

THE EFFECTS OF DIFFERENT DEGREES OF UNSTABLE SURFACES ON TRAPEZIUS MUSCLE ACTIVITY IN SUBJECTS WITH ROUNDED SHOULDER POSTURE DURING STRENGTH EXERCISES

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Abstract

Lower trapezius muscle weakness can cause round shoulder posture (RSP). Understanding the use of instability devices is beneficial to the enhancement of muscle activity. Thus, this study determined whether varying degrees of instability have different effects on muscle activity. Using surface electromyography (EMG) on 23 subjects with RSP, muscle activities of the upper, middle, and lower trapezius were recorded during three strengthening exercises on four different degrees of unstable surfaces. The ratios of the middle and lower trapezius muscle activities to the upper trapezius muscle activity were compared. Significant differences were found between the four surfaces and between the three exercises in all muscles and ratios ($p < .05$). In comparing the surfaces, muscle activities were found to increase with higher instability in each exercise situation ($p < .008$), and the two ratios decreased with higher instability only during the modified prone cobra exercise ($p < .008$). In comparing the exercises regardless of the surface, the upper trapezius muscle activity was significantly higher in the prone V-raise exercise ($p < .017$), and the middle trapezius muscle activity was significantly higher in the prone L-raise exercise ($p < .017$), the lower trapezius muscle activity was significantly lower in the modified prone cobra exercise ($p < .017$), and the two ratios were significantly higher in the prone L-raise and modified prone cobra exercises ($p < .017$). The results suggest that the prone L-raise exercise performed on a Swiss ball or a balance cone and the modified prone cobra exercise performed on a foam pad or a BOSU ball can more effectively enhance the EMG activity of the lower trapezius muscle and alleviate the imbalance between the three parts of the trapezius muscle to improve RSP.

Keywords: lower trapezius, instability, round shoulder posture, exercise.

Introduction

Musculoskeletal abnormalities and discomfort are becoming more common in modern culture as a result of repeated employment and poor work posture [1]. If poor posture is maintained over an extended length of time, it may lead to changes in the cervical bone curvature and poor muscular balance [2], such as upper-crossed syndrome, forward head posture, round shoulders, and slouched posture. Round shoulder posture (RSP) is a prevalent bending posture and appears to be one of the shoulder complex's most common anatomical defects[3,

4]. RSP is related to altered scapular posture, kinematics, and muscular activity in which the scapulae are raised, and the acromion protrudes forward in relation to the body's center of gravity[5]. The angle between the lower neck bone and the upper back bone is increased, as are the scapulae's protraction, upward rotation, and anterior tilt[2]. These modifications induce an imbalance in the surrounding muscles, particularly the three components of the trapezius. Therefore, RSP is associated with pain in the head, temporomandibular joints, neck, back, shoulders, and arms[6, 7].

Many previous experiments have studied effective methods for correcting RSP, such as the McKenzie exercise, self-stretch exercise, Kendall exercise, shoulder external rotation, latissimus pull-down, prone raise, and modified prone cobra[8]. The restoration of muscle control, specifically balanced coactivation, is a challenge for physiotherapists. The selection of effective exercises for RSP rehabilitation is dependent not only on muscle strength but also on the relative strength of one muscle with respect to another [9]. To reduce the imbalance in the three components of the trapezius muscle, selective stimulation of the weaker muscle portions with limited activity in the hyperactive muscles is crucial. Because a lack of electromyographic (EMG) activity in the middle and lower trapezius is frequently combined with excessive use of the upper trapezius, it is particularly important to balance the ratios of the middle and lower trapezius EMG activities to the upper trapezius EMG activity [10]. Based on this, the present study used three strengthening exercises: prone V-raise, prone L-raise, and modified prone cobra.

