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Arm Lifting Exercises for Lower Trapezius Muscle Activation

Background: Lower trapezius muscle function is important for the prevention and treatment of shoulder injuries. However, scapular posterior tilt movement has been overlooked in lower trapezius strengthening exercise programs.
Objective: To examine the effects of prone arm lifting with scapular posterior tilt (PALSPT) on trapezius muscles.
Design: Crossover study
Methods: 17 healthy males were recruited for participation in this study. Participants performed backward rocking diagonal arm lifting (BRDAL) and PALSPT. To train participants in scapular posterior tilt movements for PALSPT, visual biofeedback of scapular movements was provided using a motion sensor. Electromyography (EMG) activities of the middle and lower trapezius were recorded using a surface EMG system. Differences in middle and lower trapezius muscle activity between BRDAL and PALSPT exercises were analyzed.
Results: Lower trapezius muscle activity was significantly greater during PALSPT than during BRDAL (p=.006). Although greater EMG activity was observed in the middle trapezius during PALSPT than during BRDAL, this difference was not significant (p=.055).
Conclusions: The results of the present study indicate that scapular posterior tilt movements must be considered in lower trapezius muscle strengthening programs.

Key words: *Electromyography; Exercise; Lower trapezius*

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INTRODUCTION

Scapular upward rotation is essential for movement of the shoulder complex.[1] During arm elevation, movement of the glenohumeral joint and scapular upward rotation occur at a 2:1 ratio (i.e., scapulohumeral rhythm), producing normal shoulder abduction/flexion movement.[1-3] However, if scapular upward rotation is not accompanied by glenohumeral joint movement during arm elevation, then scapulohumeral rhythm is broken and the subacromial space narrows, resulting in subacromial impingement.[4,5] Thus, scapular upward rotators play important roles in normal shoulder complex functions.

Scapular upward rotators include the upper trapezius, serratus anterior, and lower trapezius muscles.[1,2] In addition to scapular upward rotation, the lower trapezius contributes to scapular stability during shoulder movement in combination with the middle trapezius to produce normal scapular movement.[6] Therefore, to prevent shoulder injuries such as subacromial impingement, many shoulder exercises focus on strengthening the middle and lower trapezius for scapular upward rotation and scapular stability.[7-12]

Previous studies have indicated that prone arm lifting with 120-125° shoulder abduction is an effective lower trapezius strengthening exercise due to the parallel muscle fiber direction of the lower trapezius.[10,11] Ekstrom et al. demonstrated that prone arm lifting with 120° shoulder abduction was the most effective of nine shoulder exercises for both the middle and lower trapezius.[12] However, another study reported that backward rocking diagonal arm lifting (BRDAL) showed greater muscle activity in the lower trapezius than prone arm lifting, suggesting that flexed upper trunk position during BRDAL is a more challenging posture than the prone position during scapular posterior tilt induction, resulting in greater muscle activity in the lower trapezius during BRDAL.[13] Subsequently, many studies include modified versions of BRDAL as lower trapezius strengthening exercises.[14-17]

The lower trapezius acts as a scapular upward rotator and an agonist of scapular posterior tilt.[1] Scapular posterior tilt movement is important during arm elevation, because it minimizes the impingement of soft tissues, including rotator cuffs, between the humeral head and anterior acromion.[18] Considering that muscle contraction produces segment movements, scapular posterior tilt may increase muscle activation among agonists of scapular posterior tilt such as the lower trapezius. However, no study has examined the effects of prone arm lifting with scapular posterior tilt (PALSPT). Therefore, the objective of this study was to compare the effects of BRDAL, which has been reported to be effective for lower trapezius muscle activation, and PALSPT, on lower trapezius and middle trapezius activity measured by electromyography (EMG).

SUBJECTS AND METHODS

Subjects

In total, 17 healthy male subjects (age: 24.12 ± .99 years; height: 171.18 ± 5.40 cm; body weight: 70.76 ± 10.47 kg) without shoulder pain at the time of participation in this study were recruited. Exclusion criteria included history of tendinitis, adhesive capsulitis, or subacromial impingement. All subjects were recruited from September 17 to October 8, 2019 via advertisement on the message board at the local university in Korea. The study protocol was approved by a public institutional review board designated by the Ministry of Health and Welfare (P01-201908-11-004).

EMG Measurements

We measured EMG activity of the middle trapezius and lower trapezius on the dominant arm during exercises to compare the effects of BRDAL and PALSPT. A surface EMG system (TeleMyo Mini DTS; Noraxon, Inc., Scottsdale, AZ, USA) was used to record activity data at a sampling rate of 1500 Hz and bandwidth filter of 10-450 Hz. EMG electrodes were placed at the middle and lower trapezius landmarks suggested by De Mey et al.[19] All EMG data were normalized using maximal voluntary isometric contraction (MVIC) maneuvers.[2] MVIC trials were repeated twice for 5 s, and data recorded in the middle 3 s were used to calculate MVIC for each muscle. The mean value of two MVIC trials for each muscle was used as the MVIC value.

