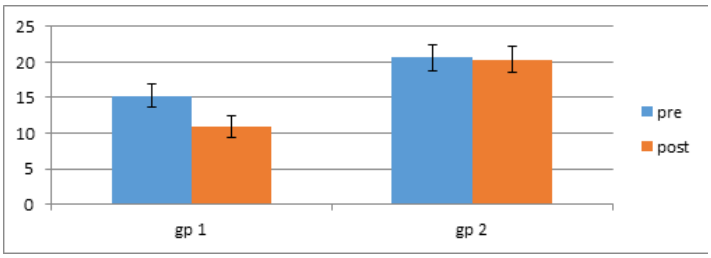
Arom of Shoulder Abduction in Both the Groups



Graph- 2: AROM of shoulder abduction in both the groups

As illustrated in graph 2, there was improvement in AROM of shoulder abduction in both the groups following treatment for 4 weeks. However, the experimental group showed greater improvement in the post treatment measurements as compare to conventional group.

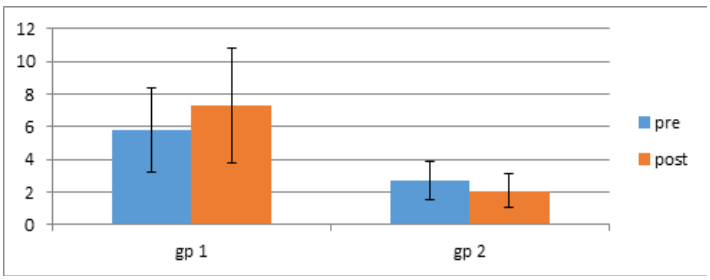
Arom of Elbow Extension in Both the Groups



Graph- 3: AROM of elbow extension in both the groups

As illustrated in graph 3, there was improvement in AROM of elbow extension in both groups following treatment for 4 weeks. However, at the end of 4 weeks of treatment experimental group improved more than control group.

Graph- 4 Arom of Wrist Extension in Both the Groups



Graph- 4 AROM of wrist extension in both the groups

As illustrated in graph 4, there was improvement in active wrist extension in experimental group. However, no improvement was

seen in conventional group.

Fugl Mayer:

Mann whitney U test shows there is significant difference in a change score of both the groups from pre to post measurement of Fugl-Meyer.

Discussion

Overall results of the study showed significant improvement in active range of motion of the affected upper extremity for shoulder and elbow except wrist in experimental group only. Scapular spine distance improved in both the groups but more significantly in the experimental group. Fugl-Meyer assessment of upper extremity showed more significant improvement in experimental group post 4 week of intervention.

Active range of motion of upper extremity was measured by universal goniometer. The results of this study post 4 weeks intervention suggested that there was a significant improvement in active range of motion of shoulder and elbow only in experimental group. For active range of motion of wrist flexion there was significant improvement with time in both the groups, without significant difference between the groups.

Conventional group treated with conventional therapy consisted of task specific activity such as bilateral activity on pegboard, ball throwing activity and reaching activities, bilateral active range of motion exercises and weight bearing exercises for upper extremity. The reason for no significant improvement of AROM of shoulder and elbow in conventional group and no significant difference between the groups for active range of motion of wrist, might be because exercise program included in the conventional therapy group might not be sufficient to improve the motor control and functional recovery and there was no treatment which concentrated on proximal muscle stabilization of affected upper extremity. Also there was no appropriate treatment protocol for wrist included in both the groups and all the activities performed in a conventional group bilaterally was assisted by the normal upper extremity.

Experimental group was treated with bilateral repetitive scapular protraction in suspension along with scapular mobilization in addition to conventional therapy. Suspension is the means whereby parts of the body are supported in slings and elevated by the use of variable length ropes fixed to a point above the body. Suspension frees the body from the friction of the material upon which body components may be resting and it permits free movement without resistance when the fixation is suitably arranged relative to the supported part [10]. Benefits of suspension therapy are patient learns to use appropriate muscles for desired movement. It promotes strengthening of muscle. In our study there was strengthening of serratus anterior muscle. It increases mobility of joint.

