Static Stretching of Rectus Femoris on Young's Modulus using Shear Wave Elastography in Healthy Men

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Disclosures: The authors declare that they have no conflicts of interest.

INTRODUCTION:

Rectus femoris stiffness is risk factor for Osgood-Schlatter disease, sports-related muscle avulsion injury and knee osteoarthritis. The age of onset for these diseases ranges from young to old. Therefore, the methods of reducing rectus femoris stiffness are valuable for a wide range of ages.

Static stretching has been shown to reduce muscle and tendon stiffness. Shear wave elastography (SWE) measure local soft tissue stiffness. Therefore, SWE can examine changes in stiffness of stretched soft tissue. Acute effects of static stretching to rectus femoris have been reported using SWE. However, little is known about effects about measured values using SWE.

This study aimed to quantitatively demonstrate the effects of static stretching on the rectus femoris using SWE. The duration of the stretching program was 4-weeks. We hypothesized that the stretching program reduces the stiffness of the rectus femoris using SWE.

METHODS:

The participants were 15 healthy men who had no knee pain and contracture of knee joint (age; 26.4 ± 2.2 years, height; 1.73 ± 0.03 m, body weight; 66.0 ± 6.9 kg, BMI; 22.0 ± 1.9 kg/m^2). This study was approved by the ethical committee for Tsuchiura Kyodo General Hospital and was conducted in accordance with the Declaration of Helsinki. Each participant provided written informed consent. We instructed participants voluntary static stretching to the rectus femoris muscle 5 times a week for 4 weeks (Figure 1 left). Each stretching was 5 minutes. We measured the Young's modulus of the rectus femoris using the Aixplorer ultrasound unit in conjunction with a 2–10-MHz linear transducer (Figure 1 right) and knee flexion range of motion (ROM) at before stretching, after 2 weeks, and after 4 weeks. SWE provides Young's modulus as the value of stiffness. Generalized linear mixed model was used for statistical analysis. p-values < 0.05 were considered statistically significant.

RESULTS SECTION:

The Young's modulus of the rectus femoris decreased, and the knee flexion ROM increased after stretching (P-values between before and after 2 weeks and before and after 4 weeks were p<0.001). Young's modulus of the rectus femoris had a fixed effect on knee flexion ROM (p=0.025).

DISCUSSION:

The static stretching program increased knee flexion ROM and decreased Young's modulus of the rectus femoris using SWE. Our results show that static stretching affects reducing muscle stiffness using SWE. Young's modulus using shear wave elastography, quantitatively demonstrated that static stretching of the rectus femoris reduced muscle stiffness in healthy men.

The rectus femoris becomes progressively stiffer when the knee is flexed. The decrease in stiffness of rectus femoris at 90° knee flexion, the position measured in this study, can indicate an improvement in flexibility. Improved flexibility could be due to Sarcomerogenesis and decreased motor neuron excitability. Increased knee flexion range of motion due to improved rectus femoris flexibility. Moreover, the mechanism by which the knee flexion ROM increased would be the increased tolerance of stretch.

This study had three limitations. First, the number of participants was small. More participants might have yielded more accurate results. Second, we did not use electromyography when measuring Young's modulus. Muscle contraction affects Young's modulus; therefore, measuring muscle tone is essential. Third, the measurement site of Young's modulus was local. The stretching effect will also occur outside Young's modulus measurement part of this study. Further studies are needed to address these limitations.

SIGNIFICANCE/CLINICAL RELEVANCE:

Stretching for at least 4 weeks may increase rectus femoris flexibility.

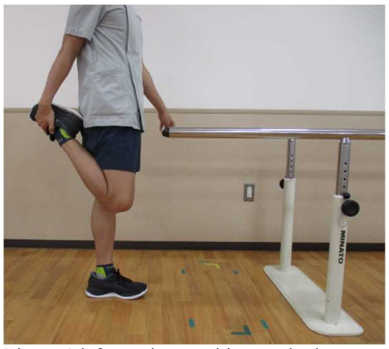

Figure 1 left. Static stretching methods
The participant grasped the right foot, extended the hip and flexed the knee.
Figure 1 right. Measurement position of Young's modulus. The participants were in a supine position with their knees bending 90°