In rehabilitation, instability devices are considered advantageous because they may elicit equal degrees of muscular activation while utilizing less external resistance [11, 12]. According to some research, an unstable surface may increase core musculature activity and shoulder muscular demand to maintain postural stability [13-17]. Furthermore, dual instability causes more muscle activation than single instability or a steady condition [18]. To the best of our knowledge, no study has examined the different types of instability devices used in exercises to improve RPS. This study aimed to investigate the effect of four different levels of an unstable surface (i.e., foam pad, BOSU ball, Swiss ball, and balance cone) on the three components of trapezius muscle activity and the ratios of the middle and lower trapezius EMG activities to the upper trapezius EMG activity during three types of muscle strengthening exercises (prone V-raise, prone L-raise, and modified prone cobra).

Method

1. Participants

This study consisted of 23 subjects (10 men and 13 women) with RSP attending Daegu University in Gyeongsan, South Korea. The average age of the subjects was 24.83 ± 2.37 years, the average height was 169.04 ± 8.14 cm, the average weight was 65.20 ± 12.52 kg, and the average RSP distance was 7.25 ± 1.15 cm. The upper, middle, and lower trapezius muscle activities of all participants were determined during three types of strengthening exercises on four levels of unstable surfaces, respectively. The patients were informed of the details of the study before participation, and the volunteer subjects gave their written consent to participate prior to study enrollment. The procedures were performed in accordance with the Helsinki Declaration. The subjects diagnosed with RSP were chosen for this study based on a distance of ≥ 2.5 cm from the table to the posterior portion of the acromion in the supine position [19]. The exclusion criteria were subjects with shoulder and neck injuries, a history of spinal surgery, heart disease, and neurological symptoms.

2. Procedures

A total of 23 subjects with RSP were selected for the study. The subjects performed prone V-raise, prone L-raise, and modified prone cobra exercises on four levels of unstable surfaces: foam pad, BOSU ball, Swiss ball, and balance cone. The right arm was reported as the dominant arm by all respondents. The three components of the

right trapezius muscle activities during the three exercises were collected using a wireless EMG system. Each subject repeated each exercise on each surface three times, that is, $3 \times 4 \times 3$ times per person.

3. Assessment

An EMG system (Telemyo DTS, Noraxon Inc., USA) was used to measure the signals from the trapezius muscle during data collection. At the beginning of the experiment, to normalize EMG data, the subjects performed maximal voluntary isometric contractions (MVIC) of the upper, middle, and lower trapezius muscle against manual resistance using previously documented procedures.

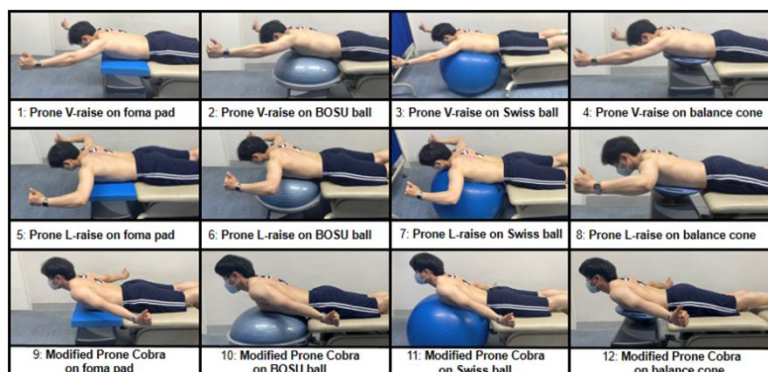
The following movements were performed for each part of the trapezius muscle. Upper trapezius: With the subject sitting in an erect position with no back support, the scapula was lifted, and the neck was bent to the side on the same side, rotated to the other side, and then stretched, while resistance was given at the head and above the elbow. Middle trapezius: With the participant in the prone position, resistance was applied to the horizontal abduction of the arm in external glenohumeral rotation. Lower trapezius: With the subject in the prone position, the arm was lifted above the head in line with the lower trapezius muscle fibers, as resistance was provided above the elbow [20]. A 2-min interval was allowed between each contraction to minimize muscle fatigue. To produce the MVIC, the root mean square (RMS) values were obtained for the 3 s in the middle, excluding the 1 s at the beginning and end of the five measurements obtained for the RMS value, and the mean MVIC value of the three trials was calculated. All EMG data were normalized as a percentage of the subject's MVIC (%MVIC).