Scapular Movement Training

To train scapular posterior tilt movements, an examiner guided scapular posterior tilt movements using both hands.[20] After guiding scapular posterior tilt movements, the examiner attached a motion sensor (4D-MT; Relive Co., Korea) on the landmark between the root of the spine and the inferior angle of the scapulae.[21] The motion sensor, which included a gyroscope, then calculated the angle of sensor tilt in three dimensions.[22] Sensor tilt angle data were transferred to an Android tablet PC using 4D-MT analysis software (Relive Co.) in real time. The motion sensor was used to provide subjects with real-time visual biofeedback of scapular posterior tilt movement. To train subjects in scapular posterior tilt movement, subjects were asked to practice with the assistance of an examiner, and then performed the movement unaided while monitoring the scapular posterior tilt angle in real time using a tablet PC in a sitting position for 10 min (Fig. 1).

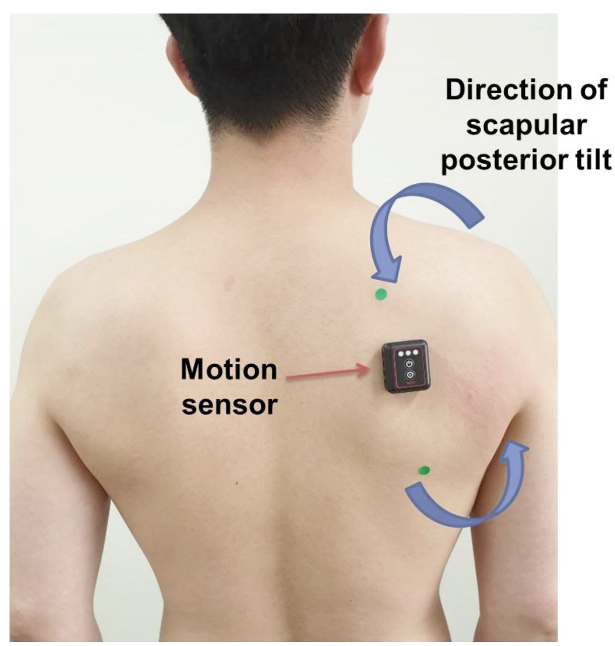

Fig. 1. Scapular posterior tilt.

Backward Rocking Diagonal Arm Lifting Exercise

Subjects assumed the quadruped position on a table and were asked to move the hip backward so that the buttocks contacted with the heels. Subjects flexed the trunk with neutral head and neck posture, while the forehead was supported on the dorsal side of the non-dominant hand on the table.[13] The dominant arm was placed with 125° of shoulder abduction, with shoulder external rotation and elbow extension. Subjects were asked to raise the dominant arm as high as possible without trunk rotation. Subjects maintained the end position for 5 s, and repeated BRDAL three times.

Prone Arm Lifting with Scapular Posterior Tilt Exercise

Subjects assumed the prone position, with 125° of shoulder abduction, shoulder external rotation, and elbow extension in the dominant arm side. Subjects were asked to perform active scapular posterior tilt to the greatest extent possible and then raised the dominant arm as high as possible without trunk rotation. An examiner monitored compensatory movements, including scapular adduction and/or depression without scapular posterior tilt, as well as trunk rotation. Subjects maintained the end position for 5 s, and repeated PALSPT three times.

Statistical Analyses

Mean EMG values for middle and lower trapezius activity in each exercise condition were calculated for data analysis. Data normality was determined using the Shapiro-Wilk test. To compare the effects of two exercises on middle and lower trapezius EMG activity, paired t-tests were performed, at a significance level of .05 using the PASW Statistics 18 software (SPSS Inc., Chicago, IL, USA).

RESULTS

The EMG data collected in this study satisfied the assumption of a normal distribution ($p > .05$). Lower trapezius EMG activity was significantly higher during PALSPT than during BRDAL ($p = .006$). Greater middle trapezius EMG activity was observed during PALSPT than during BRDAL; however, this difference was not significant ($p = .055$) (Table 1).

DISCUSSION

The objective of the present study was to compare the effects of BRDAL and PALSPT exercises on lower and middle trapezius muscle activity. The results showed significantly greater muscle activity in the lower trapezius but not middle trapezius during PALSPT than during BRDAL.

