Original Article

CHANGES IN SHOULDER MUSCLE ACTIVITIES IN SUBJECTS WITH A ROUNDED SHOULDER POSTURE DURING SCAPULAR POSTERIOR TILTING EXERCISE ON DIFFERENT SURFACES

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Abstract

The current study aimed to determine whether there are different electromyographic (EMG) activities in the lower trapezius and serratus anterior muscles of subjects with a rounded shoulder posture (RSP) during scapular posterior tilting (SPT) exercise on four different surfaces. This study included 20 subjects with RSP. They all performed SPT exercise on four different surfaces: a stable surface, upper body unstable surface, lower body unstable surface, and whole-body unstable surface. All subjects' EMG activities in the lower and upper trapezius muscles in the upper limb on the elevated side and in the upper trapezius and serratus anterior muscles on the opposite side were determined during SPT exercise on four different surfaces, respectively. Then, the ratios of the muscles' EMG activities on both sides were compared. The results of the present study show significant differences in EMG activities in the lower trapezius and serratus anterior muscles during SPT exercise on four different surfaces ($p < 0.05$). The results of a post-hoc analysis showed significantly greater EMG activity values in the lower trapezius and serratus anterior muscles during SPT exercise on the upper body unstable surface and whole-body unstable surface ($p < 0.05$). Conclusively, SPT exercise performed in upper limb instability conditions is more favorable for increasing lower trapezius muscle activity in patients with RSP.

Keywords: Scapular posterior tilt exercise; Round shoulder posture; Lower trapezius.

1. Introduction

Poor posture is common during adolescence[1], with long-term use of smart phones and personal computers leading to such posture conditions as a rounded shoulder posture (RSP), forward neck posture, and slouched posture[2]. Among these postures, an RSP has affected many people's lives and mental health to a considerable degree. An RSP directly affects the appearance and image of people, and it is a catalyst for various diseases.

An RSP is one of the most common structural anomalies of the shoulder complex[3], The scapula is prolonged, downwardly rotated, and anteriorly tipped, with enhanced cervical lordosis and upper thoracic kyphosis.[4]. An RSP also places the serratus anterior and lower trapezius positions, which are thought to influence scapular tilt negatively[5]. These changes increase muscle tension and stress in the neck and shoulder, leading to discomfort, numbness, loss of function, and a variety of neuromuscular symptoms, most commonly affecting the upper body[6].

An RSP can be caused by numerous factors, including a lack of lower trapezius and serratus anterior activity, tightness in the pectoralis minor, more thoracic kyphosis, and the scapular anatomical structure itself[7]. Several prior studies have detailed numerous RSP rehabilitation techniques, including lower trapezius and serratus anterior muscle-strengthening exercises, pectoralis major stretching, and correcting abnormal posture with a shoulder brace or tape[8, 9]. Of these methods, strengthening the serratus anterior and lower trapezius muscles have routinely been included in rehabilitation to compensate for the decrease in strength and mobility caused by an RSP[10, 11]. Scapular posterior tilt (SPT) exercise in the prone position in particular was found the most efficient means of strengthening the lower trapezius and serratus anterior muscles, as well as of stabilizing the scapular to the thoracic wall[7].

According to certain research, providing an unstable base of support during prone position training might result in increased neuromuscular system recruitment and muscle activation for shoulder rehabilitation[12]. A modest amount of research suggests that exercising on an unsteady surface increases core musculature activity compared to training on a stable surface[13], as well as that instability training is an effective recovery method[14]. Other research, however, has yielded inconsistent and contradictory results due to changes in the experimental methodologies[15, 16].

Few studies have compared muscle activities during SPT exercise performed on stable and unstable surfaces. Thus, the major aim of this research was to compare differences in muscle activities during SPT exercise on stable and unstable surfaces and to select the surface that can best maximize lower trapezius muscle activity when performing SPT exercise.

2. Methods

2.1 Experimental subjects

This study consisted of 20 subjects (9 males and 11 females) with an RSP attending Daegu University in Gyeongsan, South Korea. The mean age of the subjects is 24.40±2.37 years old, the mean height is 168.90±7.86 cm, and the mean body mass is 64.97±12.25 kg. The average BMI of the subjects is 22.60±2.66 kg/m^3, and the average RSP distance is 5.62±1.50 cm. All subjects' EMG activities in the right upper and lower trapezius muscles and in the opposite upper trapezius and serratus anterior muscles were determined during SPT exercise on a stable surface and three unstable surfaces, respectively. All participants read and signed the university-approved human subject permission form before participation, and the investigation was approved by the University Institutional Review Board (IRB No.1040621-202203-HR-029). The inclusion criterion was an RSP distance of ≧2.5 cm[4], and the exclusion criteria were (1) mental or cognitive problems that might affect the experiment or (2) subjects with a history of shoulder disease, an injury limiting activities, or cervical fractures.

