J Shoulder Elbow Surg (2017) ■■, ■■–■■

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

ORIGINAL ARTICLE

Acute effect and time course of extension and internal rotation stretching of the shoulder on infraspinatus muscle hardness

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Background: A decrease in flexibility of the infraspinatus muscle causes limitations in the range of shoulder motion. Static stretching (SS) is a useful method to improve muscle flexibility and joint mobility. Previous researchers investigated effective stretching methods for the infraspinatus. However, few researchers investigated the acute effect of SS on the infraspinatus muscle's flexibility. In addition, the minimum SS time required to increase the infraspinatus muscle's flexibility remains unclear. The aims of this study included investigating the acute effect of SS on the infraspinatus muscle's hardness (an index of muscle flexibility) by measuring shear elastic modulus and determining minimum SS time to decrease the infraspinatus muscle's hardness.

Methods: This included measuring the effect of SS with extension and internal rotation of the shoulder on the infraspinatus muscle's hardness in 20 healthy men. Hence, shear elastic modulus of the infraspinatus was measured by ultrasonic shear wave elastography before and after every 10 seconds up to 120 seconds of SS.

Results: Two-way analysis of variance indicated a significant main effect of SS duration on shear elastic modulus. The post hoc test indicated no significant difference between shear elastic modulus after 10 seconds of SS and that before SS. However, shear elastic modulus immediately after a period ranging from 20 seconds to 120 seconds of SS was significantly lower than that before SS.

Conclusion: The results suggested that shoulder extension and internal rotation SS effectively decreased the infraspinatus muscle's hardness. In addition, the results indicated that a period exceeding 20 seconds of SS decreased the infraspinatus muscle's hardness.

Level of evidence: Basic Science Study; Biomechanics

Keywords: Ultrasonic shear wave elastography; shear elastic modulus; infraspinatus; stretching; shoulder; shoulder extension stretching; minimum stretching time

This study has been approved by the Ethics Committee of the Kyoto University Graduate School and Faculty of Medicine: No. R0314.

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1058-2746/$ - see front matter
http://dx.doi.org/10.1016/j.jse.2017.04.018

Rotator cuff muscles play an important role in shoulder function because these muscles contribute to the dynamic stability of a shoulder joint.[3] Decrease in soft tissue flexibility of the posterior shoulder region, including the infraspinatus, teres minor, and posterior glenohumeral joint capsule, is defined as posterior shoulder tightness.[4,27] Several researchers have indicated that posterior shoulder tightness causes glenohumeral internal rotation deficit (GIRD) and limited range of motion (ROM) in the internal rotation of the shoulder.[9,22] A few others investigated the relationship between shoulder injuries and the manifestations of GIRD.[8,26] The researchers indicated that the manifestations of GIRD are linked to nonspecific shoulder pain,[8] and those affected are at high risk for the development of shoulder pathologic processes.[26] Some reports have shown that treatment of GIRD with physical therapy improves flexibility of the posterior shoulder muscles.[1,4]

In general, static stretching (SS) is recommended as an effective intervention to increase muscle flexibility and joint ROM. Specifically, SS is an effective method that prevents joint contracture, decreases muscle strain, and improves muscle flexibility. Several prior studies have shown that maximum ROM increased immediately after SS[5,6] and that the passive torque or muscle-tendon unit stiffness decreased after SS.[7,13] However, it is not possible to assess the flexibility of individual muscles in the shoulder using these traditional measurements, such as passive torque and muscle stiffness, because of the complex shoulder joint construction and also because of the fact that ROM is affected by pain and stretch tolerance.

Researchers recently assessed muscle hardness as an index of muscle flexibility using ultrasonic shear wave elastography.[2,17,29,31] Ultrasonic shear wave elastography enables reliable measurement of local tissue in vivo. Several authors used shear elastic modulus measured by ultrasonic shear wave elastography and investigated the effect of SS on muscle hardness.[18,28] In addition, Nakamura et al delineated a significant correlation between rate of change in shear elastic modulus and rate of change in muscle stiffness.[18] Furthermore, Rosskopf et al determined that ultrasonic shear wave elastography is reproducible to assess the shoulder muscles.[24] Therefore, the effect of SS on shoulder muscle hardness could be assessed using ultrasonic shear wave elastography.

To stretch muscles effectively, it is important to define appropriate SS positions and a minimum length of time required for SS to increase muscle flexibility. Several researchers suggested SS positions for shoulder muscles based on kinesiology and anatomy.[16,33] A previous cadaveric study showed that the middle portion of the infraspinatus is most stretched in internal rotation with shoulder extension, and the inferior portion of this muscle is most stretched in internal rotation during shoulder elevation as well as during shoulder extension.[16] Therefore, we concluded that shoulder internal rotation with extension or elevation is the effective SS position for the infraspinatus muscle. In addition, the minimum time required for SS to increase infraspinatus muscle flexibility remains unclear. Determination of appropriate SS time could be useful for clinical sites and preparatory activities (exercise and warm-up). A few researchers have examined the minimum time for SS of the lower limbs.[19,20] However, no researchers have examined the minimum time required for SS for upper limb muscles. The SS minimum time required to increase muscle flexibility could differ across the muscles. The aim of this study included investigating the acute effect of SS on infraspinatus muscle hardness and identifying the minimum time required to decrease infraspinatus muscle hardness.

Methods

Subjects

Twenty healthy men with no previous history of orthopedic disease in the shoulder (age, 22.7 ± 1.5 years) were recruited for this study. Each subject provided written informed consent before taking part in the study. The sample size required for a 2-way analysis of variance (ANOVA) with repeated measures (effect size = 0.25 [medium], α error = .05, and power = 0.95) was calculated using G* power 3.1 software (Heinrich Heine University, Düsseldorf, Germany). We used G* power to calculate the necessary sample size based on the effect size, α error, and power. Elicited results have suggested that 17 subjects were required for the current study.

Experimental protocol

A crossover trial design was adopted to investigate the effect of stretching position on the decrease in muscle hardness. All subjects participated in both the stretching condition and the control condition. A set of the stretching condition consisted of 10 seconds of SS and a 30-second period during which the shear elastic modulus of the infraspinatus muscle was measured. Subjects participated in 12 consecutive sets (total SS time of 120 seconds). A set in the control condition involved the subject's relaxing in a prone position for 10 seconds with the subject's upper limbs against the body and a 30-second period to measure shear elastic modulus. Subjects participated in 12 sets. Shear elastic modulus of the infraspinatus was measured before SS (SS0) and 12 times immediately after SS (SS1-SS12), thereby corresponding to a total of 13 times in the study.

Measurement of the shear elastic modulus

Ultrasonic shear wave elastography (Aixplorer; SuperSonic Imagine, Axi-en-Provence, France) with a SuperLinear SL 10-2 probe was used to assess the shear elastic modulus of the superior portion of the infraspinatus muscle in the nondominant shoulder. Some subjects had experience in participating in overhead sports. Therefore, we chose the nondominant side to examine only the effect of SS on infraspinatus muscle hardness. The position for measuring the shear elastic modulus of the infraspinatus muscle was termed the prone position, in which subjects placed their hands behind their backs and brought thumb tips in line with the eighth thoracic vertebra (Fig. 1). The measurement site was defined as the intersection point of 2 lines; 1 line connected a point at the top fourth from the medial margin of the spine of the scapula to the inferior angle of the scapula and the greater tubercle, and the other line connected