DETERMINING AN EFFECTIVE STRETCHING TIME FOR ACHILLES TENDON EXTENSION

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Stretching exercises are commonly undertaken for sports and rehabilitation. However, it is unknown how an in vivo muscle-tendon unit responds to added stretching stimulation. The purpose of this study was to determine an effective stretching time for Achilles tendon extension. The human medial head of the gastrocnemius muscle was stretched and ultrasonography was used to determine and then compare the length of the Achilles tendon between before and after stretching. Achilles tendon extension for one minute of stretching was 3.4±2.5mm, two 6.8±2.1mm, three 6.9±1.0mm, five 7.2±0.7mm, and ten 7.4±0.8mm. Achilles tendon length was significantly increased for up to two minutes of stretching ($p<0.01$). However, there were no significant differences for stretching for three or more minutes. From these results, we conclude that two minutes of static stretching is effective for Achilles tendon extension.

KEY WORDS: stretching, Achilles tendon extension, ultrasonography.

INTRODUCTION:

Stretching is performed for sports activities and health, and has been reported to be benificial for the human body (Nordez, Cornu & McNair, 2006; Renner, Carvalho, Soares & Mattiello-Rosa, 2006). It is conventially used in the field of sports, and is also performed for fatigue and relaxation of psychologic stress. Stretching improves flexibility making daily life easier. Stretching is also performed for rehabilitation. It is necessary for improvement of extensibility of tendinous tissue after tendon injury and for tendon rupture post operation. The Achilles tendon is the most commonly ruptured tendon in the human body (Maffulli, Ajis, Longo & Denaro, 2007). However, the amount of extension of tendinous tissue resulting from stretching is unknown. When effective stretching for extension of tendinous tissue is performed, it is important to know the relation between stretching time and the amount of extension of the tendinous tissue. It is important to achieve improvement of flexibility of the muscle-tendon complex for prevention of sports injuries. This study aimed to determine an effective stretching time for Achilles tendon extension.

METHODS:

Data Collection: Forty adult female subjects performed stretches for the study (age was 29.9±7.2 years, height was 159.6±6.4 cm, and weight was 54.6±7.6 kg, mean±SD).

1. An marker as a landmark of the muscle-tendon junction was determined on the human medial head of the gastrocnemius muscle from ultrasonic images taken in a standing position.
2. We set the position of the muscle-tendon junction on the skin and determined the Achilles tendon length between the mark and the calcaneal tuber length.
3. All subjects performed static stretching on a stretching board with maximal ankle dorsiflexion.
4. Just after stretching, we measured the Achilles tendon length by the same method as before stretching and compared measurements.
5. The times for stretching were one, three, five and ten minutes. We carried out each measurement with intervals of at least more than five days.

Data Analysis: Two-way ANOVA with repeated measure was used to assess the difference in the amount of extension at the time of each measurement. The significance in differences between before and after stretching were analysed by a paired *t*-test. The level of significance was set at $p<0.05$.

RESULTS:
A typical ultrasonic image before and after stretching is shown in Figure 1. The Achilles tendon was significantly extended by one and two minutes of stretching ($p<0.01$). However, there were no significant differences for three or more minutes. Table 1 shows the length of the Achilles tendon before and after stretching. The amount of Achilles tendon extension is shown in Figure 2.

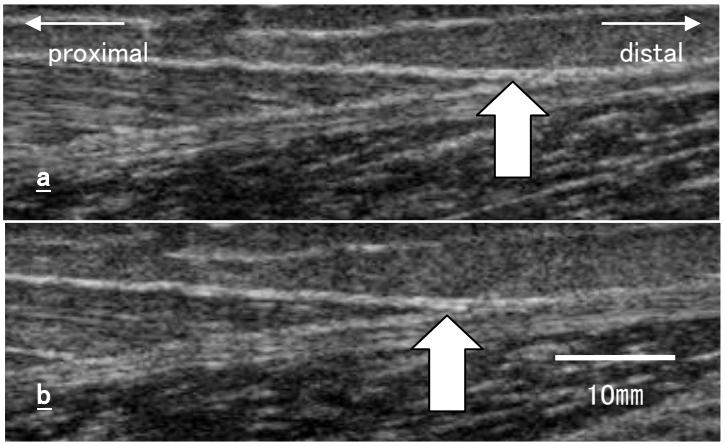

Figure 1 A positional change of the marker: (a) before stretching, (b) after stretching (10min). The muscle-tendon junction shifts 6.4 mm distal in this case.

