Türk Fizyoterapi ve Rehabilitasyon Dergisi

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UPPER TO MIDDLE TRAPEZIUS MUSCLE ACTIVATION RATIO DURING SCAPULAR RETRACTION EXERCISE AT DIFFERENT SHOULDER ABDUCTION ANGLES

ORIGINAL ARTICLE

ABSTRACT

Purpose: The purpose of this study was to evaluate the upper trapezius to middle trapezius muscle activation ratio (UT:MT) during scapular retraction exercises at different shoulder abduction degrees in healthy individuals.

Methods: Twenty healthy individuals (10 males, 10 females) participated in this study (age: 22.90±2.84 years). A surface electromyography system (TELEmyo DTS; Noraxon USA, Inc, Scottsdale, AZ) was used to measure the activation levels of the upper trapezius and middle trapezius muscles during scapula retraction exercises. For the scapular retraction exercise, participants were instructed to perform a resisted scapula retraction with an elastic band at each of the following shoulder abduction angles: 0º, 45º, 60º and 90º. A repeated measures of ANOVA was used to determine whether UT:MT ratio differed among scapula retraction exercises.

Results: There was significant exercise effect on UT:MT ratio ($F_{(3,57)}$=7.532, p<0.001). The UT:MT ratio was lower at 0º scapular retraction exercise when compared to 45º (p=0.024), 60º (p=0.031) and 90º (p=0.003) scapular retraction exercises. There was no difference between 45º and 60º (p=0.283), and 60º and 90º (p=1.000) scapular retraction exercises regarding UT:MT ratios.

Conclusion: Compared to 45° and 60° of shoulder abduction, UT:MT ratio was greater at 60° and 90° of shoulder abduction. Since UT:MT ratio was lower than one, scapula retraction exercise at or under 90° of shoulder abduction might be suggested for the individuals with shoulder problems.

Key Words: Exercise; Electromyography; Scapula; Shoulder Joint.

FARKLI OMUZ ABDUKSİYON AÇILARINDA YAPILAN SKAPULA RETRAKSİYON EGZERSİZLERİ SIRASINDA ÜST ve ORTA TRAPEZ KAS AKTİVİTESİ ORANI

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Bu çalışmanın amacı, sağlıklı bireylerde farklı omuz abduksiyon derecelerinde yapılan skapular retraksiyon egzersizleri sırasında üst trapez ile orta trapez kas aktivasyon (ÜT:OT) oranını değerlendirmekti.

Yöntem: Bu çalışmaya 20 sağlıklı birey (10 erkek, 10 kadın) dahil edildi (yaş: 22,90 ± 2,84 yıl). Skapula retraksiyon egzersizleri sırasında üst trapez ile orta trapez kaslarının aktivasyon düzeylerini ölçmek için yüzeyel elektromiyografi (TELEmyo DTS, Noraxon USA, Inc, Scottsdale, AZ) kullanıldı. Egzersizler sırasında, bireylerden 0º, 45º, 60º ve 90º omuz abdüksiyon açılarında elastik bant ile dirençli skapula retraksiyonu yapması istendi. İstatistiksel analiz için, skapula retraksiyon egzersizleri arasında ÜT:OT oranının farklı olup olmadığını belirlemek için tekrarlayan ölçümlerde ANOVA testi kullanıldı.

Sonuçlar: Skapular retraksiyon egzersizinin ÜT:OT oranına etkisi anlamlı bulundu ($F_{(3,57)}$=7,532, p<0,001). ÜT:OT oranı, 45° (p=0,024), 60° (p=0,031) ve 90º (p=0,003) omuz abduksiyonu ile kıyaslandığında 0° abduksiyonda en düşük bulundu. ÜT:OT oranı 45° ile 60° (p=0,283) omuz abduksiyonunda ve 60° ile 90° (p=1,000) omuz abduksiyonunda yapılan skapula retraksiyon egzersizleri sırasında benzer bulundu.