There was significant improvement of active range of motion of shoulder in experimental group. One of the causes of reduced range of motion (ROM) is altered scapula-humeral rhythm. Increase tone of muscles around the scapula keeps it in retraction and depressed position. These causes reduced upward scapular rotation during active/passive shoulder abduction. **Surenkok O et al.** found that scapular mobilization have reduced the tone, improve the posture and scapula-humeral rhythm thereby improved ROM [11].

Joint-mobilization techniques are assumed to induce various beneficial effects. The mechanical changes may include breaking up adhesions, realigning collagen, or increasing fiber glide. **McQuede and Smidt and McClure et al** reported a regular curvilinear relationship between scapular and humeral movement because the scapula-thoracic joint is composed by muscles, not like synovial joints [12-13]. Scapular mobilization may break up adhesions and release these muscles; hence, scapular movement may be increased. The improvement of shoulder movement might also be related to increased scapular movement. It is accepted that the glen-humeral and scapula-thoracic joints are in the closed kinetic chain. Scapular mobilization improves shoulder movements and normalizes the scapula-humeral rhythm [14]. In agreement with the result of previous studies, the current study demonstrated that when shoulder movements are improved, shoulder functional status gets better.

In our study strengthening of the serratus anterior muscle was done. In support of the result of our study there was another study done by **Mandalidisand O'Brien,** they 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 [15]. They suggested that it is important to strengthen the scapular stabilizers in order to restore the function of the distal joints of the upper extremity. In our study there was strengthening of the serratus anterior muscle, which is a strong scapular stabilizer. The muscle was strengthened by the repetitive scapular protraction. There was more focused on the proximal joint. It might be the reason for improvement of active range of motion of elbow and wrist in experimental group.

They defined the mechanism that efficient action of the muscles, which act on a distal joint, can be performed only when the proximal joint or joints are also efficiently stabilized by the surrounding musculature. The observed correlations may be due to the fact that force may be transmitted towards the proximally located regions of the upper limb, along a myofascial pathway, which permits force transmission between the sarcomeres and the endomysium [16].

Scapular spine distance was measured from the inferior angle of scapula to the T7 spinous process by the measuring tape. The result of this study post 4 weeks intervention suggested that there was a significant improvement in scapular spine distance in both the groups from pre to post-test measurement. However, the experimental group showed significantly more improvement than conventional group at the end of 4 weeks.

In Stroke the shoulder girdle droops with loss of tone or activity in the elevators of the scapula, particularly in their combined action with the serratus anterior to elevate the glenoid fossa with scapular rotation forward [6]. Viewed from behind, the scapula is seen to lie closer to the vertebrae, but particularly the inferior angle is adducted, and lower than that of the scapula on the other side, so the distance from the inferior angle of the scapula to the spine is decreases.

In conventional group improvement might be due to repetitive

performance of task specific activities. These activities protract the scapula as well as improve the activity of shoulder flexor, elbow flexor and extensor and wrist flexor and extensor. **Nestor A bayona et. al.** defined that task-oriented therapy is important [17]. It makes intuitive sense that the best way to relearn a given task is to train specifically for that task. In animals, intense but task-specific training regimens with the more affected limb can produce cortical reorganization and associated, meaningful functional improvement.

The Task Oriented Approach is based on the systems theory of motor control which considers normal movements to result from the interaction between the individual's abilities, the demands of the task, and the context in which the task was performed [18]. Abnormal movements are said to result from impairment in one or more factors within this system. Furthermore, therapeutic interventions using this approach promote the use of goal directed task practice in training.

Experimental group treated with bilateral repetitive scapular protraction in suspension along with scapular mobilization in addition to conventional therapy.

In support of our study there is a study done by **Duck-hwa Kim et al.** on the effects of serratus anterior strengthening exercises on scapular position in young adults with adducted scapula [19]. The exercise program included stretching of the scapular retractor and strengthening of the serratus anterior muscle. All subjects with adducted scapular performed the same levels of the serratus anterior strengthening exercises in the sitting position and in the quadruped position. The Subjects were asked to continue to rise up by protracting the scapula, and to do 1 set of five repetitions of each of the exercises 4 times per week for 4 weeks. Compare to our present study patient perform bilateral scapular protraction in suspension with 90 degree of shoulder flexion and supination in sitting position. 3 minute of 2 sets, with a 5 minute rest time between sets for 4 weeks. Time period was increased for progression. In their study they measured the distance from the midline of the thorax to the vertebral border of the scapular with a tape line, to compare the resting scapular position before and after exercise. The distance from the midline of the thorax to vertebral border of the scapular increased significantly ($p<.05$). In our study the distance from inferior angle of the scapula to T7 spinous process is increased significantly {$p=0.00$}. They concluded that the serratus anterior exercise program altered the resting scapular position.