Table 1 Length of the Achilles tendon (p < .01)**

Stretching time	1 min.	2 min.	3 min.	5 min.	10 min.
Before stretching (mm)	170.7 ± 20.3	171.3 ± 21.0	170.9 ± 21.2	171.5 ± 20.8	171.8 ± 21.0
After stretching (mm)	** 174.1 ± 27.4	** 178.1 ± 26.7	** 177.8 ± 26.6	** 178.4 ± 26.0	** 179.2 ± 28.5

DISCUSSION:
Stretching has been reported to improve joint flexibility and sports performance, as well as prevent sports injury (Witvrouw, Danneels, Asselman, D'Have & Cambier, 2003). Stretching is usually used in sports and rehabilitation. In the current study, we investigated the effective stretching time for the Achilles tendon and the relation between stretching time and the amount of extension of the Achilles tendon using ultrasonography.
A previous study reported that tendinous tissue in humans is extended by muscular contraction (Kubo, Kouzaki & Komuro, 2006). Kubo et al. reported that the amount of maximal extension of the tendinous tissue (Achilles tendon and deep aponeurosis of the medial head of the gastrocnemius muscle) at maximum voluntary isometric contraction in the ankle neutral position was 20's 14.4±3.1mm, 30's 11.8±4.0mm and 50's 11.2±2.3mm In our study, the Achilles tendon was extended by 7.4±0.8mm on average by stretching for 10 minutes. This value is almost 51% of the value of those in their 20's that was reported by Kubo. However, we believe that a direct comparison between our study and the study of Kubo is not possible. This is because Kubo's study measured the amount of extension of deep aponeurosis of the medial head of the gastrocnemious muscle with an Achilles tendon, whereas we did not. Nevertheless, the tendinous tissue may be extending more by maximum voluntary contraction of the muscle than it is by stretching. This information is important when we consider grading stretching in rehabilitation of tendon injuries and when we consider effective stretching for tendinous tissue.

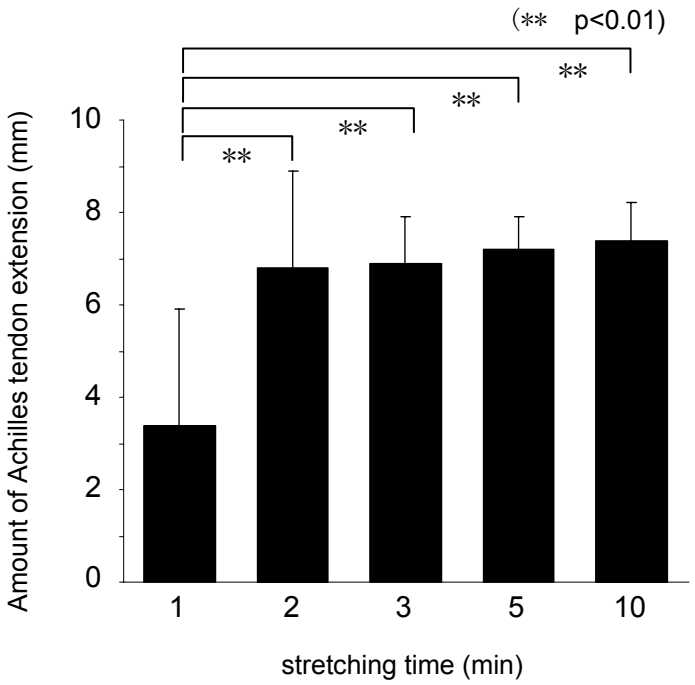

Figure 2 Amount of Achilles tendon extension

The Achilles tendon was significantly extended for two minutes from the beginning of stretching. These findings agreed with our previous study that the deep aponeurosis and the muscle-tendon junction of the medial head of the gastrocnemius muscle significantly shifts with up to two minutes of stretching (Kanazawa, Urabe, Iwamoto & Shirakawa, 2007).
In conclusion, we conclude that static stretching for two minutes is enough for extension of the Achilles tendon. When the usefulness of stretching is considered, the sustainability of the effect is important and thus further investigation is necessary.

CONCLUSION:

In the current study, the human medial head of the gastrocnemius muscle was stretched and the length of the Achilles tendon between before and after stretching was compared using ultrasonography. Achilles tendon length was significantly increased for up to two minutes of stretching ($p<0.01$). However, there were no significant differences in stretching for three or more minutes. From these results, we conclude that two minutes of stretching is effective for extending the Achilles tendon.

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