

The effects of shoulder joint abduction angles on the muscle activity of the serratus anterior muscle and the upper trapezius muscle while vibrations are applied

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Abstract. [Purpose] The purpose of this study was to examine the ratio between the upper trapezius and the serratus anterior muscles during diverse shoulder abduction exercises applied with vibrations in order to determine the appropriate exercise methods for recovery of scapular muscle balance. [Subjects and Methods] Twenty-four subjects voluntarily participated in this study. The subjects performed shoulder abduction at various shoulder joint abduction angles (90°, 120°, 150°, 180°) with oscillation movements. [Results] At 120°, all the subjects showed significant increases in the muscle activity of the serratus anterior muscle in comparison with the upper trapezius muscle. However, no significant difference was found at angles other than 120°. [Conclusion] To selectively strengthen the serratus anterior, applying vibration stimuli at the 120° shoulder abduction position is considered to be appropriate.

Key words: Serratus anterior, Upper trapezius, Vibration

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INTRODUCTION

The scapula is important for normal movement of the upper extremities, and scapular functions are greatly affected by the actions of surrounding muscles. Scapular muscles maintain balance with each other and provide both stability and mobility to the scapula¹⁾. For instance, the rotator cuff and deltoid muscles provide compressive force to the glenohumeral joint or prevent superior migration of the humeral head while the shoulder is moving, and the scapulothoracic muscles are involved in the scapula's upward rotation during humeral abduction²⁻⁴⁾. In particular, imbalance of the scapulothoracic muscles may induce scapular dyskinesia leading to glenohumeral joint instability or impingement⁵⁾. This phenomenon occurs mainly because of the imbalance in the muscle activity of both the serratus anterior and the upper trapezius⁶⁾.

Cools established that the muscle strength of the serratus anterior decreased and the ratio of the serratus anterior muscles to the upper trapezius muscles decreased in athletes with a shoulder pathology who used overhead motion in their sporting activities⁷⁾. In another study, it was found

that a hyperactive upper trapezius and a hypoactive serratus anterior could cause shoulder pain⁸⁾. Meanwhile, local vibrations are an effective method that can improve muscle strength and endurance, and Choung et al. proposed that scaption exercises were effective for selective strengthening of the serratus anterior^{9, 10)}. Although many studies have reported on the selective strengthening of the serratus anterior, thus far, there have been very few studies that have examined exercise methods that apply vibration. Therefore, the purpose of this study was to examine the ratio between the upper trapezius and the serratus anterior muscles during diverse shoulder abduction exercises applied with vibrations in order to determine the appropriate exercise methods for recovery of scapular muscle balance.

SUBJECTS AND METHODS

Twenty-four subjects (11 males and 13 females, age = 24.0±2.7 years, height = 166.9±8.1, and body weight = 62.2±13.3) voluntarily participated in this study. The subjects were selected from among people who had not experienced any shoulder joint injury or instability during the past six months and who had no problem in the range of motion of the shoulder joint and no problem in shoulder joint muscle strength. The procedures of this study were harmless to the human body. Also, this study was approved by the Daegu University Faculty of Rehabilitation Sciences Human Ethics Committee. All the subjects read and signed a written consent form. To perform oscillation movements,

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Table 1. Ratio between the upper trapezius and the serratus anterior muscles during diverse shoulder abduction exercises applied with vibrations (Unit: %MVIC, %SA/UT)

	90°	120°	150°	180°
SA/UT	83.5±65.6	106.0±86.2*	89.7±81.0	79.4±65.1

Values are mean±SD. *p<0.05, SA: serratus anterior, UT: upper trapezius

the subjects used FlexBars (Hygenic Corporation, Akron, OH, USA). FlexBars (weight = 0.59 kg, length = 0.3 m) are single oscillating devices mainly applied to the upper extremities¹¹). The subjects performed shoulder abduction in scaption at various shoulder joint abduction angles (90°, 120°, 150°, 180°) while holding one end of the FlexBar, and then they performed oscillation movements at a speed of 5 Hz for approximately 10 seconds.

To enhance the reliability of the experiment, the various shoulder abduction angles were randomly assigned¹²). In addition, a surface EMG-MP36 (Biopac System, Inc., Goleta, CA, USA) was used to measure the muscle activity of the serratus anterior muscle and the upper trapezius muscle during oscillation movements. Maximal voluntary isometric contraction (%MVIC) was used to normalize the muscle activity. The values of the serratus anterior/upper trapezius muscles were shown in percentages, and the extracted values were statistically analyzed to compare the ratios of the muscle activity of the serratus anterior and the upper trapezius. SPSS for Windows (ver. 18.0) was used for data analysis, and repeated one-way ANOVAs were used to compare the ratios of the muscle activity among the different angles. The LSD method was used as a post hoc test to examine differences between the groups, and the chosen significance level was 0.05.

RESULTS

While shoulder abduction was performed at various angles together with oscillation movements, comparison of the ratios of the muscle activity of the serratus anterior muscle and the upper trapezius muscle showed significant differences between 90° and 120°, between 120° and 150°, and between 120° and 180°. At 120°, all the subjects showed significant increases in the muscle activity of the serratus anterior muscle in comparison with the upper trapezius muscle. However, no significant difference was found at angles other than 120° (Table 1).

DISCUSSION

The purpose of this study was to find appropriate angles for shoulder abduction that can reduce the muscle activity of the upper trapezius and selectively strengthen the serratus anterior when vibration stimuli are applied. Among the scapulothoracic muscles, weakening of the serratus anterior, in particular, causes hypermobility of other cooperative muscles, such as the upper trapezius and the pectoralis major, due to compensatory actions^{6, 7}). In addition, this imbalance of muscle activity acts as a major cause of scapular imbalance¹³). Therefore, a rehabilitation exercise

method appropriate for patients with scapular imbalance is useful for reducing the activation of the upper trapezius to the minimum and increasing the muscle activity of the serratus anterior to the maximum¹⁴). A variety of studies have reported on selective strengthening of the serratus anterior muscle. Ludewig advised that standard push-up exercises were effective for selective strengthening of the serratus anterior, and Yoo et al. recommended that isometric exercise should be performed on unstable surfaces and that dynamic exercise should be performed on stable surfaces^{14, 15}). Meanwhile, in a study conducted by Choung et al., although the muscle activity of the serratus anterior and the upper trapezius did not show any significant difference among different exercise surfaces, the muscle activity of the pectoralis major, which compensates for the function of the serratus anterior when it is in the state of muscle imbalance, decreased further during scaption exercises¹⁰).

Therefore, scaption shoulder abduction was performed in this study, and the muscle activities of the serratus anterior and the upper trapezius were measured while applying vibration stimuli; currently, vibration stimuli are frequently used as a kind of resistance exercises in order to increase muscle strength. According to the results, the muscle activity of the serratus anterior increased significantly compared with the muscle activity of the upper trapezius when vibration stimuli were applied during 120° shoulder abduction. In this study, since the ratio of the muscle activity of the serratus anterior was measured in comparison with the ratio of the muscle activity in the upper trapezius, it seems as if, at other angles, the muscle activity of both the serratus anterior and the upper trapezius increased. Therefore, to selectively strengthen the serratus anterior, applying vibration stimuli at the 120° shoulder abduction position is considered to be appropriate. In addition, although vibrations are a very useful method for increasing muscle strength or power, their effects are known to appear differently depending upon the amplitudes and frequencies of the vibrations¹²). Therefore, future studies are required that examine not only joint angles but also diverse vibration stimulus application methods.

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