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Efficacy of Serratus Anterior Stimulation in Improvement of Scapular Stability in Proximal Lesion of Erbs Palsy Cases

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Abstract: The aim of this work was to show efficacy of serratus anterior electrical stimulation in improvement of scapular stabilityin proximal lesion of Erbs palsy cases. Thirty children were enrolled in this study and randomly assigned into two groups; groupA(serratus anterior electrical stimulation plus traditional physiotherapy program), and group B(traditional physiotherapy program only). Lateral slide scapular test was used to detect and follow scapular stability. This measurement was taken before initial treatment and after 12weeks of treatment. The children parents in (group A) and (B) were instructed to complete 3 hours of home routine program. Data analysis were available on 30 erbs palsy children and the mean values of the Lateral slide scapular test grading pre and post treatment in both groups was non statistical significant difference (p>0.05). Mean values of the Lateral slide scapular test grading in study group pre and post treatment was more statistical significant differences p=0.0031 while the mean values of the Lateral slide scapular test in the control group pre and post treatment was statistical significant difference p=0.0401. The improvement of scapular stability according to Lateral slide scapular test in the study group (11.35%) more pronounced than the improvement of the control group (5.33%). The combined effect of physiotherapy training plus serratus anterior stimulation is recommended to overcome the lack of scapular stability.

Key words: Serrates anterior · Electrical stimulation · Proximal lesion of Erb's palsy

INTRODUCTION

Stability at the scapulothoracic joint depends on the surrounding musculature. The scapular muscles must dynamically position the glenoid so that efficient glenohumeral movement can occur. When weakness or dysfunction is present in the scapular musculature, normal scapular positioning and mechanics may become altered. When the scapula fails to perform its stabilization role, shoulder function is inefficient, which can result not only in decreased neuromuscular performance but also may predispose the individual to shoulder injury [1].

The scapula forms the mobile base from which the free upper limb acts. Winging of the scapula is a prominence of the medial or vertebral border of the scapula. The winged scapula may also be rotated or displaced medially or laterally. The position of the winged scapula depends on the specific nerve injury and the resulting pattern of muscle paralysis. Winging of the scapula is often seen subsequent to an injury which involves the brachial plexus, an isolated paralysis of the serratus anterior, or a symptom of fascioscapulo humeral muscular dystrophy [2].

An injury to the long thoracic nerve causes paralysis of the serratus anterior. The scapula assumes a high position with the upper medial corner rotated laterally and the inferior angle medially. Injury to the spinal accessory nerve causes paralysis of trapezius muscle. In this scenario the scapula assumes a lower position with lateral rotation of the inferior angle and medial rotation of the upper corner. An injury to the dorsal scapular nerve causes paralysis of the levator scapular and rhomboid muscles. The resultant winging is mild and similar to that caused by the paralysis of the trapezius [3].

The scapula is the largest bone of the shoulder complex and has the greatest number of muscles attached to it. These muscles both stabilise the arm to the body and move the arm around in space. All these muscles act at the same time sometimes and oppose each other at other times, but work together like a well trained team to

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allow the arm to move in space. If any of these muscles are not working in the right way at the right time this leads to a break in the rhythmic motion of the scapula. Winged scapula is a common biomechanical deficiency which is caused by Loss of serratus anterior muscle function, Loss of trapezius muscle function, Weakness of all the scapula stabilizers, Loss of the scapular suspensory mechanism, Winging secondary to instability, Winging secondary to Brachial Plexus injury. The Serratus Anterior muscle is also known as the boxer's muscle, because that is one of the motions it does: it protracts (or brings the shoulder forward). If this muscle is weak, it does not hold the scapula as close to the ribcage and the result of that is called winging [4].

Scapular winging has been observed to disrupt scapulohumeral rhythm, contributing to decreased flexion and abduction of the upper extremity, as well as a loss in power and the source of considerable pain. The serratus anterior muscle attaches to the medial anterior aspect of the scapula (i.e. it attaches on the side closest to the spine and runs along the side of the scapula that faces the ribcage) and normally anchor the scapula against the rib cage. When the serratus anterior contracts, upward rotation, abduction and weak elevation of the scapula occurs, allowing the arm to be raised above the head [5].

