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The relationship of muscle strength and pain in subacromial impingement syndrome

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Objective: We evaluated the relationship between muscle strength and pain in subacromial impingement syndrome (SIS).

Methods: 18 female, 2 male twenty patients (mean age 48.15±5.9 years; range 32 to 60 years) with Stage I and II SIS were enrolled in the study. Upper, middle and lower trapezius, serratus anterior, supraspinatus and anterior deltoid muscle strengths were assessed bilaterally by a hand-held dynamometer. Each muscle was assessed 3 times and the mean value of strength was calculated. Pain and functional results were assessed with visual analog scale (VAS), and Constant scores. Modified Constant score was calculated, with the exclusion of pain parameters.

Results: Middle trapezius, serratus anterior, supraspinatus and anterior deltoid muscle strengths of the shoulder with positive impingement signs were significantly lower than healthy opposite side ($p=0.01$, $p=0.04$, $p=0.01$, $p=0.003$). The mean Constant score was 57.46 and the mean VAS 6.85, in shoulders with SIS. There was a significant correlation between VAS and Constant score, without pain assessment ($p=0.016$, $r_s= -0.44$).

Conclusion: In this study we found a relationship between the middle trapezius, serratus anterior, supraspinatus and anterior deltoid muscle weaknesses and pain in SIS. This result indicates that these muscles should be evaluated and strengthened in required cases during the rehabilitation.

Key words: Hand-held dynamometer; muscle strength; subacromial impingement syndrome.

Subacromial impingement syndrome (SIS) is one of the most common shoulder pathologies.[1] SIS treatment is mostly conservative, and includes electrotherapy, range of motion exercises,[2,3] manipulation[3,4] and muscle strengthening exercises. Those strengthening exercises focus mostly on the rotator cuff and scapulothoracic muscles.[2,5]

Muscle strengthening programs address both pathologies arising primarily from muscle weakness, and secondarily from muscle weakness caused by pain and restricted range of motion (ROM).

The glenohumeral joint is a relatively unstable joint, whose stability depends on the surrounding ligaments, capsule, and muscles, such as rotator cuff and scapulothoracic muscles. It has been shown that imbalance of scapular protractor and retractor muscles can cause subacromial impingement and shoulder pain in overhead athletes.[6] The coordination between the parts of the trapezius muscle is especially crucial. The assumption is that the increased activity of the upper and lower trapezius, the decreased activity of the serratus anterior, and the inadequate

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coordination between these muscles increase the posterior tilt, and decrease the external rotation of scapula during shoulder elevation. Ultimately, with this alternative muscle control the subacromial space significantly narrows which leads to subacromial impingement syndrome.[7] Increased imbalance between anterior deltoid and rotator cuff muscle provoking superior humeral migration is another factor causing impingement symptoms.

The above statements show the importance of muscle strength evaluation and its relationship with subacromial impingement symptoms.

Several methods have been used to assess muscle strength in previous studies. Among these methods are electromyography (EMG), isokinetic and hand-held dynamometers. The hand-held dynamometer is a reliable method for evaluating the shoulder strength.[8-11] In previous studies, the muscles were evaluated in specific positions, or during functional movements[12,13] and isokinetic devices were used to assess shoulder muscle strength.[14-19]

We have hypothesized that the muscle weakness of the trapezius, the serratus anterior, the supraspinatus, the latissimus dorsi, and the anterior deltoid muscle is related to the symptoms of SIS. The objective of our study was to analyze the relationship between pain and the muscle strength in SIS.

Patients and methods

The study was held at the department of Orthopedics and Traumatology of Istanbul Medical Faculty of Istanbul University. Twenty patients (average age 48.15±5.9 years, 18 female, 2 male; range 32-60) patients with stage I and II SIS were included in the study (Table 1).

Inclusion criteria

1. Impingement signs (Neer impingement test, Hawkins signs, Jobe supraspinatus test), 2. Passive range of motion limitation, less than 30%, when compared to the opposite side, 3. The absence of radiographic abnormalities, such as degenerative arthritis and mesoacromion, 4. An intact rotator cuff on the magnetic resonance imaging (MRI), 5. Non-athletic activities were the inclusion criteria.

Exclusion criteria

(1) Passive range of motion limitation, more than 30%, when compared to the opposite side, (2) Patients who have undergone a shoulder surgery or a physical therapy and rehabilitation program, (3) Positive findings of rotator cuff tear on MRI.

