The Effects of Exercise Training on Scapula Position of Muscle Activity Measured by EMG

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Abstract: The position of scapula and the function of shoulder girdle muscles are key contributors to normal and abnormal scapular movements and stabilization. The purpose of this study was to examine the effect of an exercise program on the position of scapulae. Twenty-four male asymptomatic protracted subjects (age 16 to 18 years) participated in the study. Subjects were assigned to control (n=12) and exercise groups (n=12) based on the distance of the inferior angle of scapula with the nearest spinous process. Kibler's Lateral Scapula Slide Test (LSST) was used to measure the distance between the vertebrae and the inferior angle of scapula in the relaxed (0 degree position) standing position. The measurements were taken three times by one minute rest. The exercise group performed an exercise program for 6 weeks while the control group did not participate in any physical activity. A progressive exercise program included resistive strengthening, stretching and postural exercises that were done daily at home. The electromyography (EMG) activity of levator scapulae and trapezius muscles of the subjects recorded with 25% maximal voluntary contraction pre and post training. The results revealed significant differences only in the scapula position of the exercise group (p<0.05). EMG activity of the muscles indicated a significant difference of MVC in levator and trapezius muscles of exercise group (p<0.05).

It is concluded that the training program caused a significant difference on the position of the scapulas in the exercise group and that the use of this exercise program in the management of scapula position may have a positive impact on individuals with protracted scapula. These findings suggest a relatively simple exercise program combined with education may be effective and, therefore, merits study in a larger trial using.

Key words: Electromyography (EMG) %Strength training %Position of scapulae

INTRODUCTION

The position of scapula is key contributor to normal and abnormal scapular motion and control. Scapula protraction is an abnormal position which has been defined as an increased distance between the inferior angle of scapula and the spinous process of the vertebra [1]. Some authors reported that imbalanced force production superior translation of the scapula with less efficient downward rotation and increased posterior tipping [2]. The findings of others also support the link between abnormal scapular position and regional muscle imbalance rather than global muscles weakness [3].

To obtain a better understanding of the effect of scapular protraction on the isometric muscle strength of shoulder rotation Smith et al. [4] measured two maximal isometric internal and external rotation contractions in two scapular positions and found significant reduction in internal rotation strength. The results indicated that protracted scapula significantly reduced internal rotation strength by 13% to 24% relative to scapula neutral. They concluded that the external rotation is position-dependent and acute changes in scapular position affect shoulder isometric internal and external strength. Improvement in upper limb muscle performance by proper positioning of scapula was considered by Morttarm [5]. This researcher stated that the ability to position and control movement of the scapula is essential for optimal upper limb function. Morttarm [5] emphasised on the importance of muscular ability to achieve stable scapula and prevent the development of shoulder and upper limb pain and dysfunction. The findings of other investigators indicated that alterations in scapular positioning can have an effect on shoulder function [6].

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The relationship between scapula position and the function of shoulder girdle muscles has been investigated by Alizadeh and Rajabi [7-8]. The performance of shoulder muscles also were compared in protracted and retracted individuals. The results indicated that muscle performance had a significant relationship with the scapula position. The protracted subjects showed weaker performance in the modified pull-up test compared with the retracted subjects. It was concluded that the position of the scapula may be considered as a predicting factor for the performance of shoulder girdle muscle.

Majority of previous investigations have spent numerous times on the assessment methods of scapula position [1, 9]. Some other researches examined the factors related to shoulder dysfunction, shoulder injury and scapula position by assessing the activation of shoulder muscles during a variety of shoulder exercises [10-13]. These studies have investigated mainly unhealthy subjects and the researchers developed several methods to characterize scapular position [6]. These investigations have advocated exercises that produce substantial activation of muscles surrounding the shoulder girdle including the trapezius, rhomboid and laveratory scapula.

To our knowledge the effect of training on the scapula position particularly in individuals with protracted scapula has not been yet addressed. Therefore the present study was designed 1) to examine the effect of an exercise program on the position of scapula in protracted individuals and 2) to compare the activation of levator scapula and trapezius muscles of group in response to training.

