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ORIGINAL ARTICLE

Scapular kinematic alterations during arm elevation with decrease in pectoralis minor stiffness after stretching in healthy individuals

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Background: Pectoralis minor tightness may be seen in individuals with scapular dyskinesis, and stretching is used for the treatment of altered scapular motion in sports and clinical fields. However, few researchers have reported on the effects of pectoralis minor stiffness on scapular motion during arm elevation. This study investigated whether an acute decrease of pectoralis minor stiffness after stretching changes the scapular motion during arm elevation.
Methods: The study allocated 15 dominant and 15 nondominant upper limbs in healthy men as control and interventional limbs, respectively. In the intervention limb group, the shoulder was passively and horizontally abducted at 150° of elevation for 5 minutes to stretch the pectoralis minor muscle. Before and after stretching, an electromagnetic sensor was used to examine 3-dimensional scapular motion during abduction and scaption. Ultrasonic shear wave elastography was used to measure pectoralis minor stiffness before and immediately after stretching and after arm elevation.
Results: In the interventional limb, pectoralis minor stiffness decreased by 3.2 kPa immediately after stretching and by 2.5 kPa after arm elevation. The maximal changes in scapular kinematics after stretching were 4.8° of external rotation and 3.3° of posterior tilt in abduction, and 4.5° of external rotation and 3.7° of posterior tilt in scaption. Upward rotation in abduction or scaption did not change.
Conclusions: Stretching for the pectoralis minor muscle increases external rotation and posterior tilt of the scapula during arm elevation.
Level of evidence: Basic Science Study; Kinesiology

Keywords: Shoulder; physical therapy; biomechanics; stretching; muscle stiffness; elastography; pectoralis minor muscle

The study design was approved by the Kyoto University Graduate School and the Faculty of Medicine Ethics Committee (R0233) and conformed to the principles of the Declaration of Helsinki.

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The shoulder joint consists of the scapula, humerus, and clavicle and is one of the largest and most complex joints in humans. The coordinated movement of these bones is important for optimal shoulder motion. Early authors investigating scapula motion in healthy individuals defined scapulohumeral

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rhythm,[10] and it has been established that the scapula rotates upward, externally, and tilts posteriorly during arm elevation in healthy individuals.[11,19,22] Additional researchers reported that scapular motion of patients with impingement syndrome or glenohumeral instability was decreased in external and upward rotation and posterior tilt compared with that of healthy individuals.[4,17,21] Scapular dyskinesis has been defined as the set of abnormal motions and positions of the scapula,[13] and the evaluation and treatment for scapular dyskinesis may be essential for shoulder rehabilitation.

Studies have shown that the onset of scapular dyskinesis is related to the tightness of soft tissue surrounding the scapula.[7,14] The tightness of the pectoralis minor muscle (PMi),[7,14] the short head of the biceps brachii,[14] the levator scapula,[7] or the rhomboid[7] has been speculated to cause scapular dyskinesis. Of these shoulder muscles, the PMi is the only muscle whose relationship between tightness and scapular dyskinesis has been verified by experimental study. Borstad et al[3] examined 3-dimensional (3D) scapular motion during elevation in healthy individuals with and without a shortened PMi and showed that a decrease in external rotation and posterior tilt are seen in individuals with a shortened PMi. The altered scapular kinematics, which is found in individuals with shortened PMi, seen in this previous study[3] was similar to that observed in many patients with shoulder disease.[15,17] PMi tension may therefore be an important factor in scapular dyskinesis.

Stretching is applied as an approach to scapular dyskinesis caused by the PMi tightness. Borstad et al[2] recommended a unilateral corner stretch as one self-stretch method for the PMi. Umehara et al[31] also showed that shoulder horizontal abduction at an elevation of 150° was the most effective stretching technique for the PMi. Considering that there is a correlation between PMi stiffness and scapular dyskinesis, investigating not only the stretching maneuver but also the change in the PMi stiffness and scapular motion after stretching is obviously important. However, few studies have examined this relationship.

The present study investigated whether the acute decrease in PMi stiffness after stretching alters the 3D scapular motion during arm elevation. Borstad et al[3] reported a decrease in external rotation and posterior tilt of scapula in individuals with a shortened PMi compared with healthy individuals. We therefore hypothesized that the decrease in PMi stiffness after stretching augments the external rotation and posterior tilt of the scapula during arm elevation.

Materials and methods

Participants

This study was a controlled experimental study with 20 men (age, 25.4 ± 3.1 years; height, 171.5 ± 5.3 cm; weight, 67.6 ± 8.5 kg) as participants. Dominant and nondominant upper limbs were allocated as control and interventional limbs, respectively. The volunteers were randomly recruited from the students at our institution. Upon selection, the participants orally confirmed that they did not meet the exclusion criteria, which included female gender, designation as an athlete, performance of any extensive exercise, or a history of orthopedic or nervous system disease in the upper limb. Considering that the low body mass index minimized skin motion artifacts in the measurement of scapular motion during arm elevation, we also excluded those with a body mass index >25 kg/m^2, calculated using the height and weight. Before the experiment, 4 men—1 with a daily extensive exercise regimen, 1 with a history of shoulder pain, and 2 with a high body mass index—were excluded. The aim and procedures of the study were explained to all volunteers, and informed consent was obtained.

Experimental procedures

The participants, while sitting on a wooden stool, performed shoulder abduction (elevation in the coronal plane) and scaption (elevation in the scapular plane) before and after the PMi stretching. The stretching procedure of the PMi is described in detail in our previous study (Fig. 1).[31] The participants underwent stretching to the point of discomfort (but not pain) for 5 minutes (30 seconds, 10 repetitions, 10-second intervals). Each elevation plane was marked on the floor using sections of elastic tape. In the starting posture, keeping the upper limb aside the body with the elbow fully extended, the palm facing the body, and the eyes looking straight forward on the target at eye height, the participant was asked to raise his arm to full elevation in 4 seconds and then lower it to starting position in 4 seconds 3 times consecutively to the rhythm of a metronome with 60 beats/

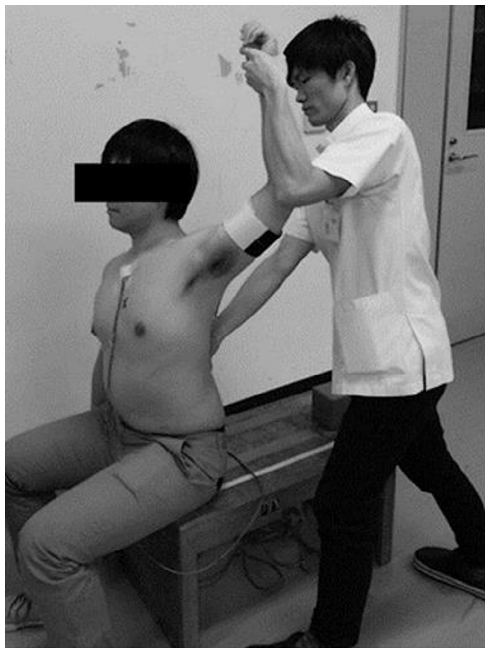

Figure 1 Stretching of the pectoralis minor muscle. As directed, the participant sat on the wooden stool. The interventional limb was brought to maximal horizontal abduction and external rotation at an arm elevation of 150° with the elbow in 90° flexion and was subsequently maximally externally rotated by the investigator. During the stretching, the participants was instructed to remain relaxed. The investigator used 1 hand to move the participant's upper limb and used the other hand to hold the trunk.