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Original article

Muscle thickness measurements of the lower trapezius with rehabilitative ultrasound imaging are confounded by scapular dyskinesis

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ABSTRACT

Alterations in scapular muscle activity have been theorized to contribute to abnormal scapular motion and shoulder pain, but pose challenges to quantify in the clinic. Rehabilitative Ultrasound Imaging (RUSI) has proved useful identifying dysfunction of lumbar regional stabilizing muscle activity, specifically contractile behavior. Although, recent examinations of scapular stabilizing trapezius muscle function using RUSI did not detect alterations individuals with shoulder pain or differences in muscle thickness between varying external loads in asymptomatic individuals, a potential confounder to prior results, scapular dyskinesis has not been controlled. It is unknown if dyskinesis alters scapular muscle thickness during activation measured with RUSI. Thus, the purpose of this study was to compare change in scapular muscle thickness between individuals with and without scapular dyskinesis. Thirty-nine asymptomatic adults with ($n = 19$) and without ($n = 20$) scapular dyskinesis, defined with a reliable and validated method, participated. Two separate ultrasound images of the serratus anterior (SA) and lower trapezius (LT) were captured under two randomized conditions, rest and isometric contraction against gravity, and saved for blinded measurement. Change in thickness with contraction was calculated and expressed as a percentage. The dyskinesis group demonstrated a greater increase ($p = 0.005$) in LT thickness with the isometric contraction than the group without (mean difference = 31.6%; 95%CI = 10.3, 53.0). No differences in SA or resting thickness of either muscle were found between groups. The presence of scapular dyskinesis alters thickness changes of the lower trapezius during activation. Furthermore, potential underlying reasons beyond muscle contractile behavior must be considered.

1. Introduction

Alterations in scapular muscle function have been proposed to contribute to abnormal scapular motion and shoulder pain (Ludewig and Reynolds, 2009; Struyf et al., 2013). During arm elevation, the scapula upwardly rotates and posteriorly tilts (Karduna et al., 2001; Ebaugh et al., 2005; Ludewig et al., 2009) while maintaining congruency to the thorax due to the regional stabilizing function of trapezius and the serratus anterior muscles (Ludewig et al., 1996). Abnormal scapular muscle function, as quantified by mean electromyographic activity in the lower trapezius and serratus anterior during arm elevation, has been demonstrated in individuals with impingement and instability (Ludewig and Cook, 2000; Struyf et al., 2013).

Activities to restore normal scapular muscle regional stabilizing function are advocated in evidenced-based shoulder rehabilitation and injury prevention programs (Wilk et al., 2002; Kuhn, 2009; Reinold et al., 2009). Unlike other impairments theorized to contribute to abnormal scapular motion, such as deficits in shoulder muscle strength, alterations in scapular muscle function including contractile behavior pose a significant challenge to quantify with reliable and valid measures in the clinic (O'Sullivan et al., 2012).

Rehabilitative Ultrasound Imaging (RUSI) has proved to be a useful tool to identify dysfunction of regional stabilizing muscle

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activity at rest and with contraction, in various musculoskeletal disorders. For example, deficits in the cross-sectional area of the cervical multifidus have been demonstrated in females with mechanical neck pain compared to healthy females (Fernandez-de-las-Penas et al., 2008). Additionally muscle deficits with smaller changes in thickness with contraction of the transverse abdominus and internal oblique muscles have been shown in individuals with lumbopelvic pain (Koppenhaver et al., 2011).

Recently, reliable measures of lower trapezius and serratus anterior muscle thickness using RUSI have been developed (O'Sullivan et al., 2007; O'Sullivan et al., 2009; Talbott and Witt, 2013; Day and Uhl, 2013). In contrast to prior investigations of lumbar and cervical dysfunction, RUSI has been unable to detect alterations of a scapular regional stabilizing muscle, the trapezius, in individuals with shoulder pain (O'Sullivan et al., 2012) or proved sensitive to detect differences between varying loads imposed on the shoulder (Day and Uhl, 2013). One reason for the limited findings using RUSI thickness measures to infer scapular muscle contractile behavior is a potential confounder, the presence of scapular dyskinesis.

Given scapular dyskinesis has been found in both individuals with and without shoulder pain, it is possible that findings of prior research using RUSI to detect changes in scapular muscle thickness with isometric contractions may have been influenced by scapular dyskinesis. Thus, the purpose of this study was to compare scapular muscle thickness and percentage change in thickness with contraction measured with RUSI between asymptomatic individuals with and without scapular dyskinesis. Results have important implications for the use of RUSI to infer alterations in scapular muscle contractile behavior.