In support of the result of our study there is another study done by **Chiang-Soon Song et. al.** on effects of scapular stabilization exercise on function of the upper extremity of individuals with chronic hemiparetic stroke. Intervention included scapular stabilization exercise program in sitting position for 30 min per session, 5 days per week, for 4 weeks [20]. In the exercise protocol the therapist placed a hand on the scapula and axillary areas. The patient then relaxed the entire body. While breathing deeply and holding the shoulder and neck in a relaxed and comfortable posture, the patient held the shoulder joint at 90° and the elbow joint at 180° and protracted the scapula for 10 seconds, and then returned to the starting position. The patient performed 3 sets of 10 movements, with 1 min breaks between sets. They used Manual Function Test. After the intervention they found, Manual Functional Test Scores for the paretic upper limb significantly improved after the scapular stabilization exercise program. They concluded that scapular stabilization exercise can improve the function of the paretic upper extremity of individuals with chronic stroke.

Motor performance and joint pain was measured by Fugl-Meyer assessment of upper extremity, which showed significantly more improvement in experimental group. There was improvement of motor performance in conventional group was 7.14% and in experimental group was 46.18%, reduction of joint pain in conventional group was 7.41% whereas in experimental group was 29.54%.

Improvement in conventional group could be due to improved motor control and functional recovery as conventional exercises are linked to improve cortical reorganization, and changes in sensori-motor maps. Recovery of motor function after stroke involves relearning motor skills and is mediated by neuro-plasticity [21]. Repeated practice of any activity such as a sequence of movements, neuronal circuits are being formed, leading to better ability to perform the practiced task with less waste of energy. In our study patient perform repeated exercises and repetition was increased for progression.

Anne Shumway cook motor learning theory suggest that procedural learning develops slowly through repetition of an act over many trails, and it is expressed through improved performance of the task it was practiced. Rehabilitation may be more successful if the movement and stimuli are important and meaningful to the person and conventional therapy group performed task specific activity. It has been shown in various studies that task specific activity improved the function of upper extremity.

Experimental group treated with bilateral repetitive scapular protraction in suspension and scapular mobilization in addition to conventional therapy. Natural symmetry of the human body and neural structures allows for easy duplication of this bimanual motion. The idea of bimanual rehabilitation is to physically couple the individual arms allowing the healthy arm to assist the impaired in making motions.

In support of the results of our study there is one study done by Lin et. al. on relative effects of distributed constraint-induced therapy (CIT) and bilateral arm training (BAT) on motor performance, daily function, functional use of the affected arm, and quality of life in patients with hemiparetic stroke [22]. The bilateral arm training group concentrated on the simultaneous movements of both the affected and unaffected UL in functional tasks such as lifting 2 cups, picking up2 pegs, reaching forward or upward to move blocks, grasping and releasing 2 towels, and so on. Each group received intensive training for 2 hours/day, 5 days/week, for 3 weeks. In our study patient performed bilateral activity on pegboard, ball throwing activity, and reaching activities, 15 repetition of each activity, 5 days in a week for 4 weeks along with bilateral scapular protraction. Pre-treatment and post-treatment measures included the Fugl–Meyer Assessment (FMA) of upper extremity similar to our study. Results shows the bilateral arm training group exhibited greater gains in the proximal part score of the FMA than the distributed constraint-induced therapy. They concluded that bilateral

arm training may uniquely improve proximal UL motor impairment.

Kyoung Ju Han et al, did a study to compare the functional and kinematic changes of bilateral and unilateral movement training in four weeks of intervention [23]. Each training session consisted of three tasks. The tasks were performed with either the impaired and unimpaired arms moving synchronously (bilateral training) or with the impaired arm alone (unilateral training). To compare the changes associated with each rehabilitation protocol, functional and kinematic assessments were performed before and after the interventions. They reported that the bilateral movement group had significantly improved motion of the shoulder compared to the unilateral movement group.they concluded that Bilateral movement training should be used to improve upper limb function in patients with chronic stroke.