Tartışma: ÜT:OT oranı, 45° ve 60° omuz abduksiyonu ile kıyaslandığında, 60° ve 90° omuz abduksiyonunda yapılan skapular retraksiyon egzersizinde daha büyük bulundu. ÜT:OT oranı birin altında bulunduğu için, 90° ve altında yapılan skapula retraksiyon egzersizi omuz problemi olan bireyler için önerilebilir.

Anahtar Kelimeler: Egzersiz; Elektromiyografi; Skapula; Omuz Eklemi.

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INTRODUCTION

The proper functioning of the upper limb and shoulder joint depends on the optimal positioning and movement of the scapula (1,2). The scapula predominantly demonstrates an upward rotation and to a lesser degree of scapular external rotation and posterior tilt during shoulder elevation (1). This three-dimensional pattern of scapular movement provides the accurate length-tension relationship of the rotator cuff muscles as well as the scapular muscles throughout the glenohumeral range of motion (3-6). During the initial phase of glenohumeral elevation, the rotator cuff muscles produce joint compression while scapular muscles produce controlled scapular movement and stability (1,6,7). The imbalance between these muscle activities, especially the deficits in scapular muscle activity, have been related to the altered scapular kinematics (6).

The scapular muscles work synergistically to control the scapular movement, and patterned scapular muscle activations are necessary for optimal scapular stabilization (8-10). The upper trapezius (UT), lower trapezius (LT) and serratus anterior (SA) are working together to move the scapula into the upward rotation. The middle trapezius (MT) and rhomboid muscles retract the scapula and LT cause upward rotation and depression of the scapula. In addition, during arm elevation, LT contributes to posterior tilt and external rotation of the scapula (10,11). Alterations in activity of these scapular muscles (e.g., an increase in UT muscle activity combined with decrease in SA) LT and MT may adversely affect scapular positioning, resulting in reduced scapular upward rotation and increased anterior scapular tilt, (12-14), and thereby would increase the risk of subacromial impingement syndrome (SIS) (1,12). Previous studies have assessed relative scapular muscle electromyographic (EMG) activity and reported higher UT:MT and UT:LT ratios in those with SIS compared with healthy controls (15,16).

The scapular retraction exercises are widely used by clinicians in an aim to balance the activity of the scapular muscles as well as the rotator cuff muscles in different upper-limb positions to improve the scapular kinematics (6,10,17). The general movement pattern of the scapula observed during scapular retraction exercises was the upward rotation, external rotation and posterior tilt (6), and in theory, this pattern results in increasing the acromio–humeral distance (1). However, there is limited information that shows how trapezius muscle activity changes during scapula retraction exercise with different shoulder abduction angles. Understanding changes in the trapezius muscle activity among retraction exercises may help guide the clinicians to select activities that are most appropriate for the rehabilitation program.

Therefore, the present study aimed to investigate the EMG activities of UT and MT and also the UT:MT ratios during scapular retraction at different degrees of shoulder abduction (0º, 45º, 60º and 90º). It was hypothesized that UT:MT ratio would gradually increase by the increase in shoulder abduction.

METHODS

Twenty healthy individuals between the ages of 18-30 years participated in this study (10 males, 10 females) (Table 1). The individuals with no history of overhead activity participation were included in the study. Individuals who reported shoulder pain and instability and had a history of surgery were excluded. This study was conducted at Hacettepe University, Department of Physiotherapy and Rehabilitation (May 2016-2017). Written informed consent was obtained from all participants, as approved by Hacettepe University Ethics Committee (GO 16/247).

A surface EMG system (TELEmyo DTS; Noraxon USA, Inc, Scottsdale, AZ) was used to measure the activation levels of the UT and MT muscles during scapula retraction exercises. Bipolar Ag/AgCl surface electrodes were placed at an interelectrode distance of 2 cm. The electrode width was 1 cm, the common-mode rejection ratio was greater than 80 Db, and the input impedance was higher than 10 mΩ. The sampling rate for EMG data was 1000 Hz. Synchronized video capture (Webcam C500; Logitech International SA, Lausanne, Switzerland) was used to determine the phases of the scapular retraction exercises.