2. Methods

2.1. Participants

Healthy volunteers aged over 18 years were recruited at the university. Subjects signed an informed consent approved by the university institutional review board prior to participation. Subjects were excluded with any of the following criteria: pain or limitations with active and resisted shoulder range of motion, history of shoulder or thorax fracture or surgery, or systemic neurological or connective tissue disorders.

Scapular motion was assessed with the scapular dyskinesis test (McClure et al., 2009; Tate et al., 2009). During this test, subjects performed 5 repetitions of full bilateral shoulder flexion and abduction holding light hand weights. Subjects weighing less than 68 kg (150 lbs) used 1.4 kg weights while subjects weighing equal to or greater than 68 kg (150 lbs) used 2.3 kg weights. The examiner rated the subjects' observed scapular motion as normal, subtle dyskinesis, or obvious dyskinesis. With this test, obvious dyskinesis was operationally defined as a clearly apparent dysrhythmia or winging of at least 2.54 cm in at least 3 out of the 5 trials of either abduction or flexion. Dysrhythmia was defined as premature or excessive scapular protraction or elevation, non-smooth motion, or rapid downward rotation motion during arm lowering. Winging was defined as scapular medial border and/or inferior angle posterior displacement from the thorax. Normal motion was operationally defined as having no evidence of abnormality. Individuals with subtle dyskinesis, defined as winging or dysrhythmia that was mild, questionable, or not consistently present were excluded. This test has demonstrated acceptable reliability with an 80%–81% agreement between examiners (McClure et al., 2009) and has been validated to detect alterations in scapular motion found with three-dimensional motion analysis (Tate et al., 2009).

In the current study, two examiners simultaneously observed the subject's scapular motion and independently classified each subject. Subjects who were not classified the same by both examiners were excluded. Examiners were trained in this evaluation method using a standardized self-instructional slide presentation including video examples (McClure et al., 2009). Subjects with dyskinesis were matched to subjects with normal scapular motion on the basis of age (+/− 5 years), gender, and laterality of shoulder tested (dominant; non-dominant).

2.2. Procedure

A diagnostic ultrasound imaging unit, (LogiQe; GE Healthcare, Wisconsin, USA) with an adjustable 5.0–12.5 MHz frequency linear array transducer set at 8.0 MHz was used to capture greyscale B-mode images of the serratus anterior and lower trapezius muscles. The accuracy of the unit was confirmed by manufacturer calibration prior to initiating the study. Two separate ultrasound images were captured of the serratus anterior and lower trapezius muscles during rest condition and two separate images during the active isometric contraction against gravity condition. Images were saved to the ultrasound unit for later blinded measurement. Between each trial, the subject was asked to relax, while the second examiner supported his or her arm, and the transducer was removed. The entire procedure was then repeated to image the second trial of each muscle. The subject remained in their prone or seated position between trials. The order of muscle tested and condition (rest; contraction) was randomized by drawing.

2.3. Lower trapezius muscle imaging

Imaging of the lower trapezius muscle was performed with the subject lying prone, with the head and neck in neutral alignment. A pillow was placed under the abdomen to minimize lumbar hyperextension. The arm of the shoulder to be tested was passively moved to 120° of abduction, and supported by a second examiner with the elbow extended and thumb pointing upward (Ekstrom et al., 2005). Shoulder position was confirmed with a goniometer. During the rest condition, subjects were verbally encouraged to relax the arm tested and then an image was captured. During the active contraction condition, the subject was asked to maintain the arm in the testing position (Ekstrom et al., 2005) with an isometric contraction while the examiner released manual support. After the

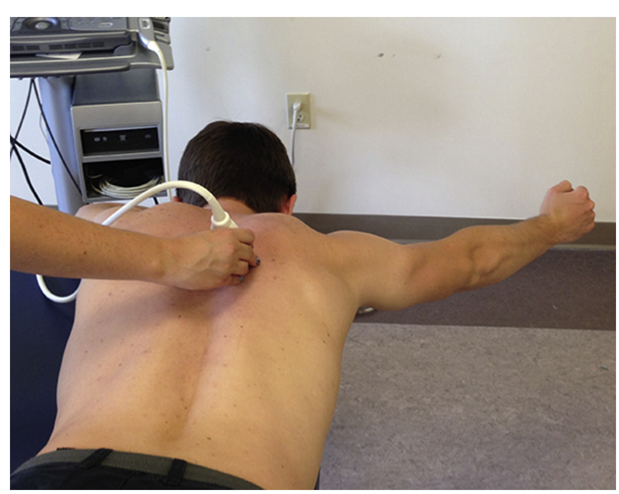

Fig. 1. Ultrasound transducer position to image the lower trapezius at the level of the 5th thoracic vertebra during active isometric contraction against gravity.