Scapular posterior tilt is a crucial movement facilitating lower trapezius muscle activation. A previous study examined the effects of various scapular posterior tilt exercises including scapular retraction with arm elevation in standing, prone arm lifting, and arm lifting with modified quadruped position, e.g., BRDAL, and recommended BRDAL exercises as inducing the greatest lower trapezius muscle activity.[13] Flexed thoracic position leads to scapular anterior tilt,[23] making scapular posterior tilt movement difficult. Therefore, it is possible that greater muscle activity is required in the lower trapezius to overcome a challenging posture for scapular posterior tilt during BRDAL. Similarly, greater EMG activity has been reported for the lower trapezius in the slouched position than in the upright position during 90° shoulder abduction in the scapular plane, probably as the result of increased scapular stabilizer muscle activation, including that of the lower trapezius, to overcome faulty alignment.[24] Based on these previous findings, BRDAL may be an effective exercise to facilitate lower trapezius muscle activation, including in the flexed thoracic position.

Despite its advantages, secondary musculoskeletal impairments can be induced during BRDAL due to excessive trunk flexion. Therefore, we examined the

Table 1. Middle and lower trapezius muscle activity during arm lifting exercises.

	Backward rocking diagonal arm lifting (BRDAL)	Prone arm lifting with scapular posterior tilt (PALSPT)	p
Middle trapezius (% MVIC)	53.15 ± 13.35	60.26 ± 19.09	.055
Lower trapezius (% MVIC)	58.20 ± 19.09	69.89 ± 19.53	.006*

*$p < .05$.
MVIC: maximal voluntary isometric contraction.

effects of a new exercise incorporating scapular posterior tilt, and found that PALSPT induced greater activity in the lower trapezius than BRDAL (p=.006). During intended functional action of a specific muscle, its activation is increased due to firing of the muscle fibers. Previous studies have shown that increased thickness of the transverse abdominis during abdominal hollowing increased its functional action.[25,26] Therefore, scapular posterior tilt, which is the functional action of the lower trapezius, is thought to facilitate lower trapezius muscle activation, resulting in increased activity of the lower trapezius during PALSPT. Because PALSPT is performed in the neutral trunk position and induces greater activity of the lower trapezius than BRDAL, this exercise may be a useful and safe alternative exercise to BRDAL.

In the present study, muscle activity was greater in the middle trapezius (about 7% MVIC) during PALSPT than during BRDAL, although this difference was not significant. The lower trapezius is active during scapular posterior tilt as well as scapular adduction,[1] which is the primary function of the middle trapezius.[1,2] Thus, increased lower trapezius activity may lead to scapular adduction as well as scapular posterior tilt, inducing greater EMG activity in the middle trapezius. Our findings may also be explained by the use of the flexed thoracic position during BRDAL, which lengthens back muscles, including the erector spinae, rhomboids, and middle trapezius.[27] theoretically, lengthening specific muscles decreases their force due to the length-tension relationship.[1] Therefore, the use of the flexed thoracic position during BRDAL may have interfered with proper middle trapezius contraction.

In this study, we recruited only healthy male subjects. Future studies should aim to recruit female subjects and subjects with lower trapezius weakness. This study compared only BRDAL to PALSPT; future studies should include a range of exercises to clarify the effects of PALSPT on lower trapezius activity. Lastly, because only trapezius muscle activity was measured, EMG activity of other muscles, including agonist and antagonist muscles needs to be examined during BRDAL and PALSPT.

CONCLUSION

The results of this study demonstrate that a combination of scapular posterior tilt movements and prone arm lifting leads to greater activity of the lower trapezius than BRDAL exercise, as measured by EMG. Therefore, clinicians must consider scapular posterior tilt movement to facilitate lower trapezius activation.

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REFERENCES

1. Neumann DA. Kinesiology of the Musculoskeletal System: Foundations for Rehabilitation. 3rd ed. St Louis: Elsevier; 2017.
2. Hislop HJ, Avers D, Brown M. Daniels and Worthingham's Muscle Testing: Techniques of Manual Examination and Performance Testing. 9th ed. St. Louis: Elsevier; 2013.
3. Magee DJ. Orthopedic Physical Assessment, 6th ed. St Louis: Elsevier; 2014.
4. Struyf F, Cagnie B, Cools A, et al. Scapulothoracic muscle activity and recruitment timing in patients with shoulder impingement symptoms and glenohumeral instability. J Electromyogr Kinesiol. 2014;24(2):277–84.
5. Michener LA, McClure PW, Karduna AR. Anatomical and biomechanical mechanisms of subacromial impingement syndrome. Clin Biomech (Bristol, Avon). 2003;18(5):369–79.
6. Johnson G, Bogduk N, Nowitzke A, et al. Anatomy and actions of the trapezius muscle. Clin Biomech (Bristol, Avon). 1994;9(1):44–50.
7. Castelein B, Cagnie B, Parlevliet T, et al. Superficial and deep scapulothoracic muscle electromyographic activity during elevation exercises in the scapular plane. J Orthop Sports Phys Ther. 2016;46(3):184–93.
8. Alizadehkhaiyat O, Hawkes DH, Kemp GJ, et al. Electromyographic analysis of the shoulder girdle musculature during external rotation exercises. Orthop J Sports Med. 2015;3(11):2325967115613988.
9. Chopp-Hurley JN, Prophet C, Thistle B, et al. Scapular muscle activity during static yoga postures. J Orthop Sports Phys Ther. 2018;48(6):504–9.

