Clinical Biomechanics 29 (2014) 201–205

Contents lists available at ScienceDirect

Clinical Biomechanics

journal homepage: www.elsevier.com/locate/clinbiomech

Modifying a shrug exercise can facilitate the upward rotator muscles of the scapula

Tania Pizzari [a,b,*], James Wickham [c], Simon Balster [d], Charlotte Ganderton [b], Lyn Watson [b,d]

[a] *Lower Extremity & Gait Studies Research Group, Australia*
[b] *Department of Physiotherapy, La Trobe University, Victoria, Australia*
[c] *School of Biomedical Science, Charles Sturt University, NSW, Australia*
[d] *LifeCare Prahran Sports Medicine, Victoria, Australia*

ARTICLE INFO

Article history:
Received 16 March 2013
Accepted 18 November 2013

Keywords:
Electromyography
Shoulder
Rehabilitation
Trapezius

ABSTRACT

Background: Scapular dyskinesis, characterised by drooping scapulae and reduced upward rotation, has been implicated in the presentation of a number of shoulder disorders. Traditionally, in shoulder rehabilitation programmes, the shrug exercise has been prescribed to facilitate upward rotation of the scapula by strengthening the upper trapezius muscle. The aim of this research was to compare muscle activation levels during the standard shrug and the upward rotation shrug in a normal and pathological population.
Methods: Surface electrodes recorded electromyographical activity from upper trapezius, middle trapezius, lower trapezius and serratus anterior muscles in 23 normal participants and 14 participants with multi-directional shoulder instability. Participants completed 10 trials of the standard shrug exercise at 0° of shoulder abduction and the upward rotation shrug exercise at 30° of shoulder abduction in the coronal plane. Muscle activity was expressed as a percentage of maximum voluntary isometric contraction.
Findings: The four muscles tested performed at a higher intensity during the modified shrug than the standard shrug. Upper trapezius and lower trapezius activity was significantly greater ($P < 0.05$) in both populations. Though for middle trapezius and serratus anterior muscles, the modified shrug was statistically significant only in the normal population, $P = 0.031$ and $P = <0.001$ respectively.
Interpretation: The upward rotation shrug is a more effective exercise for eliciting muscle activity of the upper and lower trapezius than the standard shrug in a normal and multi-directional instability population. Clinically, the upward rotation shrug might be useful to address scapular dyskinesis involving drooping shoulders and reduced scapula upward rotation.

1. Introduction

The position and motion of the scapula are crucial for the normal functioning of the shoulder joint. Scapular dyskinesis, an alteration of the normal scapula position or movement, affects scapula-humeral rhythm and results in dysfunction of the shoulder joint (Kibler and Sciascia, 2010). There has been extensive focus on the correction of scapular dyskinesis associated with weakness in the lower trapezius (Reinold et al., 2009), however not all shoulder pathology has this type of dysfunction. Scapular dyskinesis, characterised by drooping scapulae and reduced upward rotation, has been implicated in the presentation of a number of shoulder conditions (Braun et al., 2009; Kibler and Sciascia, 2010; Struyf et al., 2011; Watson et al., 2009). Addressing this type of dyskinesis in the initial upward rotation motion might include a focus on improving the upper trapezius muscle function to correct the drooping shoulder at rest, and during the early stages of elevation (Watson et al., 2010). The elevating pull of the upper trapezius on the lateral third of the clavicle and acromion orientates the glenoid superiorly and initiates upward rotation of the scapula (Levangie and Norkin, 2011; Moraes et al., 2008; Wadsworth and Bullock-Saxton, 1997). In normal shoulder function, the upper trapezius consistently activates first of all the scapular upward rotators and this recruitment order has been shown to be variable and the muscle activation latent in patients with impingement syndrome (Moraes et al., 2008; Wadsworth and Bullock-Saxton, 1997).