4. Intervention

The muscle strengthening exercises were performed on different levels of unstable surfaces using four devices: foam pad, BOSU ball, Swiss ball, and balance cone.

Based on previous studies, we performed three types of postures conducive to the activation of the lower trapezius muscle [21]. Prone V-raise: The individual lay prone on a table with shoulder flexed to 180° , abducted to 120° , and elbow extended, arms elevated off the table to ear level, and thumbs pointing up toward the ceiling. Prone L-raise: The individual lay prone on a table, arms elevated out to the sides, shoulder external rotation at 90° of abduction, elbow flexed 90° , and thumbs pointed toward the ceiling. Modified prone cobra: The individual lay prone on a table, arms by their sides, fingers pointing to their toes, and thumbs pointing toward the ceiling. They proceeded to perform trunk extension, tightening the scapula, back, and bottom to elevate their chest roughly 10 cm off the table (Fig. 1).

Fig. 1 Three strengthening exercises on four unstable surfaces



5、 Statistical Analysis

The data are indicated as means \pm standard deviations. To assess the differences in muscle activity and the two ratios during strengthening exercises performed on different unstable surfaces, a two-way analysis of variance (ANOVA) with repeated measures was used, which is an advanced analysis to evaluate potential interaction effects.

When differences were detected, a repeated measures one-way ANOVA with Bonferroni post hoc corrections was applied to determine the differences between the exercises (.05/6 = .008) and surfaces (.05/3 = .017). Statistical analysis was conducted using SPSS for Windows (version 26.0), and the statistical significance level was set to $p < 0.05$.

Results

1、 Synthesis

According to the statistics from the two-way ANOVA with repeated measure, significant differences were found between the four surfaces and between the three exercises in all muscles and ratios ($p < .05$). The upper trapezius, lower trapezius, and the ratio of the lower trapezius to the upper trapezius had interactive effects between surface and exercise ($p < .05$) (Table 1).

Table 1. Comparison of muscle activities and ratios during three exercises on four surfaces

N = 23 (Unit : %MVIC)

		Prone V-raise	Prone L-raise	Modified prone cobra	F(p)		
					surface	exercise	surface × exercise
UT	FP	42.43 \pm 5.57	27.59 \pm 4.09	13.87 \pm 3.82	44.635	1125.487	4.016
	BB	43.19 \pm 4.50	28.76 \pm 4.56	15.54 \pm 3.01	(.000) *	(.000) *	(.001) *
	SB	51.34 \pm 5.58	31.17 \pm 5.73	17.24 \pm 2.06			
	BC	52.76 \pm 6.28	35.28 \pm 3.11	18.93 \pm 2.65			
MT	FP	40.43 \pm 8.34	51.12 \pm 6.31	23.95 \pm 3.85	14.713	581.253	.977
	BB	39.43 \pm 9.52	51.60 \pm 3.37	24.80 \pm 3.96	(.000) *	(.000) *	(.441)
	SB	44.38 \pm 6.14	56.09 \pm 3.66	26.31 \pm 3.94			
	BC	44.13 \pm 5.95	58.77 \pm 5.47	28.28 \pm 4.00			
LT	FP	59.92 \pm 6.11	63.45 \pm 8.56	30.32 \pm 4.93	43.030	1079.714	9.907
	BB	66.52 \pm 6.89	63.22 \pm 4.72	32.82 \pm 4.45	(.000) *	(.000) *	(.000) *
	SB	76.66 \pm 6.59	67.98 \pm 6.78	33.16 \pm 5.10			
	BC	79.53 \pm 6.50	71.31 \pm 6.53	34.59 \pm 4.22			
MT/ BB	FP	0.98 \pm 0.29	1.88 \pm 0.31	1.80 \pm 0.34	6.573	264.432	.947
	BB	0.93 \pm 0.27	1.85 \pm 0.39	1.63 \pm 0.33			
	SB	0.87 \pm 0.12	1.86 \pm 0.37	1.54 \pm 0.22			