Before electrode placement, the electrode sites

of the body were prepared by shaving any hair on the skin, abrading the skin with fine sandpaper, and cleaning the skin with 70% isopropyl alcohol to minimize the skin impedance. The placement of electrodes for each muscle was done according to SENIAM's European Recommendations for Surface Electromyography (18). Electrodes for the UT muscle were placed midway between the spinous process of the seventh cervical vertebra and the posterior tip of the acromion process along the line of the trapezius muscle. The MT muscle electrode was placed midway on a horizontal line between the root of the spine of the scapula and the third thoracic spine.

Maximum voluntary isometric contractions (MVICs) were recorded before scapular retraction exercises. For the UT muscle, resistance was applied to the abduction of the arm; the MT muscle was tested by using resistance to horizontal abduction in the external glenohumeral rotation. For each MVIC, participants performed one practice trial, and then performed three repetitions of a 5-sec MVIC. During the test, the participants received standardized verbal encouragement to produce maximum effort. Thirty seconds of rest was given between each contraction.

For the scapular retraction exercise, participants were instructed in the performance of resisted scapula retraction at each shoulder abduction angle (0º, 45º, 60º, and 90º). Wooden bars were used to guide the position of the elbow such that it was aligned parallel with the trunk, and to maintain the designated arm angle (Figure 1). Participants first performed scapula retraction without resistance to become familiar with the movement. Scapula retraction then was conducted with band resistance (Thera-Band®, The Hygenic Corporation, Akron, OH, USA). To standardize the amount of resistance across participants, the OMNI perceived exertion scale was used (19). Participants were instructed to perform three repetitions of scapula retraction at 90º of shoulder abduction starting with the lowest resistance band, and then increased the band resistance until the level of perceived effort was rated as 5 (somewhat hard) on a 0 to 10 scale (0=extremely easy; 10=extremely hard). Each exercise consisted of concentric, isometric and eccentric phase and metronome was used to control and standardize the velocity of the exercises (60 beeps/min). The only isometric phase of the exercises was used for data analysis.

EMG data processing was accomplished using Noraxon Myo-Research XP Master Edition software (Noraxon Inc, USA). The EMG signals were band-pass filtered (10-450 Hz) and smoothed using a root-mean-square moving-window function with a time constant of 100 milliseconds. For each of the MVIC trials, the maximum value obtained over the 5-second maximum effort was recorded, and the maximum of three MVIC trials was used for normalization of the EMG data collected during exercises. For each trial of each exercise (three trials for four scapular retraction exercises), the mean signal amplitude of each phase of the task was divided by the MVIC value for each muscle of interest. The average of the trials, expressed as a percentage of MVIC, was used for statistical analysis (20).

Statistical Analysis

SPSS Version 21.0 (IBM Corporation, Armonk, NY, USA) used for all statistical analyses. The Kolmogorov-Smirnov test was used to examine the normal distribution of the data. A repeated measures of ANOVA was used to determine whether UT:MT

Tablo 1: Characteristics of the subjects.

Characteristic	Mean±SD	Range
Age (years)	22.90±2.84	21-32
Height (cm)	169.33±9.46	150-185
Weight (kg)	65.50±12.89	42-87

SD: Standart deviation

Tablo 2: Muscle Activation Levels during Scapular Retraction Exercises at Various Degrees of Shoulder Abduction.

Muscle Activation	Shoulder Angle				p
	0º	45º	60º	90º	
UT (%MVIC)	6.23±9.84	8.79±8.44	12.96±10.19	18.54±12.10	**<0.001***
MT (%MVIC)	22.39±13.99	20.62±12.75	23.07±12.74	31.40±14.15	**<0.001***
UT:MT (%)	30.47±7.67	44.17±7.41	63.56±11.65	63.36±8.74	**<0.001***

*Data are Expressed as Mean±SD. p<0.05. UT: Upper Trapezius; MT, Middle Trapezius; UT:MT, Upper Trapezius To Middle Trapezius Ratio; MVIC, Maximum Voluntary Isometric Contraction.

ratio differed among scapula retraction exercises. Post-hoc t-tests with a Bonferroni correction were used. All significance levels were set at p<0.05.