The long thoracic nerve innervates the serratus anterior; therefore, damage to or impingement of this nerve can result in weakening or paralysis of the muscle. If this occurs, the scapula may slip away from the rib cage, giving it the wing-like appearance on the upper back. This characteristic may particularly be seen when the affected person pushes against Resistance [6].

Abnormal scapular motion can result in subacromial impingement in patients with an inability to position the acromial arch away from the humeral head. Several muscles attaching to the scapula work as force couples to stabilize the scapula during movements of the upper extremity. For proper acromial elevation, the appropriate force couples are the lower trapezius and the serratus muscles, working together, paired with the upper trapezius and rhomboid muscles. Nerve injuries, such as those to the spinal accessory nerve innervating the upper trapezius or long thoracic nerve supplying the serratus anterior, have been estimated to cause abnormal scapular function [7].

The coracoclavicular ligaments suspend the scapula from the clavicle and the acromioclavicular joint is the only joint linking the scapula to the rest of the body. Therefore dislocation of the acromioclavicular joint or a fracture of the outer third of the clavicle, with rupture of the coracoclavicular ligaments, leads to an abnormal scapula rhythm and apparent scapula winging with overhead manouevers. This is one of the commonest causes of scapular winging. Dislocations of the shoulder leads to dysfunction of the muscles that move and support the shoulder complex and scapula. An essential part of treating shoulder instability is the treating scapular winging [8].

MATERIALS AND METHODS

Subject: Subject: 30 Erb's palsy children with age ranged between 4 and 7 years at the time of recruitment. The site of lesion included is the proximal type of lesion in Erb's palsy. Patients were excluded from the study if they had distal lesions of brachial plexus, seizures and patients with shoulder fixation. The thirty subjects that met the study criteria were randomly assigned into two groups of equal number:

Group A(study Group): Consists of 15 Erb's palsy cases with proximal lesion (2 females and 13 males) and were treated by specialized physiotherapy program(traditional physiotherapy program plus faradic stimulation to serratus anerior muscle)

Group B(control Group): Consisted of 15 patients (10 females and 5 males) and were treated with traditional physiotherapy program only.

Outcome Measurements: The study was a comparative experimental design with a baseline therapeutic procedure of traditional physiotherapy program. The effect of specialized physiotherapy program on scapular winging control compared between study and control group. Skin sensation assessment was carried out on the scapular and deltoid muscles compartments of the shoulder girdle to ensure that none of them had defective skin sensation.

Postural Evaluation: examination for cervical hyper-lordosis, thoracic kyphosis, or scoliosis. Signs of atrophy should be noted in the trapezius, supra-spinatus, infra-spinatus, and inferior trapezius areas, suggesting either a peripheral nerve injury or disuse in turn suggesting a chronic problem.

ROM of Scapula: Scapular motion can be observed for asymmetry by having the patient perform repeated flexion of the shoulder (e.g., 10 times), because abnormalities may not appear until the patient’s muscles fatigue.

Another method from side lying facing physiotherapist apply upward and downward, adduction and abduction movement of scapula

Flexability Test: Tightness of the posterior capsule may be suggested by decreased internal rotation of the affected arm with the shoulder at 90 degrees of flexion and the elbow flexed to 90 degrees.

Lateral Slide Scapular Test: The lateral slide scapular test (LSST) used to clinically measure static scapular positions. This test involves measuring the distance from the inferior angle of the scapula to the nearest vertebral spinous process using a tape measure in three positions: shoulder in neutral, shoulder at 40-45 degrees of coronal plane abduction with hands resting on hips and the shoulder at 90 degrees abduction with the arms in full internal rotation. It is contends that the injured or deficient side would exhibit a greater scapular distance than the uninjured or normal side and asserted that a bilateral difference of 1.5 cm (15 mm) should be the threshold for deciding whether scapular asymmetry is present. Also it is suggested that the LSST may be used to monitor the scapular stabilizer muscles in any rehabilitative program that involves shoulder strengthening exercises.