UT	BC	0.85 ± 0.16	1.68 ± 0.24	1.51 ± 0.22	(.000) *	(.000) *	(.462)
LT	FP	1.43 ± 0.21	2.32 ± 0.23	2.28 ± 0.45	7.578	149.315	4.138
/	BB	1.56 ± 0.23	2.26 ± 0.46	2.16 ± 0.32			
/	SB	1.51 ± 0.16	2.24 ± 0.39	1.92 ± 0.19	(.000) *	(.000) *	(.001) *
UT	BC	1.52 ± 0.18	2.03 ± 0.22	1.85 ± 0.24			

*p<.05

M±SD: Mean ± Standard Deviation

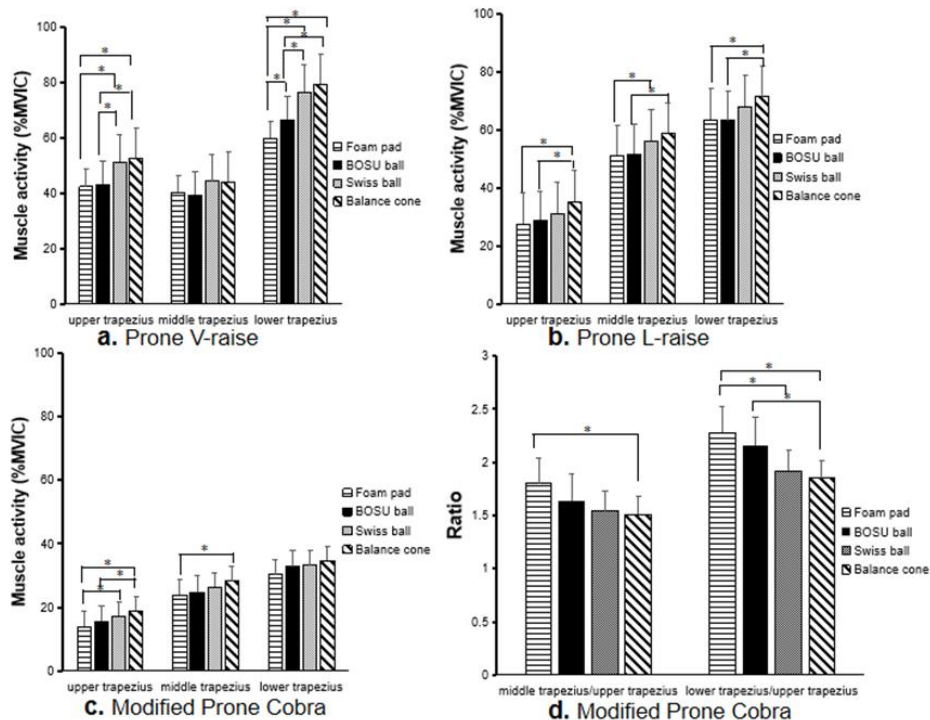
UT: upper trapezius; MT: middle trapezius; LT: lower trapezius

FP: foam pad; BB: BOSU ball; SB: Swiss ball; BC: balance cone

2、Exercise

The upper and lower trapezius muscle activities were significantly higher on the balance cone and Swiss ball during the prone V-raise exercise ($p < .008$; Fig. 3a). All three muscle activities were significantly higher on the balance cone during the prone L-raise exercise ($p < .008$; Fig. 3b). There was a significantly higher activation of the upper and middle trapezius on the balance cone during the modified prone cobra exercise ($p < .008$; Fig. 3c). The two ratios were significantly higher on the foam pad during the modified prone cobra exercise only ($p < .008$; Fig. 3d).

