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Original article

Modifying the shoulder joint position during shrugging and retraction exercises alters the activation of the medial scapular muscles

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ABSTRACT

Background: In patients with shoulder or neck pain, often an imbalance of the activation in the scapular upward and downward rotators is present which can cause abnormalities in coordinated scapular rotation. Shrug exercises are often recommended to activate muscles that produce upward rotation, but little information is available on the activity of the downward rotators during shrugging exercises. The position used for the shrug exercise may affect the relative participation of the medial scapular rotators.
Objectives: To compare muscle activity, using both surface and fine-wire electrodes, of the medial scapular muscles during different shoulder joint positions while performing shrug and retraction exercises.
Design: Controlled laboratory study.
Method: Twenty-six subjects performed 3 different exercises: shrug with the arms at the side while holding a weight ("Shrug"), shrug with arms overhead and retraction with arms overhead. EMG data with surface and fine wire electrodes was collected from the Upper Trapezius (UT), Levator Scapulae (LS), Middle Trapezius (MT), Rhomboid Major (RM) and Lower Trapezius (LT).
Results: The results showed that activity levels of the main medial scapular muscles depend upon the specific shoulder joint position when performing shrug and retraction exercises. High UT activity was found across all exercises, with no significant differences in UT activity between the exercises. The LS and RM activity was significantly lower during "ShrugOverhead" and the RM, MT and LT activity was significantly higher during "RetractionOverhead".
Conclusions: This study has identified that all three exercises elicited similar UT activity. LS and RM activity is decreased with the "ShrugOverhead" exercise. The "RetractionOverhead" was the most effective exercise in activating the medial scapular muscles.

1. Introduction

The position and motion of the scapula is crucial for normal functioning of the shoulder and neck region (Kibler and McMullen, 2003). Patterned scapular muscle activations are necessary to place the scapula in an optimal position. The Upper Trapezius (UT) moves the scapula into upward rotation and elevation, the function of the Middle Trapezius (MT) is to retract the scapula and the Lower Trapezius (LT) causes upward rotation and depression of the scapula. In addition, the inferomedial directed fibres of the LT may also contribute to posterior tilt and external rotation of the scapula during humeral elevation. The Serratus Anterior is able to protract the scapula and to work with the UT and LT to upwardly rotate the scapula. The Levator Scapulae (LS) is believed to elevate the scapula and to work together with the Rhomboid Major (RM) to retract and rotate the scapula downwards (Escamilla et al., 2009; Castelein et al., 2015). Scapular dyskinesis (known as alterations in static scapular position and loss of dynamic control of scapular motion) and alterations in scapular muscle activation patterns are commonly found in association with shoulder and neck pain conditions (Szeto et al., 2002; Ludewig and Reynolds, 2009; Helgadottir et al., 2010; Kibler and Sciascia, 2010; Helgadottir et al., 2011; Kibler et al., 2012).

Patients with shoulder or neck pain often present with muscle imbalances between the upward rotators (UT and SA) and the

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downward rotators (LS and RM) of the scapula (Ludewig and Cook, 2000; Sahrmann, 2002; Cools et al., 2004; Ludewig and Reynolds, 2009; Struyf et al., 2014). These changes in muscular balance among the scapular rotators can cause abnormalities in coordinated scapular rotation (Sahrmann, 2002; Cools et al., 2003). Therefore, it is important to integrate exercises in the scapular rehabilitation program that target activation of the scapular muscles, with a focus on the activation of upward rotators while minimizing the activation of the scapular downward rotators (Sahrmann, 2002).

Often the “Shrug”-exercise has been prescribed in scapular rehabilitation programs to facilitate upward rotation of the scapula (Hintermeister et al., 1998; Ekstrom et al., 2003; Pizzari et al., 2014). This exercise is mainly performed in order to correct the drooping shoulder at rest, and during the early stages of elevation. However, Sahrmann (2002) did not find the “Shrug” optimal to emphasize the UT activity and the upward rotation as the “Shrug” was suggested to reinforce the activity of the RM and LS, contributing to the dominance of these scapular downward rotator muscles. Also other authors described that the “Shrug” with the arms by the side may activate the LS rather than UT (Moseley et al., 1992; Smith et al., 2004). So, in order to elicit improved balance among the upward and downward rotators, it may be desirable to modify a shrug exercise. Sahrmann (2002) advises that the “Shrug” should be performed with arms overhead so that the scapula is in upward rotation (“ShrugOverhead”). However, to date, no specific EMG research of the medial scapular muscles has been performed to confirm or reject the hypothesis of Sahrmann (2002) and consequently no evidence exists in order to support these recommendations.