**MATERIALS AND METHODS**

Twenty four asymptomatic students without a history of shoulder pain, trauma, fracture, dislocation, or surgical procedure participated in this study. The subjects were formed into the exercise (n=12, weight 58.16±5.2 kg, height 170.84±8.5 cm) and the control (n=12, weight, 55.25±7.5 kg and height, 167.84±11.3 cm) groups. Kibler’s LateraScapula Slide Test (LSST) was used to measure the distance between the vertebrae and the inferior angle of scapula in the relaxed (0 degree) standing position [16]. This test evaluates the position of the scapula on subjects in relationship to a fixed point on the spine. In the relaxed position, the inferomedial angle of the scapula was palpated and marked on both sides and the reference point on the spine was the nearest spinous process. The measurements from the difference point on the spine to the medial border of the scapula were taken three times by one minute rest on both sides. Studies on the accuracy of marking the inferomedial border of the scapula in comparison with radiographic evaluation of the same point when marked by a lead shot have shown a correlation of 0.91 with the different position (17). The exercise group carried out an exercise program including strengthening of trapezius and lavatory scapula muscles and stretching pectoralis major and anterior portion of deltoid muscles while the control group had not participated in any scheduled exercise program. Exercise program was included warming up (5 minutes), stretching and strengthening exercises. The stretching exercises aimed to elongate pectoralis major/minor muscles. The sets of each exercise were performed with a minimum of 2 repetitions for 10 seconds. Isometric and isotonic strengthening exercises were performed for upper back extensor, rhomboid, trapezius and levator scapula muscles by 1 set with 6 repetitions in the first week progressed into 1 set with 20 repetitions at the last week). Two minute rest periods were allowed between each exercise. General education regarding proper posture by sitting and standing positions was given to the subjects. All measurements were performed by the same investigator.

EMG data were collected using ME3000P8 surface electrodes and computer Megawin software synchronized the collection of EMG within a source-to-sensor separation. The EMG recording electrodes were placed on the subject’s lavatory and trapezius muscles. Electrode preparation included shaving hair from the electrode placement area if present, wiping skin surface with alcohol and applying conductive gel on the electrode’s active surface. No skin abrasion was necessary due to the high input impedance of the amplifier. Three surface electrodes were applied to the levator and trapezius muscles parallel to the muscle fibres. Correct electrode placement was verified through observation of the oscilloscope during resisted arm abduction. To normalize EMG data, subjects performed maximal voluntary contractions (MVC) of the levator and trapezius against a dynamometer resistance using previously documented procedures [2]. The levator and trapezius MVC were performed with the subjects standing and the arms abducted to 90°. Five percent of MVC was applied by the dynamometer against arm abduction for 10 seconds in the standing position and the activations (IEMG) of levator and trapezius were recorded by a single examiner.
Data Analysis: Descriptive statistics were computed and distributions of the data were assessed for normality. Independent paired t-tests were also used to assess differences between the activation of lavatory scapula and trapezius of protracted and the retracted subjects. Values are presented as mean±SD. The acceptable probability level was set at p<0.05. All statistical analyses were performed using SPSS version11.0 (SPSS, Chicago, USA).

RESULTS AND DISCUSSION

The purpose of present study was to examine the effect of an exercise program on the position of scapula and comparing the function of levator scapula and trapezius muscles in the protracted individuals before and after the intervention. The results revealed significant differences in the scapula position of the exercise group compared to the control group (Table 1). The substantial changes in scapula position of the exercise individuals may be based on hypothesis suggesting that protracted scapula places important stabilizer muscles such as trapezius in a lengthened position and this may decrease its ability to keep the scapula in normal position and therefore generating sufficient tension [16]. Regardless of attachment of many muscles to the scapula, it is generally accepted that the three trapezius parts play a primary role in the stabilization and the movement patterns of the scapula [19]. Meanwhile the role of rhomboid as a synergic muscles originated from the spinous processes on the medial aspect of the scapula can not be ignored but it is beyond the scope of this study.

In a recent study, Cools et al. examined the balance of inter-muscular (serratus anterior vs. trapezius) on a group of overhead athletes with chronic impingement symptoms [19]. The results indicated that overhead athletes had disturbed balance between upper and lower part of trapezius muscle activity and therefore disorders in timing of trapezius muscle activity.