Traditionally, in shoulder rehabilitation programmes, the shrug exercise has been prescribed to strengthen the upper trapezius muscle (Burkhead and Rockwood, 1992; Hintermeister et al., 1998). It has been theorised that a modification of the shrug exercise, the upward rotation shrug, generates greater upper trapezius muscle activity than the standard shrug and facilitates upward rotation (Watson et al., 2009). The upward rotation shrug involves completing the exercise in 30° of glenohumeral abduction rather than with the arm by the side. Facilitating the initiation of upward rotation by using this shrug may also have the added benefit of increased recruitment of the serratus anterior when compared with the standard shrug.

* Corresponding author at: Department of Physiotherapy, La Trobe University, Bundoora, Victoria 3086, Australia.
E-mail address: t.pizzari@latrobe.edu.au (T. Pizzari).

0268-0033/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.clinbiomech.2013.11.011

In order to determine the value of the modified shrug in both a normal and a pathological population, a comparison of upper trapezius, middle trapezius, lower trapezius and serratus anterior muscle activation was made between the upward rotation shrug and the standard shrug exercise. Glenohumeral multi-directional instability (MDI) patients were chosen as the pathological group since it has been suggested that downward rotation or 'drooping' of the scapula may be involved in the development of MDI (Graichen et al., 2005; Ogston and Ludewig, 2007; von Eisenhart-Rothe et al., 2009). In addition, the reported insufficient upward rotation of the scapula during elevation in this group (Ogston and Ludewig, 2007) may allow the humeral head to slide inferiorly creating through-range subluxations (Neer and Foster, 1980). It was hypothesized that the scapular upward rotators would activate at a greater intensity during the upward rotation shrug in both groups of participants.

2. Methods

Twenty-three normal participants (12 Male, 11 Female) aged between 18 and 37 years and 14 participants with multi-directional instability (7 Male, 7 Female) aged 16 to 31 years participated in this research project. Normal participants had no past history of shoulder surgery, or any previous shoulder pain or injury and were a sample of convenience from a University population. The MDI group were all referred to an orthopaedic outpatient clinic for rehabilitation, all formally diagnosed by an orthopaedic surgeon, and underwent magnetic resonance imaging (MRI) to exclude a structural lesion. In both groups, participants were excluded if they had an allergy to adhesives since the electrodes are held on by a strong adhesive tape. Similarly, all participants required sufficient English skills to read and understand the information and consent form due to the risks involved with participating in the study. The La Trobe University Ethics Committee approved all research procedures reported in this study and all participants gave written consent prior to participation (09-027).

2.1. Instrumentation

Four DE-3.1 Double differential (Delsys® Inc., Boston, USA) surface electrodes were applied to the upper trapezius, middle trapezius, and lower trapezius according to the guidelines of Delagi and Perotto (2005) and serratus anterior, according to the guidelines of Geiringer (1999). A Delsys Bagnoli-16 channel electromyography (EMG) system (Delsys® Inc., Boston, USA 02215) was used to accurately detect raw EMG signals and electrogoniometer signals at a sampling rate of 2 kHz before A–D conversion and storage on an IBM compatible computer. A band pass filter (built into the amplifier) of 20–450 Hz was applied to the surface electrodes. The gain was set for all channels at 1000.

2.2. Procedure

Participants were permitted to practice the exercises prior to testing. Holding a light dumbbell, the participants performed 10 trials of the standard shrug exercise at 0° of abduction and 10 trials of the upward rotation shrug exercise at 30° of abduction (Watson et al., 2009) in the coronal plane. The weight of the dumbbell was calculated as 25% of the force output (Lafayette Manual Muscle Tester positioned on the subjects' wrist; Lafayette Instrument Company, Indiana, USA 47903) for an abduction maximum voluntary isometric contraction (MVIC) performed at 90° shoulder abduction (Wickham et al., 2010). This allowed for the normalisation of load to each participant's strength and equated to a 2.5 kg dumbbell as the average weight (SD 0.65 kg) for the normal group and 2.0 kg (SD 0.47 kg) for the MDI group. The duration of each repetition was standardised by having the investigator count the timing of the movement aloud to a four second period standardised by the timing on the Delsys EMG system (2 second elevation, 2 second return to neutral). Participants were given a 30 second rest between each repetition to reduce fatigue effects. The order of these exercises was randomised between participants to prevent order effects.