Some studies have investigated EMG activity of scapular muscles during shrug exercises (Moseley et al., 1992; Choi et al., 2015; Pizzari et al., 2014). One study by Moseley et al. (1992) showed that the Shrug was an optimal exercise for the LS (muscle activity >50%MMT). A limitation of the study was that no statistical investigations were made to compare EMG activity between muscles or exercises. Pizzari et al. (2014) investigated the influence of starting a shrug in 30° of glenohumeral abduction (component of slight upward rotation) rather than with the arm by the side, and found that it generated greater Trapezius muscle activity in comparison with the shrug with the arms at the side. The muscle activity of the downward rotators however, such as LS and RM was not investigated in that study. Choi et al. (2015) investigated the EMG activity of the UT, LT and LS with surface electrodes during shrug exercises with different starting positions of shoulder abduction (30°–90°–150°) in patients with downward rotation positioning of the scapula. While LS muscle activity showed no significant differences, the muscle activity of the scapular upward rotators (UT, LT, and SA) did show significant differences among the shoulder abduction angles during shrug exercises. A limitation of this study was that LS activity was measured with surface EMG electrodes and that possible cross talk could have occurred between the UT and LS. In addition, this study did not investigate RM and MT EMG activity. Overall, there is a lack of research evaluating the activity of the downward rotators, namely the RM and LS during different shoulder joint positions of shrugging and retraction exercises. The main reason for the lack of information on the EMG activity of those muscles may be that they are located too deep to be investigated by surface EMG electrodes (Rudroff, 2008).

Therefore, the purpose of this study was to compare muscle activation levels, using both surface and fine-wire electrodes, of the medial scapular rotators (UT, MT, LT, RM, LS) during 1) the shrug exercise (=shrug with the arms at the side and with a weight), 2) the shrug exercise when arms are elevated, and 3) a retraction exercise while arms are elevated. Understanding variations in the recruitment of all medial scapular muscles (including the downward rotators) during shrug and retraction exercises and the influence of different starting positions may help guide clinicians to select the appropriate exercises for each patient.

2. Materials and methods

2.1. Subjects

Twenty-six subjects (15 female, 11 male, mean age 33.3 ± 12.3 years, ranging from 21 to 56 years old, mean height: 174.7 ± 7.8 cm, mean weight: 67.5 ± 8.9 kg) participated in this study. All subjects were free from current or past shoulder or neck pain and demonstrated full pain-free range of motion of both shoulders. They did not perform overhead sports nor upper limb strength training for more than 6 h/week. Twenty-two subjects were right-handed and 4 were left-handed. Written informed consent was obtained from all participants. The study was approved by the ethics committee of X.

2.2. General design

EMG data was collected from 5 scapulothoracic muscles (UT, MT, LT, LS, RM) on the dominant side of each subject during the performance of the shrug exercise, the shrug exercise started from an overhead position of the arms, and retraction exercise started from an overhead position of the arms.

2.3. Test procedure

The experimental session began with a short warm-up procedure with multidirectional shoulder movements, followed by the performance of the maximum voluntary isometric contractions (MVIC) of the muscles of interest. This data is needed for normalization of the EMG signals.

A set of 4 MVIC test positions was completed to allow normalization of the EMG data (Castelein et al., 2015). These consisted of the following:

1. “Abduction 90°” (sitting)
2. “Horizontal Abduction with external rotation” (prone lying)
3. “Arm raised above head in line with LT muscle fibers” (prone lying)
4. “Shoulder flexion 135°” (sitting)

Each MVIC test position was performed 3 times (each of the 3 contractions lasted for 5 s-controlled by a metronome) with at least 30 s rest between the different repetitions. The order of tests was randomized and there was a rest period of at least 1.5 min between the different test positions. Manual pressure was always applied by the same investigator and strong and consistent encouragement from the investigator was given during each MVIC to promote maximal effort. Before data collection, MVIC test positions were taught to each subject by the same investigator. When the participants were able to perform the proper movement pattern and timing of the exercise, EMG data was collected from the MVICs.

In the second part of the investigation, the subject performed three exercises. Fig. 1 shows the description of the different exercises. The exercises were performed randomly (simple randomization: envelopes containing the name of each exercise were shuffled for each participant and this sequence of exercises was allocated to that participant). Before data collection, the subject was given a visual demonstration of each exercise by the investigator. Each exercise consisted of a concentric phase of 3s and an eccentric phase of 3s. A metronome was used to control and