All patients signed an informed consent form before the study. Twenty patients had positive impingement signs. The strength of upper, middle, lower trapezius, anterior deltoid, serratus anterior, supraspinatus, and latissimus dorsi muscles of both shoulders, healthy and with SIS, were measured with a hand-held dynamometer (kg/Newton) "Nicholas Manual Muscle Tester" (model 01160. The Lafayette Instrument Company, Lafayette, Indiana). This dynamometer allowed a measurement of muscle strength from 0.0 up to 199.9 kg, with 0.1 kg precision. The dynamometer was placed in the appropriate area, where we wanted to measure the muscle power. The test subjects were allowed to make a one time practice, in order to learn the test procedure. The test subject was asked to forcibly contract his/her muscle, while a resistive force was applied with the dynamometer in the opposite direction of the intended movement.[20] During the test the device recorded the maximal isometric strength of the muscle in kg/Newton. The test positions were set particularly for the assessment of the scapulothoracic joint. These positions were defined in previous electrophysiological studies.[21-25] Each muscle was assessed 3 times and mean value was calculated. During the test, a camera recorded the patients to determine whether there was any compensatory movement during the test, and if there was, the test was repeated. Pain was assessed by visual analog scale (VAS), and the function by Constant score.

Table 1. Patient demographics (n=20).

Patients (n=20)	
Age	48.15±5.9
Gender	
Female	18
Male	2
Weight	63.76±13.8
Height	168.21±13
Tobacco usage	
Less than 1 pack	4
More than 1 pack	2
Diabetes mellitus	2
Thyroid disorder	2

Muscle tests

Upper trapezius: While the patient was in sitting position, the dynamometer was placed on top of scapula and the patient was asked to elevate his/her shoulder against resistance (Fig. 1).

Middle trapezius: While the patient lied in prone position, the arm was held in 90° of shoulder abduction and 90° of elbow flexion. The dynamometer was placed in the middle line of the scapula, in between the acromion and the spine of scapula. While the patient lifted his/her arm upward, resistance with the dynamometer was applied in the lateral direction. The patient was asked to keep his arm in this position against resistance (Fig. 2).

Lower trapezius: While the patient lied in prone position, the arm was positioned in 140° flexion. The dynamometer was placed in the middle line of the scapula, in between the acromion and the spine of scapula. While the patient lifted his/her arm upward, resistance was applied in lateral and superior direction with the dynamometer.

Supraspinatus: The patient's shoulder in a sitting position was put in 30° abduction in and 90° flexion. The resistance was applied just above the elbow. The patient was asked to resist the force applied with the dynamometer.

Serratus anterior (lower fibers): While the patient was in supine position, the elbow and the shoulder were put in 90° flexion. A force with the dynamometer was applied over the ulna along the humeral axis, while the patient was asked to resist this force.

Anterior deltoid: While the patient was seated, the shoulder was placed in 90° forward flexion position. The resistance was applied from just above the elbow. The patient was asked to resist the force applied with the dynamometer.

Latissimus dorsi: While the patient was in sitting position, the elbow was put in 90° flexion and the shoulder in 30° extension. The force was applied through posterior just above the elbow with the dynamometer and the patient was asked to resist the force.

In statistical analysis unpaired sample t-test was used in the comparison between the healthy shoulders and shoulders with SIS. Spearman correlation coefficient was used in correlation analysis between VAS and modified Constant score. The level of significance was set at $p<0.05$.

Results

The muscle strengths of the shoulders with SIS were lower than those of the healthy sides. However this difference was not statistically significant for all muscles. In 20 patients with SIS middle trapezius, serratus anterior, supraspinatus, and anterior deltoid strengths were significantly lower than the opposite side ($p=0.01$, $p=0.04$, $p=0.001$, $p=0.003$).

The mean Constant score of the shoulders with SIS was 57.46 and their mean VAS was 6.85. The mean Constant score was also calculated with the exclusion of the pain parameter and was found as 50. A statistically significant correlation was found between VAS and Constant score, without pain assessment ($p=0.016$, $r_s=-0.44$). The pain and

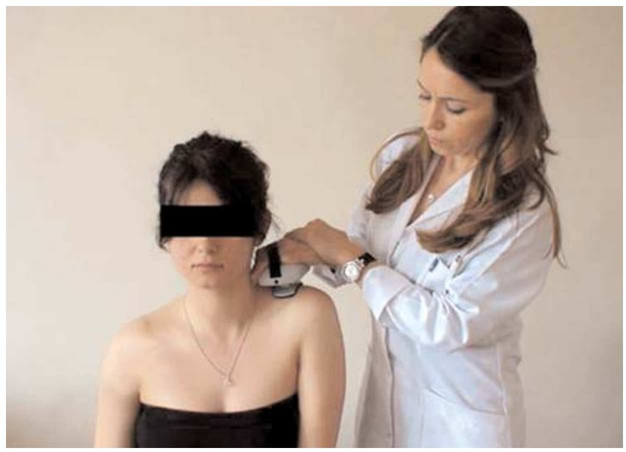

Fig. 1. Upper trapezius assessment with hand-held dynamometer. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Fig. 2. Middle trapezius assessment with hand-held dynamometer. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Constant score were, that is, the VAS increased as the Constant score decreased.