2.2 Experimental procedure

The preparatory experiment began before the formal experiment. The study lasted from October 25, 2021, to November 20, 2021. In total, 20 subjects with an RSP were selected for the study. The subjects performed SPT exercise on four different surfaces. In all experiments, the dominant arm (the favored arm for eating and writing tasks) was employed[11], and all respondents stated that their dominant arm was the right arm. Each subject repeated the exercise three times.

2.3 Experimental assessment

A straight ruler was used to measure the distance in the supine position from the posterior side of the acromion to the table, as shown in Figure 1, and a angle-measuring instrument was used to measure the abduction angle of the shoulder joint when subjects were performing SPT exercise. In the experiment, we used the aircushion balance balls as an unstable surface. To collect the EMG activities of the right upper and lower trapezius muscles and of the opposite upper trapezius and serratus anterior muscles, the conduction material and processing of signals will use Telemyo system DTS (Noraxon Inc. USA) . When the experiment begins, to standardize EMG data, participants performed maximal voluntary isometric contractions (MVIC) of the right lower trapezius and upper trapezius muscles and the opposite serratus anterior and upper trapezius muscles against manual resistance using previously documented procedures. For each muscle: Lower trapezius muscle - With the individual in the prone position, lift the arm over the head in line with the lower trapezius muscle fibers while applying resistance above the elbow; Serratus anterior muscle - With the individual in the supine position, the scapular protrudes at 90° of shoulder flexion when resistance is applied across the hand and at the elbow; Upper trapezius muscle - With the individual sitting in an erect position with no back support, the scapula is lifted with the neck-first side bent to the same side, rotated to the other side, and then extended, as resistance is provided at the head and above the elbow[5]. To avoid fatigue, a 2-min rest period was permitted between each contraction.

To compute the MVIC, root-mean-square (RMS) values were collected for the 3 sec in the center, eliminating 1 sec at the beginning and end of the five measures, and the average of the middle three values was utilized. The EMG activities of the right upper and lower trapezius muscles and the opposite serratus anterior and upper trapezius muscles measured in distinct individuals were normalized against the MVIC to measure %MVIC.

Fig. 1 RSP distance

2.4 Experimental intervention

The SPT exercise was performed on four different surfaces (Fig. 2).

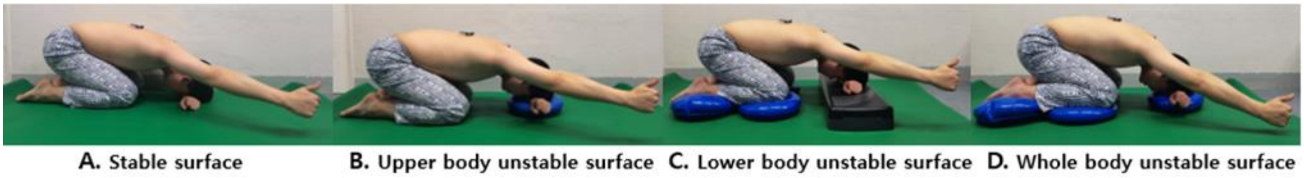
•A—Stable surface: On the ground, the individuals were positioned quadrupedally and asked to rock backward slowly until achieving contact between the buttocks and both heels. To stabilize the neck and thoracic spine, the patients were instructed to position the non-experimental arm under the brow and slightly press the brow with the dorsum of the hand. We abducted the subject's experimental arm up to 145° and used a goniometer to validate the angle[7]. The participant was then directed to raise the experimental arm until it reached the radial boundary of the wrist near the ear.

•B—Upper body unstable surface: Other conditions were equivalent to the stable surface, and we placed an aircushion balance ball under the non-experimental arm.

•C—Lower body unstable surface: Other conditions were equivalent to the stable surface, and we placed four aircushion balance balls under both sides of the lower body to prevent the inconvenience of exercising due to a posture in which the lower body was higher than the upper body. We placed a similar height plate under the upper body when in a state of lower body instability.

•D—Whole body unstable surface: The combination of upper body instability and lower body instability led to a state of whole body instability.

