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ORIGINAL ARTICLE

Shoulder horizontal abduction stretching effectively increases shear elastic modulus of pectoralis minor muscle

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Background: Stretching maneuvers for the pectoralis minor muscle, which involve shoulder horizontal abduction or scapular retraction, are performed in clinical and sports settings because the tightness of this muscle may contribute to scapular dyskinesis. The effectiveness of stretching maneuvers for the pectoralis minor muscle is unclear in vivo. The purpose of this study was to verify the effectiveness of stretching maneuvers for the pectoralis minor muscle in vivo using ultrasonic shear wave elastography.

Methods: Eighteen healthy men participated in this study. Elongation of the pectoralis minor muscle was measured for 3 stretching maneuvers (shoulder flexion, shoulder horizontal abduction, and scapular retraction) at 3 shoulder elevation angles (30°, 90°, and 150°). The shear elastic modulus, used as the index of muscle elongation, was computed using ultrasonic shear wave elastography for the 9 aforementioned stretching maneuver–angle combinations.

Results: The shear elastic modulus was highest in horizontal abduction at 150°, followed by horizontal abduction at 90°, horizontal abduction at 30°, scapular retraction at 30°, scapular retraction at 90°, scapular retraction at 150°, flexion at 150°, flexion at 90°, and flexion at 30°. The shear elastic moduli of horizontal abduction at 90° and horizontal abduction at 150° were significantly higher than those of other stretching maneuvers. There was no significant difference between horizontal abduction at 90° and horizontal abduction at 150°.

Conclusions: This study determined that shoulder horizontal abduction at an elevation of 90° and horizontal abduction at an elevation of 150° were the most effective stretching maneuvers for the pectoralis minor muscle in vivo.

Level of evidence: Basic Science Study; Imaging

The study design was approved by the ethics committee of Kyoto University Graduate School and Faculty of Medicine (R0314).

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In shoulder rehabilitation, clinical evaluation and intervention for scapular dyskinesis are important because of its relation to various shoulder injuries, such as subacromial impingement,[4,12,17,19,22] rotator cuff tear,[14,24] unstable shoulder,[20] and frozen shoulder.[10] The literature suggests that scapular dyskinesis may be caused by multiple factors such as bone, joint, neurologic, or soft-tissue mechanisms.[13] In soft-tissue mechanisms, the tightness of the pectoralis minor muscle (PMi) is one of the factors inducing scapular dyskinesis, which can be examined and treated by a therapist.[8] Previous studies have reported that the tightness of the PMi is related to posture, including scapular internal rotation in the resting position,[3] and decreases in scapular external rotation and posterior tilt during arm elevation.[5] These changes, which comprise scapular internal rotation and anterior tilt, are similar to the change in scapular motion found in many shoulder injuries,[19,20] and it is also possible that there might be a relationship between shoulder injury and the tightness of the PMi. Therefore, the flexibility of the PMi is important for preventing and improving scapular dyskinesis.

Stretching interventions are recommended to increase and improve muscle flexibility, and stretching of the PMi is frequently used in rehabilitation programs.[1,18,21] Therefore, some studies have investigated stretching maneuvers for the PMi. Borstad and Ludewig[6] compared the length of the PMi during 3 stretching maneuvers using an electromagnetic motion-capture system with skin surface markers in healthy adults. Their study concluded that the most effective PMi stretching maneuver was a unilateral corner self-stretch similar to horizontal abduction of the shoulder joint. On the other hand, Muraki et al[25] directly measured the length of the PMi during 3 passive shoulder motions and 3 stretching techniques using displacement sensors in fresh cadavers. They advocated that scapular retraction resulted in the greatest change in PMi length. The contradictory findings of these 2 studies most likely resulted from differences between the subjects (living persons vs cadavers) or measurement methods. In addition, it is unknown whether the results of these previous studies apply to living persons with regard to effective stretching positions of the PMi because Borstad and Ludewig did not measure the tension of the PMi during stretching but instead measured the distance between the coracoid process and the fourth rib–sternum junction; moreover, Muraki et al used cadavers in their study. Therefore, an investigation of the effectiveness of in vivo stretching maneuvers for the PMi determined by measuring muscle tension during stretching is needed.

A new ultrasound-based technology called *ultrasonic shear wave elastography* (SWE) has been developed, allowing reliable and noninvasive measurement of soft-tissue viscoelastic properties.[2] SWE monitors the propagation of shear waves generated in tissue using acoustic radiation forces and is able to evaluate the shear elastic modulus of individual muscles.[26] Because of the strong linear relationship, identified by prior studies, between passive muscle tension calculated by traditional methods and the shear elastic modulus measured by SWE in vitro,[9,15] SWE has been used in many studies of skeletal muscle stretching.[9,15,27,28] In addition, our previous studies indicated an increase in the shear elastic modulus with muscle elongation during stretching.[27,28] Therefore, SWE has proved to be a valid technology for noninvasively investigating muscle elongation in vivo.

Regarding stretching maneuvers for the PMi, a unilateral corner self-stretch and scapular retraction at a 30° shoulder flexion angle have been recommended by Borstad and Ludewig[6] and Muraki et al,[25] respectively. Muraki et al also reported that the PMi can be stretched by 150° of passive shoulder flexion and scapular-plane elevation, as well as scapular retraction or shoulder horizontal abduction. Thus, we hypothesized that shoulder horizontal abduction or scapular retraction with the shoulder in an elevated position is an effective maneuver for stretching the PMi. The objective of this study was to quantitatively verify the effectiveness of stretching maneuvers for the PMi using the shear elastic modulus measured by SWE in vivo.

Materials and methods

Participants

Eighteen men (age, 26.2 ± 4.0 years; height, 171.1 ± 5.0 cm; weight, 67.4 ± 7.8 kg) with no orthopedic or nervous system abnormalities in the upper limbs participated in this study. The participants were recruited from the students at our institution. The participants orally confirmed that they complied with the following exclusion criteria: women, athletes or persons who perform any extensive exercise, and persons having a history of orthopedic disease or neuropathy in the upper limbs. The sample size was calculated by use of G*Power software (version 3.1; Heinrich Heine University, Dusseldorf, Germany) for a 1-way analysis of variance (ANOVA) with repeated measures (effect size, 0.25; α error, .05; power, 0.8), which showed that 17 participants were required. The study protocol conformed with the principles of the Declaration of Helsinki.

Experimental procedures

This study was an experimental study, with randomized allocation of the stretching intervention for each participant using a random number table. Healthy male participants were randomly recruited. After the aim and procedures were explained to all participants, the participants underwent 9 stretching maneuvers performed by 1 researcher. The outcome was measured and analyzed by another researcher.