The range of normal position of scapula has been defined as a translation of scapula around the curvature of the thoracic wall over distances of 15 to 18 cm [16]. Kibler has also clarified that protracted scapula may also proceed in a slightly upward or downward motion depending on the position of the arm in activity [16]. A possible explanation for significant difference between two groups may be insufficient action of trapezius muscle in stabilizing the scapula back toward the midline of the trunk and levator muscle in downward movement of the scapula by the exercise program. The protracted individuals had a scapula distance more than 20 cm in compare to the control individuals and this may susceptible them to improve their scapula position significantly. The findings of present study suggest that a relatively simple exercise program combined with patient instruction may be effective and they support the findings of Wang et al. [14] who investigated the effectiveness of a 6-week exercise program on scapula stabilizer muscles. They found an increased relative contribution of the glenohumeral joint compared with the scapulothoracic joint during shoulder elevation after a 6-week exercise program that focused on the posterior scapular stabilizers and glenohumeral external rotators. The aim of McClure et al.’s study was at strengthening the rotator cuff, increasing the flexibility of the posterior glenohumeral capsule and encouraging upper thoracic extension and a retracted head position by a simple 6-week exercise program [11]. The findings indicated an improved muscle force, motion, pain and function in a group of patients with shoulder impingement, however in the absence of a control group the results should not interpret with certainty whether the intervention led to changes in the patients’ status.

The findings of present study also indicated significant difference between pre-and post-training EMG of trapezius (Table 2) and levator scapula of the exercise group (Table 3). This reflects the role of these muscles particularly trapezius muscle as stabilizer of the scapula and confirmed findings of previous studies which
Table 4: Mean, SD and independent t test value of levator scapula muscle EMG of the exercise and control groups before and after the exercise program

<table>
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<th>Before exercise</th>
<th>After exercise</th>
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<tr>
<td>Exercise group</td>
<td>3561.4±105.25</td>
<td>3983±56.92</td>
<td>0.012</td>
</tr>
<tr>
<td>Control group</td>
<td>3618±348.32</td>
<td>3614.4±354.11</td>
<td>0.974</td>
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proposed the scapula stabilization as a main function of trapezius [17]. The aim of Cools et al.’s study was examining optimal scapular position and movement control when they compared normalized trapezius muscle activity with EMG [18-20]. They stated that normal shoulder function is mainly depends upon its scapula muscles such as trapezius muscle to provide stability.

The levator scapulae originate on the transverse processes of the cervical spine and inserts on the superior angle of the scapula. The levator scapulae elevate the superior angle, resulting in upward and medial rotation of the scapular body. A number of investigations have drawn attention to understanding the role of a balanced levator scapula function as a shoulder muscle on the neck and head. Loukas et al. stated that anatomical variations of levator scapula have the potential to cause functional and postural abnormalities, which in turn could lead to chronic myofascial and skeletal pain [21]. Menachem purported that contraction of levator scapula may change not only the forces acting on the shoulder girdle, but also the position of the scapula [22]. Based on these findings they concluded that anatomical variation of the insertion of the levator scapulae may explain the constant trigger point and crepitation. However the findings of present study support the findings of mentioned investigations, it should be taken into consideration that normal function of levator scapulae contributes to normal position of scapula as well as it may prevent levator scapulae syndrome.

Apart from the importance of the exercise in strengthening and stretching shoulder girdle muscles, insufficient muscle function due to the alteration of scapula may be the reason for increasing the risk of regional injuries. The improper position of scapular may result in creating the risk of shoulder instability and injuries. In fact, scapular instability may be found as a contributing factor in all shoulder instability. Warner [23] and Voight [24] reported that scapular instability is found in as many as 68% of rotator cuff problems and 100% of glenohumeral instability problems. A change in the position of the scapular influences proper scapular function and thus, it may decrease shoulder stability. Ludewig and Cook [2] found that subjects with impingement symptoms anteriorly tilted their scapulae about 2 degrees during humeral elevation (60°–120°) in the scapular plane, in contrast to the posteriorly titled scapulae seen in the subjects without impingement symptoms. Although care was taken to position of scapular, it would be more desirable to measure glenohumeral orientation and other muscle functions while the performance is being measured. It should be taken into consideration that the alteration of scapula position such as protracted scapula may be a source of shoulder injuries; however, it is beyond the scope of this study.

**CONCLUSION**

In this study conclusions are drawn on how shoulder muscles performance relates to scapula position and scapula orientation; however, these variables were not measured simultaneously. The results of current study suggest that individuals who have protracted position because of poor posture may be at a disadvantage of muscle function. It should be taken into consideration that altering scapula position may affect scapular kinematics and therefore decreasing the performance of shoulder muscles girdle. A simple 6 weeks of exercise program aimed at strengthening and stretching of trapezius and levator scapula and pectoralis muscles increased the muscle performance of protracted individuals and improved their scapula position. The alteration of scapula position not only may have an effect on shoulder muscles performance but also it may predispose the protracted individuals to injuries because of weaker muscles performance and poor posture.

**REFERENCES**