Discussion

We compared the muscle strength of the shoulders with SIS with the healthy opposite side. The result of the comparison showed that, the muscle strength of the middle trapezius, the serratus anterior, the anterior deltoid, and the supraspinatus muscle in the shoulders with SIS were significantly lower than those of the healthy side.

Several studies have used hand-held and isokinetic dynamometers or electromyography to assess the muscle strength in SIS. These studies showed that muscle activation was decreased or delayed in SIS.[26-32] Muscle strength in SIS has been evaluated in several electrophysiological studies. In the study of Reddy et al., infraspinatus and supraspinatus muscle activities were found lower in shoulders with SIS. In a review of electrophysiological studies, it was found that there were some differences between the upper and lower trapezius activities of healthy subjects and those with SIS. However, the authors did not a retrieve a significant conclusion.[25,33] Ludewing et al. found an increase in both the upper and lower trapezius activities during shoulder elevation.[26] While these studies provide some general information on the involvement of shoulder muscles in SIS, there is still a lack of knowledge on individual activities of each muscle.

In our study, we analyzed the supraspinatus muscle, scapulothoracic muscles and the anterior deltoid in specific positions using a hand-held dynamometer.[18] The shoulders with SIS, middle trapezius, serratus anterior, supraspinatus, and anterior deltoid muscle strengths were weaker than the opposite side.

It has been postulated that the pain might be responsible for the muscle weakness with reflex inhibition, resulting in SIS, while muscle weakness itself might also be the primary cause of SIS, resulting in pain. This discussion was beyond the scope of our study. In our study, we could not find the muscle strength-pain relationship, using regression analysis. When we analyzed the relationship between the modified Constant score and the VAS, excluding the pain parameter, we discovered that the functional state of pain was affected as statistically significant ($p=0.016$).[34] Our results suggest that the pain in SIS may be a cause of muscle weakness. In a study comparing 13 stage I and II SIS patients with 25 healthy subjects, no relation was found between muscle weakness and pain.[14]

In another study, the relation between scapular muscle strength and shoulder problems were analyzed on 176 over-head athletes. They assessed the upper, middle, and lower trapezius, the rhomboid muscles, and the serratus anterior. In conclusion the elevation/depression muscle strength rate was 2.5/1, the upwards/downwards rotation rate was 1.5/1, and the protraction/retraction rate was 1.25/1. The imbalance between the muscle strengths was accepted to be statistically significant, and the importance of scapular muscles in shoulder rehabilitation was highlighted.[35] In our study, we have obtained similar results. The muscle strength of the serratus anterior, the middle trapezius, and the supraspinatus was lower than the muscle strength of shoulders with negative impingement syndrome. However, we unable to prove the correlation of increased upper and decreased lower trapezoids caused by impingement symptoms as stated in the available literature.[36]

The relationship between deltoid muscle strength and the impingement syndrome has not been studied yet. In our study, the anterior deltoid muscle strength was statistically lower shoulders with SIS. With the assumption that the mainly dominant shoulders (85%) in our study would be stronger than the non-dominant shoulders, the likelihood that there was a relationship between the weakness of the anterior deltoid and impingement symptoms strengthened. We believe that the weakness is not the primary cause of SIS, but a consequence of it.

During the muscle test, the shoulder's position is important. It has been shown that the scapular protraction and retraction affects the strength of rotator cuff muscles and the optimal strength measurement was done with scapular retraction.[10,11] Morella et al. assessed the infraspinatus strength while the scapula was in neutral position and retracted. They found a statistically significant increase in the strength of the infrasupinatus, when the scapula was in retraction.[37] We assessed the deltoid and supraspinatus muscle tests without protracting the shoulders of our patients and subsequently reviewed their video recordings.

The clinician should be aware of the several disadvantages of the hand held dynamometers while isokinetic testing can provide reliable results. However, the muscle strengths can not be evaluated individually with this method. Isokinetic tests generally evaluate the internal and external rotation strengths with 60°, 120° and 180° of shoulder flexion or scaption, and optimal rotator cuff strength can not be measured in these positions.[12-14,26,38] Difficulty in taking the optimal test position, especially for scapulothoracic muscles is another disadvantage of isokinetic measurement devices.[12]

As a result, we discovered a statistically significant relationship between SIS and the weakness of the middle trapezius, the serratus anterior, the supraspinatus, and the anterior deltoid muscles. This outcome highlights the importance of assessing muscles and, if necessary, strengthening them during the conservative treatment of SIS.

Conflicts of Interest: No conflicts declared.

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