10. Ekstrom RA, Soderberg GL, Donatelli RA. Normalization procedures using maximum voluntary isometric contractions for the serratus anterior and trapezius muscles during surface EMG analysis. J Electromyogr Kinesiol. 2005;15(4):418-28.
11. Kinney E, Wusthoff J, Zyck A, et al. Activation of the trapezius muscle during varied forms of Kendall exercises. Phys Ther Sport. 2008;9(1):3-8.
12. Ekstrom RA, Donatelli RA, Soderberg GL. Surface electromyographic analysis of exercises for the trapezius and serratus anterior muscles. J Orthop Sports Phys Ther. 2003;33(5):247-58.
13. Ha SM, Kwon OY, Cynn HS, et al. Comparison of electromyographic activity of the lower trapezius and serratus anterior muscle in different arm-lifting scapular posterior tilt exercises. Phys Ther Sport. 2012;13(4):227-32.
14. Choi SA, Cynn HS, Shin AR, et al. Effects of verbal cue for scapular depression during scapular posterior tilt exercise on scapular muscle activities and clavicular tilt angle in subjects with rounded shoulder posture and upper trapezius myofascial pain. Phys Ther Korea. 2017;24(3):30-9.
15. Ko CH, Cynn HS, Lee JH, et al. Figure-8 strap application: immediate alteration of pectoralis minor length and scapular alignment during arm-lifting exercise in participants with forward shoulder posture. J Sport Rehabil. 2016;25(3):273-9.
16. Lee JH, Cynn HS, Yoon TL, et al. Comparison of scapular posterior tilting exercise alone and scapular posterior tilting exercise after pectoralis minor stretching on scapular alignment and scapular upward rotators activity in subjects with short pectoralis minor. Phys Ther Sport. 2015;16(3):255-61.
17. Lee JH, Cynn HS, Yoon TL, et al. The effect of scapular posterior tilt exercise, pectoralis minor stretching, and shoulder brace on scapular alignment and muscles activity in subjects with round-shoulder posture. J Electromyogr Kinesiol. 2015;25(1):107-14.
18. Escamilla RF, Yamashiro K, Paulos L, et al. Shoulder muscle activity and function in common shoulder rehabilitation exercises. Sports Med. 2009;39(8):663-85.
19. De Mey K, Danneels LA, Cagnie B, et al. Conscious correction of scapular orientation in overhead athletes performing selected shoulder rehabilitation exercises: the effect on trapezius muscle activation measured by surface electromyography. J Orthop Sports Phys Ther. 2013;43(1):3-10.
20. Kim SY, Weon JH, Jung DY, et al. Effect of the scapula-setting exercise on acromio-humeral distance and scapula muscle activity in patients with subacromial impingement syndrome. Phys Ther Sport. 2019;37:99-104.
21. Yu IY, Kang MH. Change in pelvic motion caused by visual biofeedback influences trunk and hip muscle activities during side-lying hip abduction in asymptomatic individuals. J Int Acad Phys Ther Res. 2019;10(3):1818-22.
22. Scibek JS, Carcia CR. Validation of a new method for assessing scapular anterior-posterior tilt. Int J Sports Phys Ther. 2014;9(5):644-56.
23. Kebaetse M, McClure P, Pratt NA. Thoracic position effect on shoulder range of motion, strength, and three-dimensional scapular kinematics. Arch Phys Med Rehabil. 1999;80(8):945-50.
24. Lee ST, Moon J, Lee SH, et al. Changes in activation of serratus anterior, trapezius and latissimus dorsi with slouched posture. Ann Rehabil Med. 2016;40(2):318-25.
25. Mew R. Comparison of changes in abdominal muscle thickness between standing and crook lying during active abdominal hollowing using ultrasound imaging. Man Ther. 2009;14(6):690-5.
26. Henry SM, Westervelt KC. The use of real-time ultrasound feedback in teaching abdominal hollowing exercises to healthy subjects. J Orthop Sports Phys Ther. 2005;35(6):338-45.
27. Sahrmann SA. Movement System Impairment Syndromes of the Extremities, Cervical, and Thoracic Spines. St Louis: Elsevier; 2011.