RESULTS

Descriptive data for UT and MT muscle activation levels during scapular retraction exercises are shown in Table 2.

There was significant exercise effect on UT: MT ratio ($F_{(3,57)}$=7.532, p<0.001). The UT: MT ratio was lower at 0º scapular retraction exercise when compared to 45º (p=0.024), 60º (p=0.031) and 90º (p=0.003) scapular retraction exercises. There was no difference between 45º and 60º (p=0.283), and 60º and 90º (p=1.000) scapular retraction exercises regarding UT:MT ratios.

UT activity was significantly different among exercises ($F_{(3,57}$=12.844, p<0.001). There was no difference between 0º and 45º shoulder abduction (p=0.742). The UT activity was greater at 60º abduction compared to 45º abduction (p=0.005). No difference was observed between 60º and 90º shoulder abduction (p=0.100).

MT activity was significantly different among exercises ($F_{(3,57)}$ =10.151, p<0.001). The only difference was observed between 60º and 90º shoulder abduction. There was no difference between 0º and 45º (p=1.000) and between 45º and 60º (p=1.000) shoulder abduction.

DISCUSSION

The primary focus of this study was to investigate the activity balance between UT and MT muscles

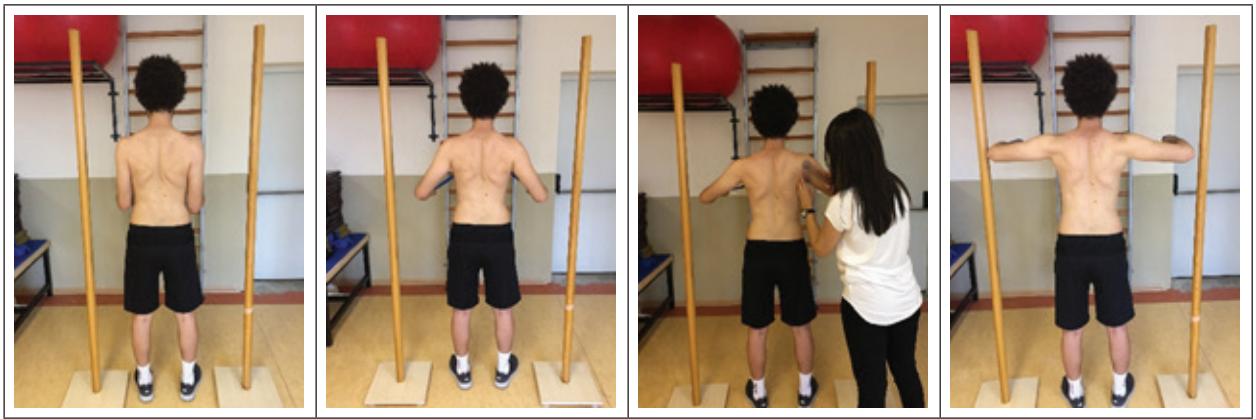

Figure 1: Scapular Retraction Exercise at 0º, 45º, 60º, and 90º of Shoulder Abduction.

during scapula retraction exercise at various shoulder abduction angles. The results indicate that UT:MT ratio was lower at scapular retraction exercise with 0º of shoulder abduction compared to scapular retraction exercise with 45º, 60º, and 90º of shoulder abduction. In addition, UT:MT ratio did not differ between the scapular retraction exercise at 60º and 90º of shoulder abduction. The greatest UT activity was observed in scapular retraction exercise at 60º and 90º of shoulder abduction while MT activity was in scapular retraction exercise at 90º of the shoulder.

The purpose of the exercises for shoulder rehabilitation is to recruit MT, LT, and SA with the minimal activity of the UT (17). Scapula retraction exercises are the starting point of the several shoulder rehabilitation protocols, and these exercises are prescribed for recovering the scapular control via strengthening scapula-thoracic muscles primarily MT, LT and rhomboid muscles (17,21). Since excessive UT activity might increase the anterior tilt of the scapulothoracic joint that causes SIS, UT activity of the individuals who have scapular dyskinesia and shoulder pain has been the primary interest of both clinicians and researchers (8,9,17,22,23). However, there is no information in the literature regarding what is the optimal UT:MT ratio should be during exercises.

