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Various shrug exercises can change scapular kinematics and scapular rotator muscle activities in subjects with scapular downward rotation syndrome

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ABSTRACT

Scapular dyskinesis, characterized by scapular downward rotation syndrome (SDRS) affects scapula-humeral rhythm and results in shoulder dysfunction. Previous study has led to the recommendation of standard shrug exercise to contend with SDRS and strengthen the upper trapezius (UT) muscle. However, few researchers have examined which shrug exercise is most effective. The aim of this research was to compare scapular kinematic changes and scapular rotator muscles activity across three different shrug exercises in SDRS. The amounts of scapular downward rotation were measured by a caliper and the scapular upward rotation angle was measured using two digital inclinometers. Surface electromyography was used to measure EMG amplitude from the UT, lower trapezius (LT), serratus anterior (SA), and levator scapula (LS). Seventeen subjects with SDRS were recruited for this study. The subjects performed three shrug exercises with 30° shoulder abduction (preferred shrug, frontal shrug, and stabilization shrug). The stabilization shrug showed a significantly greater scapular upward rotation angle compared with the preferred shrug ($P = 0.004$) and frontal shrug ($P = 0.006$). The UT activity was significantly greater in the frontal shrug than in the preferred shrug ($P = 0.002$). The UT/LS muscle activity ratio was also significantly greater in the frontal shrug than in the preferred shrug ($P = 0.004$). The stabilization shrug should be preferred to enhance the upward rotation angle. In addition, the frontal shrug can be used as an effective method to increase UT activity and to decrease LS activity in SDRS.

1. Introduction

The upper trapezius (UT) muscle is the key contributor to normal scapular motion and control and it activates the scapular upward rotators in normal shoulder functions (Moraes, Faria, & Teixeira-Salmela, 2008; Wadsworth & Bullock-Saxton, 1997). Muscle imbalance between the elongated UT muscle and the shortened levator scapulae (LS) may cause scapular dyskinesis, characterized by a drooping scapula and increased downward rotation. This type of dyskinesis is defined as

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scapular downward rotation syndrome (SDRS) (Sahrmann, 2002). Increased UT muscle length in SDRS does not allow for the transfer of weight from an upper extremity load to the sternoclavicular joint (Johnson, Bogduk, Nowitzke, & House, 1994). Furthermore, increased stiffness of the LS muscle may contribute to an increased compressive load and shear force on the cervical spine during active neck movement (Szeto, Straker, & Raine, 2002). Previous investigations show that LS can be activated simultaneously with UT during shoulder rehabilitation exercises, such as rowing, shoulder abduction, and shrug exercises (Moseley, Jobe, Pink, Perry, & Tibone, 1992). Thus, the UT muscle is the focus of therapeutic exercise protocols for rehabilitation from SDRS.

Traditionally, the standard shrug exercise has been prescribed in shoulder rehabilitation programs to strengthen the UT muscle (Burkhead & Rockwood, 1992; Hintermeister, Lange, Schultheis, Bey, & Hawkins, 1998). However, previous studies reported that the shrug, with a 30° shoulder abduction exercise (i.e., completing the exercise with 30° of shoulder abduction, rather than with the arm by the side), generates greater activity in the UT muscle, as well as the serratus anterior (SA) and lower trapezius (LT), than the standard shrug (Pizzari, Wickham, Balster, Ganderton, & Watson, 2014; Watson, Balster, Finch, & Dalziel, 2005; Watson, Pizzari, & Balster, 2010). For this reason, the shrug with a 30° shoulder abduction exercise has been recommended for increasing the activation of the scapular upward rotators. Although the shrug with 30° abduction was proven to be superior to the traditional shrug, other shrug exercises could potentially produce even greater benefits for training the UT and upward rotators. Previous investigators reported that UT muscle activity was higher during arm abduction in the frontal plane (abduction plane) compared to the sagittal (flexion) plane (Antony & Keir, 2010). This is likely due to the relatively increased constant moment arm in the frontal plane compared with the flexion plane (Hughes & An, 1996). In addition, Hellwig and Perrin (1991) demonstrated that abduction within the frontal plane requires significant scapular upward rotation. Previous studies also revealed that the trapezius increases its activity as the plane of humeral elevation moves from the sagittal plane to the frontal plane (Bagg & Forrest, 1986; Inman, Saunders, & Abbott, 1944). These findings indicate that the exercise plane, where the shrug exercise is performed, is another critical factor that should be taken into consideration because the UT muscle may activate differently depending on the exercise plane during the shrug exercise. Moreover, previous researchers have focused on altered craniocervical and thoracic postures during scapular movement because spinal alignment is thought to influence scapular position and movement (Cole et al., 2013; Kibler, 1991). Others have reported that scapular upward rotation significantly decreased in flexed-head positions (Ludewig & Cook, 1996) and decreased with greater thoracic kyphosis (Finley & Lee, 2003; Kebaetse, 1999). Cervical stability may require synergistic muscle actions for active shoulder functions (Behrsin & Maguire, 1986). The LS can be particularly activated as a cervical stabilizer (extensor), rather than a scapular elevator, during arm movements because it directly connects the cervical spine to the scapula (Kendall, McCreary, & Provance, 2007).

However, no study has determined the influence of the exercise plane and craniocervicothoracic stability during shrugs with 30° shoulder abduction exercises on scapular kinematic changes and scapular rotator muscle activity, even though arm elevation on various planes, and craniocervical and thoracic stabilization have been shown to affect scapular kinematics and scapular rotator muscle activity during shrugs with 30° shoulder abduction exercise. The purpose of this research was to compare the amount of scapular downward rotation (SDR), scapular upward rotation angle, UT, LT, SA, and LS electromyography (EMG) activity, and the EMG activity ratio of UT/LS during three different shrug exercises in SDRS, including the preferred shrug, frontal shrug, and stabilization shrug. The hypothesis is that the amounts of SDR, scapular upward rotation angle, UT, LT, SA, LS EMG activity, and the EMG activity of the UT/LS ratio would differ during three different shrug exercises in SDRS. The results of current study could provide valuable evidence to shoulder rehabilitation strategies for individuals with SDRS.

2. Methods

2.1. Subjects

G-power software was used for the power analyses. The necessary sample size of seven subjects was calculated using data obtained from a pilot study of 10 subjects to achieve a power of 0.80 and an effect size of 0.59 (calculated from the partial η^2 of 0.26 from the pilot study), with an α level of 0.05. Finally, 17 subjects with SDRS participated including 10 participants of the pilot study (age = 19.82 ± 1.60 years, height = 167.77 ± 6.92 cm, weight = 56.93 ± 6.38 kg, BMI = 20.19 ± 1.52, and amount of SDR before the exercises = 1.05 ± 0.55 cm). The SDR determination was confirmed using a caliper. This SDR measurement was modified using Kibler's method to measure scapular alignment (Kibler, 1991; Watson et al., 2010). Both sides were measured to determine the amount of SDR in the subject. Next, the side that had greater scapular downward rotation was used in the data collection process (one subject had SDR in the right side and 16 Subjects had SDR in the left side). The exclusion criteria were a history or clinical exam revealing pain or dysfunction that substantially limited shoulder motion or resulted in gross instability of the shoulder during daily activities, signs and symptoms of cervical pain, adhesive capsulitis, thoracic outlet syndrome, or a current complaint of numbness or tingling in the upper extremity, forward head posture, and scoliosis. Prior to participation, the subjects provided written informed consent. The investigation was approved by Yonsei University Wonju Institutional Review Board.