Fig. 3 Comparison of muscle activities and ratios between the four surfaces in each exercise



3、Surface

A significantly higher activation of the upper trapezius was found during the prone V-raise exercise, and the middle trapezius muscle activity was significantly higher during the prone L-raise exercise ($p < .017$; Fig. 4). The lower trapezius muscle activity was significantly greater during the prone V-raise and prone L-raise exercises than during the modified prone cobra exercise ($p < .017$; Fig. 4). The two ratios were significantly higher during the prone L-raise and modified prone cobra exercises than during the prone V-raise exercise ($p < .017$; Fig. 5).

Fig. 4 Comparison of muscle activities between the three exercises on each surface

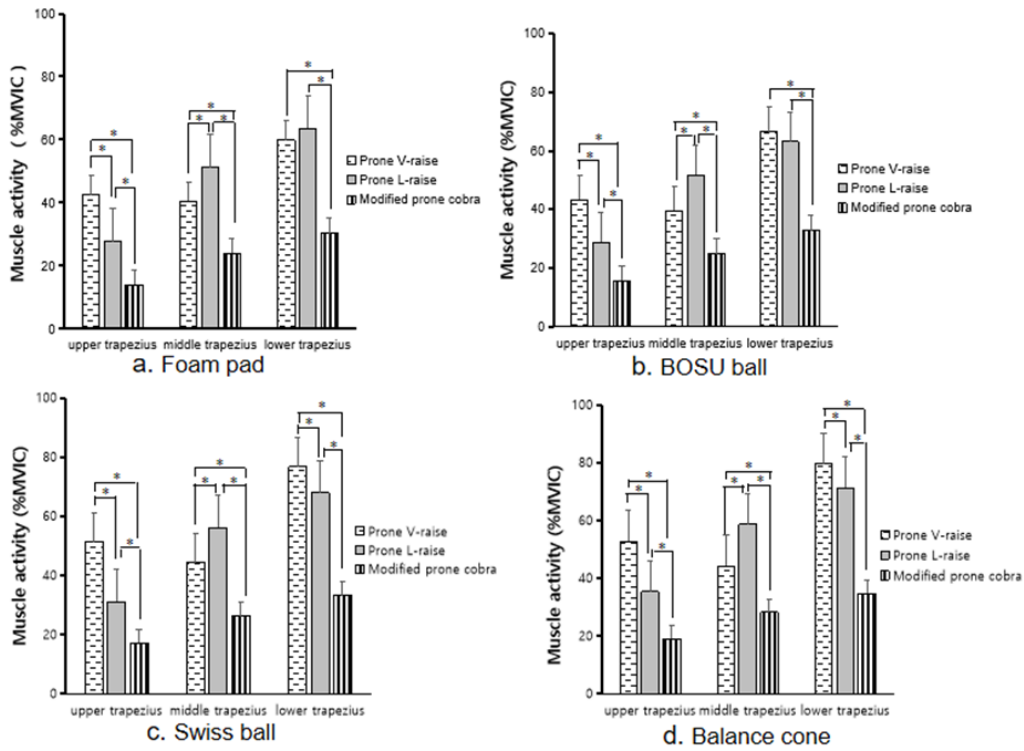
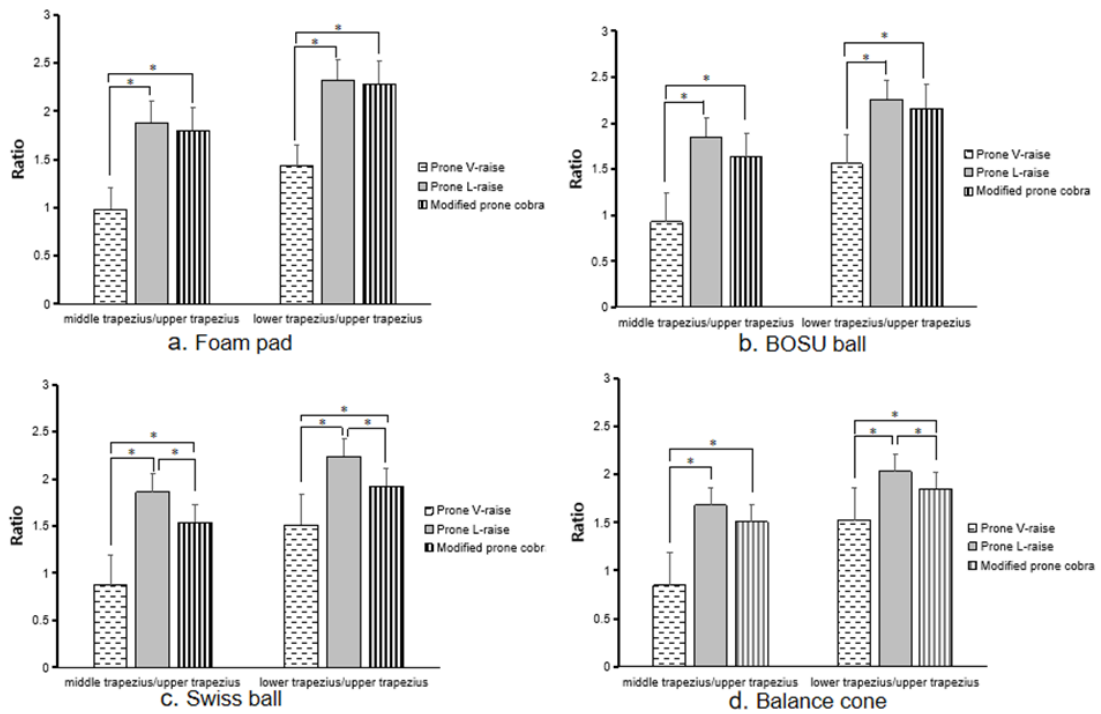