In addition to the shrug trials, four different MVICs were completed to allow the EMG data to be normalised. These consisted of standing shoulder abduction at 90° of shoulder joint elevation in the coronal plane, standing shoulder flexion at 90° of shoulder joint elevation in the sagittal plane, seated external rotation at 90° of shoulder joint abduction with neutral rotation, and seated maximum scapula retraction. These positions have previously been demonstrated to elicit maximal muscle activity for the muscles of interest (Wickham et al., 2010).

Each subject was asked to perform an MVIC for 5 s and a total of three MVICs were performed for each movement. Participants rested for 3 mins between tests to prevent fatigue limiting maximal output.

2.3. Data analysis

All EMG data from standard and upward rotation shrug trials in both the normal and MDI populations were full wave rectified and low pass filtered at a cut-off frequency of 6 Hz through a 4th order Butterworth filter with phase lag. To obtain graphs, data were time normalised to 100 points (Chapman et al., 2006; Franettovich et al., 2010).

To calculate the MVIC for each muscle, the highest average intensity (root mean square: RMS) value was derived from a 600 ms window centred around the highest peak in the linear envelope signal. All 4 MVIC positions were analysed for each muscle, in order to obtain the highest MVIC reference value. This value (100%) was compared to the RMS values obtained from muscle onset to termination during the shrug trials.

Average intensity values were obtained for repetitions 4, 5, 6 and 7 in order to reduce learning and fatigue effects (Malanga et al., 1996; Myers et al., 2005; Yasojima et al., 2008). Mean RMS values were expressed as a percentage of MVIC and compared in order to determine differences in intensity between the exercises. A Kolmogorov–Smirnov test demonstrated that the data were not normally distributed, and as such Wilcoxon signed-rank tests were performed and medians and interquartile ranges presented (Corder and Foreman, 2009) using IBM SPSS Statistics data analysis program (version 19, IBM SPSS Inc., Chicago, IL, USA).

3. Results

The contraction intensity (RMS) values for the upper trapezius, middle trapezius, lower trapezius and serratus anterior muscles were compared between the exercises in a normal and an MDI population (Table 1). Fig. 1 illustrates a comparison of muscle intensity at 0° and 30° degrees of abduction between normal and pathological populations in all muscles tested. All four muscles performed at a higher intensity (%MVIC) during the modified shrug than the standard shrug. Upper trapezius and lower trapezius activity was statistically significant

Table 1
Median %MVIC (interquartile range) and *P*-value for each muscle in each both groups.

Muscle	Population	Median (IQR)		*P*-value
		0°	30°	
Upper trapezius	Normal	32.6(17.8)	51.1(31.7)	0.010
	MDI	31.0(19.8)	36.4(26.8)	0.009
	Total participants	32.6(15.9)	49.2(30.0)	<0.000
Middle trapezius	Normal	26.2(28.1)	38.9(31.7)	0.031
	MDI	21.5(36.1)	30.3(28.7)	0.109
	Total participants	24.6(27.8)	35.9(32.6)	0.001
Lower trapezius	Normal	3.5(18.4)	12.8(30.8)	0.010
	MDI	7.0(11.1)	14.8(19.6)	0.001
	Total participants	5.0(14.3)	12.8(25.3)	<0.000
Serratus anterior	Normal	6.6(9.5)	17.3(12.2)	<0.001
	MDI	19.6(16.0)	22.7(13.8)	0.925
	Total participants	9.7(15.9)	18.1(14.6)	0.001