J Int Acad Phys Ther Res 2021; 12(2): 2308~2313
ISSN 2092-8475

www.iaptr.org
https://doi.org/10.20540/JIAPTR.2021.12.2.2308

Effects of the Additional Scapular Posterior Tilt Movement on Selective Muscle Activation of the Lower Trapezius during Prone Shoulder Extension

Background: Although the scapular posterior tilt movement could facilitate the lower trapezius (LT) muscle activity, no study identified the effects of the scapular posterior tilt movement on the selective activation of the LT muscle during prone shoulder extension.
Objectives: To examine the influences of additional scapular posterior tilt on electromyography (EMG) of the upper trapezius (UT) and the LT muscles during prone shoulder extension.
Design: Cross-sectional study.
Methods: There were 15 asymptomatic male participants in this study who performed prone shoulder extension with and without scapular posterior tilt movements. For the scapular posterior tilt movements, participants performed visual biofeedback training for scapular movement using motion sensor. During the exercises, the EMG activity of the UT and LT was recorded using surface EMG system.
Results: The EMG activity of the LT significantly increased during prone shoulder extension with scapular posterior tilt compared to that of general prone shoulder extension, whereas that of the UT was not significantly different between the two exercises. Moreover, scapular posterior tilt application significantly decreased UT/LT muscle activity ratio.
Conclusion: Scapular posterior tilt movement may be emphasized during exercise when facilitating LT muscle activation.

Keywords: *Electromyography; Lower trapezius; Scapular movement; Shoulder extension*

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Received : 14 April 2021
Revised : 21 May 2021
Accepted : 11 June 2021

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INTRODUCTION

Abnormal scapular movements is related to shoulder injuries.[1-3] Previous studies demonstrated increased scapular anterior tilt, an internal rotation together with scapular upward rotation during arm elevation, in patients with subacromial impingement syndrome (SIS).[1-3] These altered scapular movements occur with the abnormal electromyography (EMG) activity of the periscapular muscles, including decreased muscle activity of the lower trapezius (LT) and serratus anterior and increased muscle activity of the upper trapezius (UT).[1-5] Therefore, acquiring and/or maintaining an EMG activity balance of the periscapular muscles in the shoulder rehabilitation program is important.

Previous studies have suggested various exercises for EMG activity balance of the periscapular muscles.[6-13] A 120°-125° prone arm lifting at the shoulder abduction position effectively increases LT muscle activity because the shoulder position is parallel with the LT muscle fiber.[6,7] Arm lifting in the quadruped position facilitates LT muscle activity by counteracting scapular anterior tilt movement caused by the thoracic flexion position.[8,9] Shoulder external rotation in the side-lying position induces scapular retraction movement, facilitating LT muscle activity.[10,11] Prone shoulder extension increases UT/LT muscle activity ratio by minimizing UT activity during shoulder movement, which has been suggested as an exercise

for the selective activation of the LT muscle.[12,13] Being performed in the low shoulder abduction position, this exercise can be used in patients with SIS.

Recently, new strategy using scapular posterior tilt movement has been reported for increasing LT muscle activity.[14,15] Previous study showed that prone arm lifting with scapular posterior tilt leads to greater LT muscle activity compared to that of arm lifting in quadruped position.[14] Because scapular posterior tilt movement occurs with LT muscle activation,[16] it may be effective for increasing LT muscle activity.

Many studies revealed effective exercises, including prone arm lifting, arm lifting with quadruped position, prone shoulder extension, and exercise with scapular posterior tilt strategy, for increasing LT muscle activity.[6-15] However, it should be considered that the patients with SIS have difficulty in performing shoulder rehabilitation exercises in the shoulder abduction position due to shoulder pain.[17] It is important for patients with SIS to increase LT muscle activity, because increased LT muscle activity contributes to widening the space of the subacromial area through the scapular posterior tilt.[1-5] Therefore, an exercise to effectively increase LT muscle activity in the low shoulder abduction position needs to be developed. Considering the effects of the scapular posterior tilt movement on LT muscle activity, combining scapular posterior tilt movement with prone shoulder extension may positively affect the periscapular muscle balance, including increased LT muscle activity. However, before applying the newly developed exercise to patients with SIS, it should be demonstrated whether it can effectively increase the selective activation of the LT muscle in asymptomatic individuals to establish evidence for the effects of scapular posterior tilt strategy in adducted shoulder position on LT muscle activation. Thus, this study was performed to identify the effects of prone shoulder extension with scapular posterior tilt on the EMG activity of the UT and LT.

SUBJECTS AND METHODS

Subjects

Fifteen asymptomatic males, who has no shoulder pain, with mean age, height, and body weight of 21.67±2.32 years, 175.60±5.12 cm, and 82.27±17.54 kg, respectively, participated in this study. Those with history of adhesive capsulitis or shoulder impingement were excluded in this study.[14,15] All participants were recruited from a local university. The sample size was calculated based on large effect size with 0.8 of power. The participants gave written informed consent before participating in the study. The study's protocol was approved by the Pukyong National University Institutional Review Board (IRB No. 1041386-202003-HR-18-02).