The assessment of scapular stability using lateral slide scapular test was carried out prior to the commencement of the treatment sessions (pre-treatment). These assessment was also carried out at the end of the 12th week (post-treatment) on all the children. The stability of scapula was determined by performing the three steps of lateral slide scapular test with comparison between pre- and post treatment test.

Intervention: For all children, the programs were conducted three times weekly, for 12 weeks. Each session lasted 45 minutes manual and 15 minutes electrical in addition to 1 hours of home program, 7 days a week during the treatment period.

Both groups (A and B) received a traditional physiotherapy program, as the following:

An appropriate therapy program consists of maintaining full shoulder motion and strengthening of the shoulder using proper posture and proprioceptive xercises. Particular attention should be directed toward stretching the posterior capsule of the shoulder and adequate strength of the serratus anterior, trapezius and rhomboids. Theoretically, stretching the posterior capsule, especially in abduction, because this is the insertion of the spinoglenoid ligament, will reduce tension on the ligament during overhead sports activities. The goal of a strengthening program is to enhance the compensatory muscles and to regain muscular balance about the shoulder.

- Hot packs on shoulder girdle to improve circulation and relax muscle tension for 10 minutes
- Facilitation of peri-scapular and shoulder muscles: tapping, scratching followed by movement, quick stretch, weight bearing ex., approximation, vibration, irradiation to weak muscles by strong muscles, ice application for brief time. For 5minutes
- Passive stretching was performed to tight muscles as sub-scapularis, pronator, pectoralis major, biceps brachii, wrist flexors to destruct adhesions in muscles and sheath.also passive stretch occur for levator scapulae and pectoralis minor is used to prevent contracture of these muscles due to the loss of serratus anterior activity. For 10 minutes
- shoulder joint manipulation: the child in side lying backed to physiotherapist, one hand of physiotherapist fix scapula and the other hand perform adduction of shoulder with gradual flexion in shoulder which perform stretch on posterior capsule of shoulder. repeat 3 times for 5 minutes
- Graduated active exercise was performed for upper limb muscles, serratus anterior, trapezius and rhomboids muscles. for 5 minutes.
- scapular mobilization is performed from side lying position facing to physiotherapist, the index hold medial border of scapula, thumb hold lateral border of scapula and web space hold inferior angle of scapula, then perform mobilization in upward rotation and down ward rotation, adduction the abduction of scapula 5times for 5 minutes
- Balance training program which include dynamic approach for 5 minutes

The experimental group (group A) received specialized physiotherapy program as following:

Serratus anterior muscles can not be stimulated effectively except in winging of scapula as in proximal lesion of Erb's palsy due to the appearance of its fibers.In addition to traditional physiotherapy program as above. the electrical stimulation apparatus with two channels electrodes were applied on rhomboid-deltoid technique for improving normal scapular rotation. The subject was enrolled in a day after day stimulation continue for 15 minutes with70 HZ, pulse width of 300 microsecond. Stimulation of the muscles surrounding the scapula for the purpose of stabilization during other joint movements may be desirable. Although activation of the middle trapezius and rhomboid muscles may achieve a degree of scapular adduction, winging of the scapula generally is not resolved without stimulation of the serratus anterior muscle. The patient demonstrating serratus anterior muscle weakness and secondary scapular winging can use electrical stimulation for facilitation as when a scapula has separated from the rib cage sufficiently so that an electrode can be placed over the ventral aspect of scapular surface A second, electrode may be placed on the lower lateral side of the trunk or one electrode under the winged scapula and the second electrode over the broad area of the serratus anterior muscle's origin, stimulation can provide adequate realignment of the scapula to correct its winged posture. As the patient gains strength in the serratus anterior muscle and the winging of the scapula becomes less pronounced, placement of the electrode becomes increasingly difficult. After the scapula is repositioned appropriately on the trunk and no longer wings, achieving further realignment of the scapula with electrical stimulation may be difficult or even impossible. We have been unsuccessful in activating the serratus anterior muscle unless we can position the a electrode over the ventral(anterior) surface of the scapula.