M. Heather Mudie and Thomas Matyas, reported that bilateral simultaneous movement promotes inter-hemispheric disinhibition likely to allow reorganization by sharing of normal movement commands from the undamaged hemisphere [24]. Dis-inhibition may also encourage recruitment of undamaged neurons to construct new task-relevant neural networks.

Reduction of joint pain in conventional group was 7.41%. It might be because the activities involved in the conventional group like active range of motion exercises of upper extremity. These activities maintain joint and connective tissue mobility. Maintain physiological elasticity and contractility of the participating muscle, Assist circulation and vascular dynamics. It enhances synovial movement for cartilage nutrition and diffusion of material in the joint and decrease or inhibits the pain [25].

In experimental group the reduction of joint pain was 29.54%. Patients of stroke are mostly affected by the shoulder pain. Experimental group treated with bilateral scapular protraction and scapular mobilization in addition to conventional therapy. In support of the result of our study there is a study done By Surencok O et al on initial effects of scapular mobilization (SM) on shoulder range of motion (ROM), scapular upward rotation, pain, and function [11]. Subjects with painful restriction of shoulder movement that had persisted for at least 4 weeks were considered for this study. Restriction was defined as painful limitation of shoulder ROM. In this study superior and inferior gliding, rotations, and distraction to the scapula of the affected shoulder is given in side lying position. Pain severity was assessed with a visual analog scale. Constant Shoulder Score (CSS) was used to measure shoulder function. In our study scapular mobilization is given in sitting position, medial to lateral glide was given by holding the inferior angle of scapula. After the intervention they found significant improvements for shoulder ROM, scapular upward rotation, and Constant shoulder score. They concluded that Scapular mobilization may be a useful manual therapy technique to apply to participants with a painful limitation of the shoulder. Scapular mobilization increases ROM and decreases pain intensity.

Patricia M. Davies defined position of the scapula is passively corrected by the examiner, by holding the inferior angle firmly and draws it sufficiently away from the vertebrae [6]. In our study this maneuver used in Experimental group in which mobilization with movement was done, patient perform active scapular protraction along with passive scapular mobilization, which was given by holding the inferior angle of scapula, we glide the scapula medial to laterally.

Joint-mobilization techniques also have neurophysiologic effects, which are based on the stimulation of peripheral mechanoreceptors and the inhibition of nociceptors at the spinal cord and brainstem level [26-27]. Gliding movements are used to cause synovial fluid motion, which is the vehicle for bringing nutrients to the avascular portions of the articular cartilage and intra-articular fibrocartilage when present. Gentle mobilization technique help maintain nutrient exchange and, prevent the painful effect of stasis when a joint is painful and cannot move through range of motion [25].

Conclusion

Bilateral repetitive protraction in anti-spastic position of suspended upper extremity is more effective in improving scapular position and upper extremity motor performance when given with conventional therapeutic exercises of upper extremity than conventional therapeutic exercise alone for 4 weeks.

Limitations

Small sample size, Upper extremity spasticity was not measured, Carry over effect of the study has not been studied, and cardio respiratory effects have not been measured.