Experimental Procedures

The participants performed prone shoulder extension to measure the baseline data. After recoding the data, participants performed scapular posterior tilt training for 10 min, and then took a rest for 5 min. After rest period, participants performed prone shoulder extension with scapular posterior tilt.

Outcome Measures

During prone shoulder extension with and without scapular posterior tilt, the EMG activity of the UT and LT was measured, using the Ultium EMG system (Noraxon Inc., Scottsdale, AZ, USA) to record the data. The EMG system collected raw EMG data with a 2000 Hz sampling rate and 10-450 Hz bandwidth. The collected EMG data was converted using the root mean square algorithm. According to previous studies, the EMG electrodes were attached to the dominant shoulder side.[14,15] The EMG electrodes were attached to the middle site between spinous process of C7 and acromion along with direction of UT muscle fiber for UT muscle,[14] while the EMG electrodes were placed on the site between spinous process of T7 and scapular spine along with direction of LT muscle fiber for LT muscle.[15]

Before recording the EMG data during prone shoulder extension with and without scapular posterior tilt, the maximal voluntary isometric contraction (MVIC) value was measured. For the UT, the participants performed shoulder elevation, cervical lateral flexion to the ipsilateral side, and cervical rotation to the contralateral side against an examiner's resistance.[18] For the LT muscle, the participants performed prone arm lifting at 120°-125° at shoulder abduction position against an examiner's resistance.[14,15,18] The mean value of the two MVIC trials, for the UT and LT muscles, respectively, were calculated, determining the MVIC values.

During isometric prone shoulder extension with and without scapular posterior tilt, the EMG activity of the UT and LT was measured, with measured values being normalized to the MVIC value in the present study.

Interventions

The scapular posterior tilt training protocol followed the previous study by Kang.[14] To provide a visual biofeedback of the scapular movement, a 4D-MT motion sensor (Relive Co., Gimhae, Korea) was attached to the midpoint between the inferior scapular angle and the root of the scapular spine. The information for motion sensor movement was sent to the tablet PC by an android application, enabling a real-time scapular movement monitoring.

An examiner demonstrated the correct scapular posterior tilt movement to the participants, in which the scapular should be moved to the posterior direction in a semicircle making no excessive scapular adduction and/or lateral rotation. The participants monitored whether scapular posterior tilt occurred through the tablet PC. The training was performed for 10 min.

Prone Shoulder Extension Exercises

For the prone shoulder extension exercise, the participants were in a prone position with both arms placed on the side next to the trunk. They were asked to externally rotate both shoulders and then extend them with maximal effort (Figure 1).[12,13]

Prone shoulder extension with scapular posterior tilt was performed after scapular posterior tilt movement training. The participants were in the prone position, externally rotating both shoulders next to the trunk like the general prone shoulder extension. Before extending both shoulders, they were asked to perform scapular posterior tilt and then instructed to perform both shoulder extensions while maintaining the intensity of the scapular posterior tilt.

Both prone shoulder extension with and without scapular posterior tilt exercises were performed three times, respectively, in this study.

Data and Statistical Analysis

The mean value of the EMG activity of the UT and LT during isometric prone shoulder extension exercises was calculated for data analysis. Shapiro-Wilk test was performed to determine normality of data. Only data of LT muscle activity satisfied normal distribution (P>.05). Therefore, the paired t-test was used to compare the EMG activity of LT, while Wilcoxon signed-rank tests were performed to compare the EMG activity of UT and UT/LT muscle activity ratio, between prone shoulder extension exercises with and without scapular posterior tilt. The α-value was .05. The IBM SPSS Statistics (ver. 25.0; IBM Corp., Armonk, USA) was used for statistical analysis.

RESULTS

The LT EMG activity was significantly increased during prone shoulder extension with scapular posterior tilt compared to that with prone shoulder extension without scapular posterior tilt (P=.017) (Table 1), whereas the UT EMG activity was not significantly changed between the two conditions (P=.281) (Table 1). The UT/LT muscle activity ratio was significantly decreased during prone shoulder extension when applying scapular posterior tilt (P=.018) (Table 1).