Fig. 2 SPT exercise performed on four different surfaces



A. Stable surface **B.** Upper body unstable surface **C.** Lower body unstable surface **D.** Whole body unstable surface

2.5 Statistical analysis

The data were indicated as the means ± standard deviations（M±SD）. One-way ANOVA was utilized to evaluate the data to assess differences in muscle activity and the muscle activity ratios of both sides during SPT exercise performed on different surfaces in subjects with RSP. If significant interaction for conditions was found, a post hoc analysis was performed to determine any differences using pair-wise comparison. To guard against Type I error, we used the Bonferroni correction. Bonferroni-corrected p’ value = $\frac{significant\ level}{n}$, n is the number of surfaces in the exercise (n = 4). Statistical analysis was conducted using SPSS for Windows (ver. 26.0), and the statistical significance level was set to $p<0.05$. Bonferroni-corrected p’ value = $\frac{0.05}{4}$, so the Bonferroni adjustment was set to $p < 0.013$ for statistical significance.

3. Results

3.1 Changes in EMG activities between four different surfaces

According to statistics from the one-way ANOVA, the EMG activities of the lower trapezius muscle and opposite serratus anterior muscle were found to be significantly different during the SPT exercise on four different surfaces ($p < 0.05$; Table 1). Based on the Bonferroni post hoc analysis, the EMG activities of the lower trapezius muscle and opposite serratus anterior muscle were significantly increased during SPT exercise on the upper body unstable surface and whole body unstable surface ($p < 0.05$; Fig.3).

Table 1. Comparison of four muscle activities among four different surfaces N = 20 (Unit:%MVIC)

	A (M±SD)	B (M±SD)	C (M±SD)	D (M±SD)	F	p
LT	57.27±10.37	75.20±11.72	64.25±10.76	78.66±11.51	15.776	.000*

UT	28.40±8.86	33.77±10.88	31.19±9.91	35.69±11.64	1.862	.143
SAO	13.84±8.08	20.35±9.47	16.15±8.45	23.00±10.22	4.098	.009*
UTO	11.01±6.59	14.80±7.32	12.84±6.77	16.89±8.14	2.448	.070

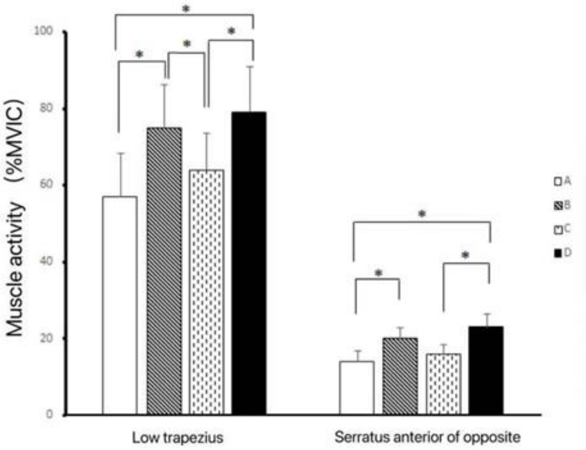
* *p*< .05

Mean±SD: Mean±Standard Deviation

A: stable surface; B: upper body unstable surface; C: lower body unstable surface; D: whole body unstable surface.

LT: lower trapezius; UT: upper trapezius; SAO: serratus anterior of opposite; UTO: upper trapezius of opposite

Fig.3 Comparison of muscle activities among four different surfaces



3.2 Changes in two ratios between four different surfaces

There were no significant different about ratios of right lower trapezius/upper trapezius and opposite serratus anterior/upper trapezius during the SPT exercise on four different surfaces (p > 0.05; Table 2).

4. Discussion

When the weak lower trapezius or serratus anterior muscle leads to RSP, SPT exercise can be a common component of a rehabilitation program. The justification for this choice was based on the exercise's strong activation of the lower trapezius[17].

We investigated muscle activity in the lower trapezius during SPT exercise on four different surfaces. de Oliveira et al. (2008) reported that the EMG activity of the muscles investigated during workouts varies depending on the base of support used, that is, whether on a stable or unstable platform[15]. We believe ours is the first study to assess the activity of the lower trapezius muscle during SPT exercise on four different surfaces. In this study, besides the right lower trapezius, we also investigate the EMG activities of the right upper trapezius, opposite upper trapezius, and serratus anterior muscles, as well as the muscle activity ratios between each side.