References

1. Song CS (2013) Effects of scapular stabilization exercise on function of paretic upper extremity of chronic stroke patients. J. Phys. Ther. Sci 25: 403-405.
2. Voight ML, Thomson BC (2000) The role of the scapula in the rehabilitation of shoulder injuries. J Athl Train 35: 364-372.
3. Başkurt Z, Başkurt F, Gelecek N, Mustafa H Özkan (2011) The effectiveness of scapular stabilization exercise in the patients with subacromial impingement syndrome. J Back Musculoskeletal Rehabil 24: 173-179.
4. Park SE, Ekim YR, Younkim Y (2018) Immediate effects of scapular stabilizing exercise in chronic stroke patient with winging and elevated scapula: A case study. J. Phys. Ther. Sci 30: 190-193.
5. Davies PM. Steps to follow. Second edition. 327-328.
6. Summers JJ, Kagerer FA, Garry MI, CY Hiraga, A Loftus, et al. (2007) Bilateral and unilateral movement training on upper limb function in chronic stroke patients: A TMS study. J NeurolSci 252: 76-82.
7. Stinear JW, Byblow WD (2004) Rhythmic bilateral movement training modulates corticomotor excitability and enhances upper limb motricity poststroke: A pilot study. J Clin Neurophysiol 21: 124-131.
8. Han KJ, Kim JY (2016) The effects of bilateral movement training on upper limb function in chronic stroke patients. J. Phys. Ther. Sci 28: 2299-2302.
9. Nasb M, Li Z (2016) Sling Suspension Therapy Utilization in Musculoskeletal Rehabilitation. Open Journal of Therapy and Rehabilitation 4: 99-116.
10. Hollis M. Cook PF Practical Exercise Therapy. Fourth Edition. Pg no. 96
11. Surenkok O, Aytar A, Baltaci G (2009) Acute Effects of Scapular Mobilization in Shoulder Dysfunction: A Double-Blind

Randomized Placebo-Controlled Trial. Journal of Sport Rehabilitation18: 493-501.
12. McClure PW, Michener LA, Sennett BJ, Karduna AR (2001) Direct 3 dimensional measurement of scapular kinematics during dynamic movements in vivo. J Shoulder Elbow Surg10: 269-277.
13. McQuade KJ, Smidt GL (1998) Dynamic scapulohumeral rhythm: the effects of external resistance during elevation of the arm in the scapular plane. J Orthop Sports Phys Ther 27: 125-133.
14. Kibler WB, McMullan J (2003) Scapular dyskinesis and its relation to shoulder pain. J Am AcadOrthop Surg.11: 142-151.
15. Mandalidis D, O'Brien M (2010) Relationship between handgrip isometric strength and isokinetic moment data of the shoulder Isometric hand grip strength correlated with isokinetic data in stroke 279 stabilisers. Journal of Bodywork and Movement Therapies 14: 19-26.
16. Huijing PA (2003) Muscular force transmission necessitates a multilevel integrative approach to the analysis of function of skeletal muscle. Exercise and Sport Sciences Reviews 31: 167-175.
17. Bayona NA, Bitensky J, Salter K, Teasel R (2005) The role of task-Specific training in rehabilitation therapies. Topics in stroke rehabilitation 12: 58-65.
18. Shumway-Cook and Woollacott. The task oriented approach. 2001.
19. Kim DH, Kwon OY, Yi CH, Jeon HS (2007) The Effects of 4-Week Serratus Anterior Strengthening Exercise Program on the Scapular Position and Pain of the Neck and Interscapular Region. PTK 14 (4).
20. Song CS (2013) Effects of Scapular Stabilization Exercise on Function of Paretic Upper Extremity of Chronic Stroke Patients. J. Phys. Ther. Sci 25: 403-405.
21. Mang CS, Campbell KL, Ross CJD, Boyd LA (2013) Promoting Neuroplasticity for Motor Rehabilitation after Stroke: Considering the Effects of Aerobic Exercise and Genetic Variation on Brain-Derived Neurotrophic Factor. American Physical Therapy Association.
22. Lin KC, Chang YF, Wu CY, Chen YA (2009) Effects of Constraint-Induced Therapy Versus Bilateral Arm Training on Motor Performance, Daily Functions, and Quality of Life in Stroke Survivors. Neurorehabilitation and Neural Repair 23: 441-448.
23. Han KJ, Kim JY (2016) The effects of bilateral movement training on upper limb function in chronic stroke patients. J. Phys. Ther. Sci 28: 2299-2302.
24. Heathermudie M, Matyas T Can simultaneous bilateral movement involve the undamaged hemisphere in reconstruction of neural networks damaged by stroke?
25. Kisner C. sixth edition. pg nu. 52-53.
26. Nicholson GG (1985) The effects of passive joint mobilizations on pain and hypo mobility associated with adhesive capsulitis of the shoulder. J Orthop Sports PhysTher 6: 238-246.
27. Paungmali A, Vicenzino B, Smith M (2003) Hypoalgesia induced by elbow manipulation in lateral epicondylalgia does not exhibit tolerance. J Pain. 4: 448-454.