In the present study, UT activity during scapular retraction exercises was found lower than 20% that could be accepted as a minimal activation. We expected to see a gradual increase in UT activity with the increased shoulder abduction. However, there was a small difference between 45° to 60°, and no difference was observed from 0° to 45° and from 60° to 90° of shoulder abduction. Scapula retraction exercise mainly recruits the MT as this exercise includes scapular adduction, posterior tilt, and external rotation motions. Previous 3-D studies showed that upward scapular rotation and posterior tilt gradually increased during shoulder abduction and they were more obvious beyond 90° of shoulder abduction (6,24). Scapula retraction could be more achieved with the increase in the upward scapular rotation which explained the significant increase in MT activity from 60° to 90° of shoulder abduction in the present study.

Oyama et al. (6) investigated the UT and MT activity during different scapular retraction exercises in healthy individuals. Similar to the findings of the present study, the UT:MT ratios were lower than one during different scapular retraction exercises. However, they documented the lowest UT:MT ratio in scapular retraction at 90° of shoulder abduction with the upper extremity externally rotated while we found the lowest ratio in shoulder retraction at 0° of shoulder abduction. They also reported greater UT and MT activation levels when compared to the results of the present study. The difference between the two studies might be due to different body position used during scapular retraction exercise. In one study, the participants performed the exercises in the prone position while the participants in the present study performed the exercises in standing position (6). Performing exercises against the gravity might result in greater muscle activation according to Oyama et al. study (6).

In another study that investigates scapular muscles activity during scapula retraction exercises found that MT activity (16.1% MVIC) was lower than UT (28.4% MVIC) during overhead retraction in the standing position (10). It is important to consider that direct comparisons between the study of Castelein et al. (10) and the present study are difficult to make as they did not measure UT and MT activity during scapula retraction lower than 90° of shoulder abduction angles. The UT muscle acts as an upward scapular rotation, which is shown to greater beyond 90° shoulder abduction that could explain greater UT activity during overhead retraction in study of Castelein et al. (10).

There is no study in the literature examining isolated scapula retraction exercises effect on shoulder function and scapular kinematics in healthy persons or patients with shoulder pathologies. Previous studies documented improvements in shoulder function and pain without any change in scapular kinematics after scapular muscle strengthening exercises (22,24). Therefore, the existing knowledge indicates that improvements in shoulder function and pain may be not related to yerine may not be related with scapular kinematic changes, may be due to a change in the activation of the scapular muscles. Further investigation is required to demonstrate the long-term effect of scapula re-

traction exercises on shoulder function, scapular kinematics in patients with SIS.

All participants in this study were young and healthy adults with no known shoulder dysfunction. It is not clear if a patient population would show the same amount of muscle activity during scapular retraction exercise. It should be kept in mind that UT and MT muscle activity occurring with the retraction exercises might differ in patients. Therefore, caution needs to be taken when applying the results of this study to the patients. Another limitation of the present study was the contribution from the other scapular muscles, such as LT and rhomboids, were not considered. Since the scapular muscles work synergistically, including these muscles' activities could give a broader aspect of designing the exercises for scapular muscle control.

The UT:MT ratio could differ among the scapula retraction exercises at different shoulder abduction angles that UT:MT ratio was greater at 60° and 90° of shoulder abduction. Since UT:MT ratio was lower than one, scapula retraction exercise at or under 90° of shoulder abduction could be used in shoulder rehabilitation where excessive UT activity is not desired. Future studies are needed to determine whether scapular retraction exercises influences UT:MT ratios in persons with subacromial impingement syndrome.

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Conflict of Interest: None declared.

Ethical Approval: The study was approved by Hacettepe University Ethics Committee (GO 16/247).

Informed Consent: Written informed consent was obtained from all study participants.

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