Fig. 5 Comparison of ratios between three exercises on each surface



Discussion

In rehabilitation, instability devices have been considered useful as training tools [12]. Owing to the current popularity of "functional training," aspects of instability have been included in traditional workouts [22, 23]. To the best of our knowledge, this is the first study comparing the EMG muscle activation of the upper, middle, and lower trapezius and the ratios of the middle and lower trapezius EMG activities to the upper trapezius EMG activity in different levels of instability devices (foam pad, BOSU ball, Swiss ball, and balance cone) in three muscle strengthening exercise positions.

In the current study, with an increase in instability levels, the EMG muscle activation of the three parts of the trapezius muscle also increased overall. Jeff et al. (2007) suggested that exercising in an increasingly unstable setting could be an effective way to activate the core stabilizing muscle [24] and could favorably affect the distal extremities, implying a positive relationship between instability and muscle activation [25]. The level of instability is determined by elements such as the nature of the work, the qualities of the subject, and the various properties of the instrument [26]. We established the degree of instability properties of the devices used (balance cone > Swiss ball > BOSU ball > foam pad), and it concurred with the Seaterbakken and Fimland criterion for determining the extent of instability (unstable dimensions and magnitude of contact) [27]. Several studies have found that unstable surfaces enhance not just trunk musculature activation but also limb muscle activation and co-contractions due to a continuous muscular response necessary to tolerate the postural perturbations caused by unstable support [28-30]. In previous studies, subjects reported exerting more effort when performing on an unsteady surface because the increased instability placed a larger strain on the neuromuscular system [30, 31]. Greater neuromuscular demand, as measured by EMG activity in the agonist muscles in our study, is considered related to increased perceived effort in unstable surface exercises.