Our results showed that the EMG activities of the serratus anterior and lower trapezius muscles increased significantly more during SPT exercise on the upper body unstable surface and whole body unstable surface than on the other two surfaces (p<0.05). Changes in the serratus anterior muscle may be attributed to a shift in the gravitational field, when the right upper limb is lifted, the gravity will shift to the opposite side, and the contralateral upper body will generate a greater push power, leading to greater serratus anterior muscle activity. Park et al. (2011) supported that the serratus anterior muscle showed greater muscle activity for stabilizing the scapular position on an unstable surface than on a stable surface[16], while other studies indicated that performing push-up exercise on a shaky surface requires greater effort for shoulder and trunk stabilization; especially, serratus anterior muscle activity was highest in the unstable conditions[13, 18]. One previous study reported that the demands of an unstable surface enhance trunk muscular activation to maintain postural stability during a specific exercise or to perform the task in a controlled manner[19]. In addition, Atkins et al. indicated that doing a prone plank while utilizing the unstable suspension training approach resulted in the highest peak muscle activation of the trunk, and it may be that the upper body supported on an unstable base should be prioritized when the goal is to increase the exercise challenge by emphasizing the core trunk muscles[13, 20]. Conscious trunk muscular activation enhances the engagement of the agonist, one of the most critical muscles in sustaining scapular motor function[21]. In therapeutic settings, an unstable surface is frequently employed to promote proximal muscle activity by demanding control of the center of mass and engaging the proprioceptive joint receptors. In our study, lower trapezius muscle activity significantly increased when we performed SPT exercise on an upper body unstable surface. In this condition, the trunk and shoulder muscles must maintain balance and postural stability[16]. Then, the shoulder muscles, including the lower trapezius muscle, is co-activated to regulate the arm-lifting posture of the limb or to accomplish a job precisely[22]. We also found similar research by Jiang and Kim (2015), who focused on whether the trunk is fixed and determined that lower trapezius muscle activity was greater when performing isometric shoulder abduction with no external support than with pelvic and thoracic supports[10]. This shows that the muscle activity of the upper limb increases when the trunk is not fixed, supporting our research.

Table 2. Comparison of LT/UT and SAO/UTO between four different surfaces N = 20

	A (M±SD)	B (M±SD)	C (M±SD)	D (M±SD)	F	p
LT/UT	2.18±0.65	2.42±0.73	2.24±0.69	2.41±0.78	0.578	.631
SAO/UTO	1.29±0.33	1.42±0.32	1.31±0.37	1.43±0.39	0.934	.428

* *p*< .05

Mean±SD: Mean±Standard Deviation

A: stable surface; B: upper body unstable surface; C: lower body unstable surface; D: whole body unstable surface.

LT: lower trapezius; UT: upper trapezius; SAO: serratus anterior of opposite; UTO: upper trapezius of opposite

In the current study, we found no significant difference in the lower trapezius and serratus anterior muscles during SPT exercise on a lower body unstable surface. The explanation for this result may be the shift in weight when performing SPT exercise, which involves supporting the left upper limb and raising the right upper limb, causing the center of gravity to move left and right, not back and forth. Thus, the stability of the lower limb support surface cannot affect the arm-lifting muscles, it appears the instability affects the upper more than the lower body in our research[23].

In addition, this study also compared the bilateral upper trapezius muscles and the ratios of two pairs of muscles on both sides, and the result for the four different surfaces revealed no significant differences (p>0.05). In this study, the bilateral upper trapezius showed slight EMG activities because it was not to required to provide a big part. We originally wanted to improve the RSP by selecting the most effective surface for SPT exercise using the difference in ratios. The ratios on both sides showed no significant difference, which could be interpreted using the relatively consistent changes in each muscle, as they function as scapular and glenohumeral stabilizers, respectively[24]. Trunk stabilization is an important component of force production and proximal stability in shoulder and scapular motions during limb movement[25], so we designed different unstable surfaces using aircushion balance balls to select the surface that is most effective in activating the target muscle and thus improving the RSP.

Our study has several limitations. Firstly, all the subjects we recruited were college students; in future studies, we need to choose subjects of various ages. Secondly, during SPT exercise, all subjects raised their arms to the edge of their ears as a reference standard, but there may be individual differences in this practice. Thirdly, in addition to EMG, investigations should include a motion analysis to identify correspondence in scapular tilt angle for each patient.

5. Conclusions

The current investigation assessed EMG activities in the right upper and lower trapezius muscles, as well as in the opposite serratus anterior and upper trapezius muscles during SPT exercise on four different surfaces. Lower trapezius and serratus anterior muscle activities were considerably elevated after SPT exercise on an upper body unstable surface and a whole body unstable surface. This result suggests SPT exercise performed on an unstable surface, especially under conditions of instability in the upper body, will be more beneficial to increase lower trapezius muscle activity in patients with an RSP.

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