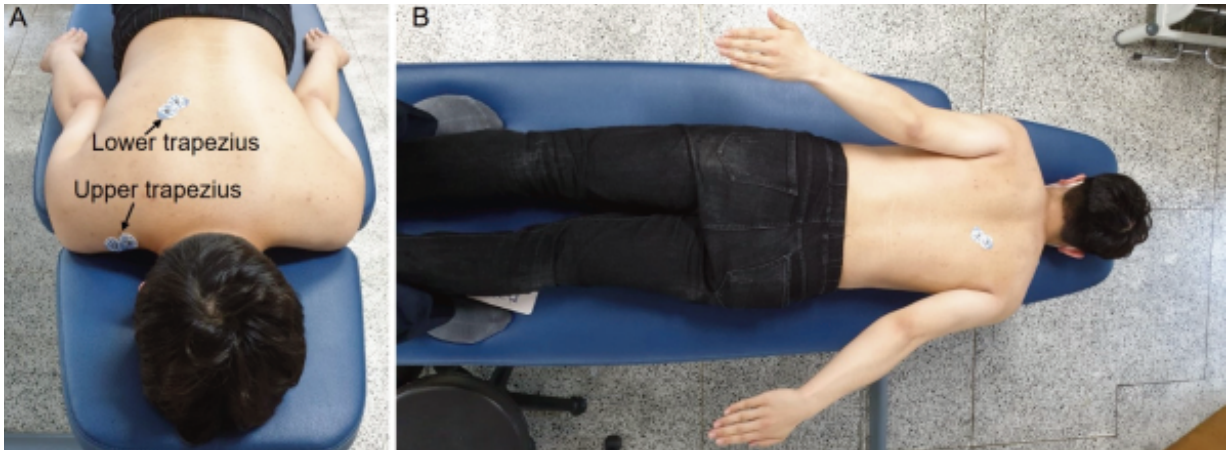

Figure 1. The placements of EMG electrodes (A) and prone shoulder extension exercise (B)

Table 1. The upper and lower trapezius muscle activities during exercises

	Prone shoulder extension	Prone shoulder extension with scapular posterior tilt	*P*
UT (% MVIC)	5.36 ± 3.53	5.13 ± 3.60	.281
LT (% MVIC)	15.98 ± 7.44	18.75 ± 9.59	.017*
UT/LT (ratio)	.41 ± .32	.35 ± .34	.018*

*$P<.05$
LT: Lower trapezius, MVIC: Maximal voluntary isometric contraction, UT: Upper trapezius

DISCUSSION

The present study demonstrates that the additional scapular posterior tilt movement to the prone shoulder extension exercise increases LT muscle activity and consequently improves UT/LT muscle activity ratio.

The scapular posterior tilt movement was crucial in producing the normal arm elevation movement. The previous study showed that increased scapular posterior tilt and scapular upward rotation and external rotation occurred during arm elevation in asymptomatic individuals.[19] Moreover, the authors of the previous study stated that the LT muscle contributes to the increased scapular posterior tilt movement.[19] Compared to asymptomatic individuals, the patients with SIS show decreased scapular posterior tilt and scapular external rotation and superior translation of the humerus during arm elevation.[20] Taken together, scapular posterior tilt should be emphasized to produce a normal arm elevation movement.

To facilitate LT muscle activity, we examined the influences of prone shoulder extension with scapular posterior tilt in the present study. The effects of the addition of scapular posterior tilt on the prone shoulder horizontal abduction has been reported in the previous studies,[14,15] revealing a greater LT muscle activity compared to that with the general prone shoulder horizontal abduction and backward rocking diagonal arm lifting.[14,15] The author of the previous study suggested that the intended specific action could facilitate the EMG activity of the muscle acting the specific action. Therefore, the intended scapular posterior tilt motion could result to a greater LT muscle activation.[14] Following this point of view, we infer that the additional scapular posterior tilt led to increased LT muscle activity and relative LT muscle activation concerning the UT during prone shoulder extension in the present study. Further, our findings demonstrated that the intentional scapular posterior tilt could facilitate LT muscle activation during shoulder extension in adducted shoulder position. Since the patients with SIS could not perform exercise in the abducted shoulder position due to painful arch, our findings may provide a useful exercise strategy because the exercise suggested in the present study can be performed in the adducted shoulder position.

Although a significantly increased LT muscle activity after adding scapular posterior tilt was found in the present study, the amount of increased muscle activity was about 3% MVIC, which was smaller than the previous finding (about 10% MVIC).[15] This difference may result from different shoulder positions during the exercises between our study and the previous studies. The Kim and Kang's study added scapular posterior tilt in the abducted shoulder position,[15] whereas our study added scapular posterior tilt in the adducted shoulder position. Oyama et al. suggested that LT muscle activity increases with increasing shoulder abduction angle during shoulder horizontal abduction and/or extension.[13] Therefore, lesser shoulder abduction angle may restrict the greater facilitation of the LT muscle when performing prone shoulder extension with scapular posterior tilt, influencing our findings.

In the present study, EMG activity of UT was not significantly different between two exercises. Considering the fact that the UT muscle is involved in scapular elevation and not scapular anterior/posterior tilt,[16] this is a logical finding. The additional scapular elevation movement was not added during prone shoulder extension with scapular posterior tilt, which may result in no significant difference in EMG activity of UT between two exercises.

This study has some limitations. First, only male subjects participated in this study, making it difficult to generalize the results. Second, despite using prone shoulder extension exercise to emphasize clinical implication for the patients with SIS, only asymptomatic subjects participated in this study. Thus, future study should include the patients with SIS to extend our findings.

CONCLUSION

This study examined the influences of additional scapular posterior tilt movement on UT and LT muscle activity during prone shoulder extension. Our findings demonstrated that additional scapular posterior tilt movement improves LT muscle activity and selective LT muscle activation concerning the UT muscle activation. These emphasize the clinical implication of scapular posterior tilt movement when facilitating LT muscle activation.

ACKNOWLEDGEMENTS

This paper was supported by RESEARCH FUND offered from Catholic University of Pusan.

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