RESULTS

Patients Characteristics: Table 1 shows the demographic and clinical characteristics of all patients. There were 18patients (60%) boys and 12 patients (40%) girls.. Right hand dominance reported in 17patients (56.66%), while 13patients (43.33%) were left hand dominance. There was no significant difference between the two groups in terms of age (p=0.5958), hand dominance (0..8813) but significant in term of sex (p=0.0035).

Changes in Lateral Slide Scapular Test: Mean test scores and standard deviations for both groups are shown in the Table 2. The mean value of lateral slide scapular test in both groups at baseline measurement (pre-treatment) was insignificant (p>.05). Both groups had a significant improvement in scapular stability post-treatment. The statistical difference between pre and post treatment results was significant in both groups in favor of the study group (p=0.0031). The average improvement of scapular stability tended to being highly significant in the study group (2.933±0.904 versus 2.600±0.604, p=0.0079) than in the control group (2.867±0.876 versus 2.714±0.955 p=0.040). The percentage of improvement of scapular stability was (11.35%) in the study group compared to the (5.33%)in control group.

DISCUSSION

Under Lying Mechanism of Neuro-Muscular Electrical Stimulation in Erb's Palsy Children: The electrical stimulation inhibited increases in all 3 protein degradation pathways linked to atrophied serratus anterior and stimulate protein synthesis(increase number of sarcomere) inside muscle so it can be used to treat and prevent muscle atrophy. Skeletal muscle atrophy is characterized by decreased protein synthesis and increased protein degradation. The decrease in protein synthesis reaches a peak within a few days after the start of unloading, whereas the increase in protein degradation reaches a peak 14 days after unloading. it was hypothesized that the increase in protein degradation was related closely rather than the decrease in protein synthesis to the atrophied muscle. Three major protein degradation pathways are implicated in skeletal muscle atrophy resulting from a variety of disuse conditions (e.g., unloading, immobilization, denervation) the lysosomal protease pathway, the cytosolic calcium-dependent calpain pathway and the ubiquitin-proteasome pathway.

Table 1: patient's characteristics

variables	Control group n=15	Study group n=15	p-value
age	5.07±.92	5.27±1.03	0.5958
Sex N(%)			
Boys	5(33.3%)	13(86.66%)	
girls	10(66.6%)	2(13.33)	0.0035
Hand dominance N%			
Right	8(53.3%)	9(60%)	
left	7(46.7%)	6(40%)	0.8813

Table 2: The average test of lateral slide scapular test grading in both groups

Average test of lateral slide scapular test grading	Study group Mean ± SD	Control group Mean ± SD	p-values (Between group)
Pre-treatment	2.933±0.904	2.867±0.876	0.8226
Post-treatment	2.600±0.604	2.714±0.955	0.7010
% improvement	11.35%	5.33%	0.2620
p-values (Within group)	0.0031	0.0401	

It can be postulated that the decreases in muscle mass and muscle fiber cross-sectional areas in muscles were due to the activation of the 3 major protein degradation pathways [1,8].

Denervated muscles had an abnormal structural appearance. Myofibrils were thinner and fewer in number and they were often discontinuous. Sarcomeres lacked M-lines or showed streaming of Z-lines and the registration normally seen across the fiber was lost. Wide spaces between the myofibrils were filled with amorphous cyto-skeletal material, Mitochondrial function may have been disrupted by the loss of their normal distribution and structural associations within the fibers and fragments of the sarcoplasmic-reticulum (SR) and T-system [3].