The modified prone cobra exercise has not been identified as a lower trapezius exercise in the literature, and prone V-raise is not considered an exercise in which middle trapezius activity clearly dominates [21]. This seems to explain that there were no significant differences in the middle and lower trapezius muscle activities between the four different surfaces during the two exercises ($p > .008$). Additionally, the upper trapezius muscle activity increased with higher instability, while the lower trapezius muscle activity did not differ significantly when the subjects performed the modified prone cobra exercise. Behm et al. (2002) found that the risk of imbalance increased when the center of gravity was away from an unstable surface, and that the reduction of muscle activity amplification at this time could be attributed to distraction (neural drive) [32]. In this way, the ratios of the middle and lower trapezius EMG activities to the upper trapezius EMG activity decreased with higher instability ($p < .008$).

Ronald et al. (2016) reported that with more freely moving instability devices, the surrounding musculature could be subjected to greater muscular demands, resulting in increased muscle activity [33]. However, certain discrepancies emerged, possibly indicating that utilizing instability devices in one direction allows for greater activation of the paraspinal musculature compared to using instability devices in other directions [25]. Although the majority of studies have indicated that the more unstable the support surface, the better, many studies on healthy participants have shown that not all workouts are superior and that some only enhance certain muscle areas. An increased risk of injury was also identified when performing strength training in extremely unstable situations, which could be attributed to balance deficits [34, 35].

In the current study, compared to the other two exercises, the prone V-raise exercise caused a comparatively high amount of upper trapezius muscle recruitment ($p < .017$) because the participants used their upper trapezius muscle to extend their heads during the activity. Although the subjects were advised to maintain a neutral spine, the platform on which the exercises were performed did not provide enough head/neck support, and thus the participants might have been compelled to hold their heads against gravity during the exercise [21]. During the prone L-raise exercise, the middle trapezius showed a significantly higher muscle activity than the other two exercises ($p < .017$) because when the shoulder joint was horizontally abducted with external rotation, the middle trapezius muscle produced the greatest amount of mean EMG activity [20]. Ekstrom et al. (2003) found that the middle trapezius muscle was a scapular stabilizer and adductor [36], thus assisting in keeping the scapula in its

plane of motion during the prone L-raise exercise. In this study, for the three types of muscle strengthening exercises, the lower trapezius did not show high activity in the modified prone cobra exercise. Owing to the decreased engagement of the upper trapezius muscle during the modified prone cobra, it has been considered the exercise of choice for persons who want to preferentially strengthen the middle and lower trapezius muscles over the upper trapezius muscles [21]. As proof, our results showed that the prone L-raise and modified prone cobra exercises produced higher ratios of the middle trapezius/upper trapezius to the lower trapezius/upper trapezius than the prone V-raise exercise ($p < .017$). Therefore, prone L-raise and modified prone cobra exercises could be beneficial in targeting and isolating lower trapezius muscle strengthening.

This study has several limitations. First, as the data were collected from a sample of young individuals, caution should be exercised when extending the results to different age groupings. Second, we were unable to identify the long-term usage of these surfaces during rehabilitation treatment, as our investigation was a cross-sectional study investigating the acute effect of utilizing unstable surfaces. Third, this study used several unstable gadgets. Although commercial devices were available, the current study was confined to four devices that provide varying degrees of stability and are routinely utilized in fitness and rehabilitation settings.

Conclusion

The findings of this study revealed that with a greater degree of instability devices (e.g., Swiss ball and balance cone), surrounding musculature (e.g., upper, middle, and lower trapezius muscle) could require additional muscular demands, resulting in increased EMG activities. It should also be treated differently according to the difficulty of the exercises and whether the subjects have experienced special training.

The degree of activation of the lower trapezius muscle and the balance of the three components of the trapezius must be considered. To enhance the ratio of the middle and lower trapezius muscle activities to the upper trapezius muscle activity, decrease muscular imbalance, and improve RSP, we recommend the prone L-raise exercise performed on a Swiss ball or a balance cone and the modified prone cobra exercise performed on a foam pad or a BOSU ball.

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