

Achilles Tendon Stiffness Modulates Medial Gastrocnemius Muscle-Tendon Behavior During Isokinetic Joint Action

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Summary

The effect of Achilles tendon stiffness on the muscle-tendon behavior of the medial gastrocnemius muscle during isokinetic joint action was investigated. Initial results show differences in fascicle and tendon lengthening between subjects with varying tendon stiffness. Early findings suggest there may be important implications for tendon rehabilitation for people with Achilles tendinopathy.

Introduction

Substantial muscle-tendon interactions are observed during isokinetic joint action, where about half of the length change of the muscle-tendon unit (MTU) can be attributed to tendinous tissue, with considerable individual variation [1]. However, the role that tendon stiffness plays in altering muscle-tendon behavior during isokinetic movement is unclear. Given that pathology such as Achilles tendinopathy can alter the mechanical properties of the tendon [2], it is important to understand the implications of such changes to muscle-tendon behavior. Thus, the purpose of this study is to clarify the influence of Achilles tendon stiffness on the muscle-tendon behavior during controlled isokinetic joint action. It is hypothesized that lower tendon stiffness will correspond to greater tendon length change and less fascicle length change.

Methods

As part of an ongoing study, two male participants (age: 28.5 ± 2.12 years, height: 180.75 ± 1.76 cm, mass: 74.29 ± 1.57 kg) gave informed consent to be involved in this study. Participants were positioned on an isokinetic dynamometer (Biodex) with their thigh-trunk angle at 110 degrees ($180 =$ full extension), knees fully extended, and ankle in a neutral position. Maximal eccentric plantar flexion contractions were performed at pre-set angular velocities of 30, 60, and 90°/sec. Prior to the isokinetic trials, plantar flexion ramp isometric maximal voluntary contractions were performed. During the isokinetic and isometric trials, a B-mode ultrasound apparatus (Philips EPIQ Elite) was used to obtain real-time longitudinal images of the medial gastrocnemius (MG) muscle. The images were obtained at 68 Hz synchronously with the torque and angular position data (1 kHz) from the Biodex.

Isokinetic torque, ankle angular position, and ultrasound images were analyzed in the range of 15° (PF) to -5° (DF). Fascicle lengths and pennation angles were measured manually using ImageJ. Tendon length was calculated as the difference between the MTU length and the “effective fascicle” length [1]. Fascicle and tendon lengthening was defined as the difference between the maximum and minimum lengths during the isokinetic plantar flexion trial. Achilles tendon stiffness was defined as the slope of the tendon force-

elongation curve above 50% of MVC. Tendon force was calculated as torque divided by the estimated Achilles tendon moment arm [3], and tendon elongation was calculated as the difference between the tendon length and its resting length.

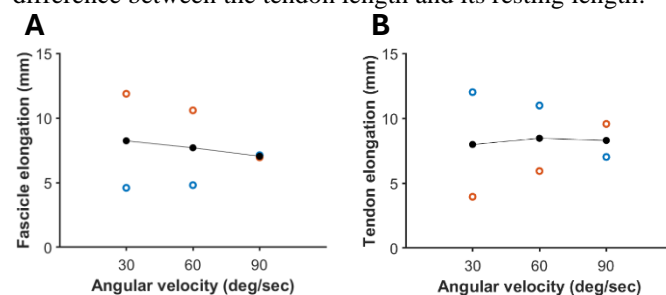


Fig 1. A) Fascicle and B) Tendon elongation as a function of joint angular velocity. S1: open blue, S2: open orange, Mean: closed black

Results and Discussion

Given the small current sample size, no statistical tests were used. Achilles tendon stiffness differed considerably between subjects (S1: 79.2 N/mm; S2: 117.5 N/mm). During the isokinetic trial, fascicle and tendon elongation variation was apparent (Fig. 1).

While absolute conclusions are not possible with the current sample size, our initial results indicate a possible role of Achilles tendon stiffness in modulating muscle-tendon behavior. The subject with lower tendon stiffness exhibited greater tendon length change and lesser fascicle length change at the 30 and 60°/sec conditions. As tendon stiffness is thought to decrease with Achilles tendinopathy, such results may suggest that those with such pathology have altered muscle-tendon behavior and could have implications toward designing appropriate rehabilitative exercises. Continuation of this work will include a larger sample size, including participants who have current symptoms of Achilles tendinopathy.

Conclusions

Initial findings suggest that Achilles tendon stiffness may play a role in modulating muscle-tendon behavior during isokinetic joint action. Continuation of this work will clarify the role of Achilles tendinopathy on muscle-tendon behavior.

Acknowledgments

This work was supported by the Wu Tsai Human Performance Alliance and the Joe and Clara Tsai Foundation.

References

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