Denervation of muscles occurs when there is trauma to peripheral nerves and roots as in brachial plexus injury with concomitant root damage. The flaccid paralysis that results from these lower motor neuron injuries has more serious consequences (1). The muscles lose mass rapidly and much of the cross section becomes occupied by non-contractile tissues, notably collagen and fat. As a result, the force that can be elicited by electrical stimulation quickly declines. This phase of atrophy is followed, after about 1 year to 18 months, by progressive necrosis of muscle fibers. Although some muscle regeneration does occur (2), it is at a level insufficient to replace the degenerative loss. Such a denervating injury has secondary consequences over and above the loss of mobility, greatly increases the risk of developing pressure sores. Bones become osteoporotic. The severely wasted appearance of the affected limbs is a source of distress to the patients [9].

Primary scapular winging occurs when one of the main muscles that hold the scapula steady stops working as it should. Injury to the nerve controlling scapular muscles is one cause of primary scapular winging. risk for nerve paralysis causing primary scapular winging.

Secondary scapular winging is the result of a problem somewhere else in the shoulder complex. That other problem could be a rotator cuff tear, shoulder bursitis, shoulder dislocation, or a frozen shoulder. Any injury or condition that can alter the way the muscles fire or cause muscular fatigue can result in impairment of the scapular rhythm needed for normal arm movement. Likewise, anything that changes the alignment of the scapula can have the same effects on scapular position and movement [4,6].

Biceps brachii, as a strong antagonist of the serratus anterior, is a leading factor in the production of classic "winging of scapula. The weight of the forearm and hand is transmitted through the biceps and coracobrachialis muscles to the coracoid process and supraglenoid tubercle, pulling the scapula to cause the winging. The disappearance of winging by the motion of flexion of forearm is evidence that the biceps muscle, rather than the deltoid, is responsible for this deformity [10].

The mobility of the shoulder complex involves combined motions of different joints, particularly of the scapula-thoracic and gleno-humeral joints, which must be coordinated to perform full arm elevation. Previous studies showed that healthy subjects use a complex and reproducible pattern of scapular kinematics with a large ROM during arm elevation. The scapular upward rotation linearly varies with humeral angle and contributes to approximately 30% to 40% of the overall arm elevation, classically described as the scapula-humeral rhythm [11].

The serratus anterior is a broad flattened sheet of muscle originating from the first nine ribs and passes posteriorly around the thoracic wall before inserting into the costal surface of the medial border of the scapula. The serratus anterior has three functional components. The superior component originates from the first and second ribs and inserts into the superior medial angle of the scapula. This component serves as the anchor that allows the scapula to rotate when the arm is lifted overhead. The middle component of the serratus anterior originates from the third, fourth and fifth ribs and inserts on the vertebral border of the scapula, serving to protract the scapula. The inferior component originates from the sixth to ninth ribs and inserts on the inferior angle of the scapula. This third portion serves to protract the scapula and rotate the inferior angle upward and laterally. As a whole, the main function of the serratus anterior is to protract and rotate the scapula, keeping it closely opposed to the thoracic wall and optimizing the position of the glenoid for maximum efficiency for upper extremity motion [2,4].

The serratus anterior is solely innervated by the long thoracic nerve (C5, C6 and C7), originating from the anterior rami of the fifth, sixth and seventh cervical nerves. Branches from the fifth and sixth cervical nerves pass anteriorly through the scalenus medius muscle before joining the seventh cervical nerve branch that coursed anteriorly to the scalenus medius. The long thoracic nerve then dives deep to the brachial plexus and the clavicle to pass over the first rib. Here, the nerve enters a fascial sheath and continues to descend along the lateral aspect of the thoracic wall to innervate the serratus anterior Muscle [11].

CONCLUSION

The combination of physical therapy and the NEMS management had a substantial improvement in scapular stability. The patient still continues to gain strength. The faradic has had a valuable effect on regaining of function in serratus anterior. A 12% decrease in the scapular winging and increased recruitment of the scapular musculature and the patient reported his arm felt stronger. Research studies need to be conducted to determine the best physical therapy treatment approach combined with the use of a well-designed and effective electric stimulation for winging of the scapula due to serratus anterior paralysis.

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