Ultrasound Echogenicity is Associated with Fatigue Damage of Achilles Tendon in a Cadaveric Loading Model

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Introduction

One in twenty patients with tendinopathy sustain an Achilles tendon rupture[1]. Clinical diagnoses currently rely on patient-reported symptoms of pain, a reduction in ankle range of motion, and tendon swelling. However, by the time Achilles tendinopathy becomes symptomatic, many degradative changes to the tendon have already been initiated[2]. Detecting markers of pre-symptomatic tendinopathy may lead to better treatment and improved outcomes for patients. This study sought to determine the efficacy of quantitative ultrasound imaging to explain in vitro fatigue-induced degradation of Achilles tendon mechanical properties.

Methods

Achilles tendons were harvested from 3 fresh-frozen cadaveric feet. The calcaneus was potted in PMMA and the tendons were cut into dog-bone shapes to ensure failure at the mid-substance. Tendons were tested with a universal test frame and a custom tank that included a temperature controlled PBS bath (Figure 1). Tendons were cycled between 10-20 MPa at 1 Hz until complete mid-substance failure. An ultrasound probe was fixed in place and images were acquired were recorded every 500 cycles. At these times, 2 cycles were performed at 0.25 Hz to allow for thorough image analysis. images were post-processed using custom MATLAB image analysis algorithm.

Results and Discussion

Mean echogenicity decreased when tendon fatigue damage increased. This decrease in ultrasound image intensity was most apparent after 95% of fatigue life (Figure 2A). For all three specimens, mean echogenicity plateaued during the second phase before decreasing rapidly proceeding tendon failure. From 50% fatigue life to failure, mean echogenicity decreased by 2.5 ± 0.4%. In two of the three specimens, changes in mean echogenicity increased with increased fatigue damage (Figure 2B).

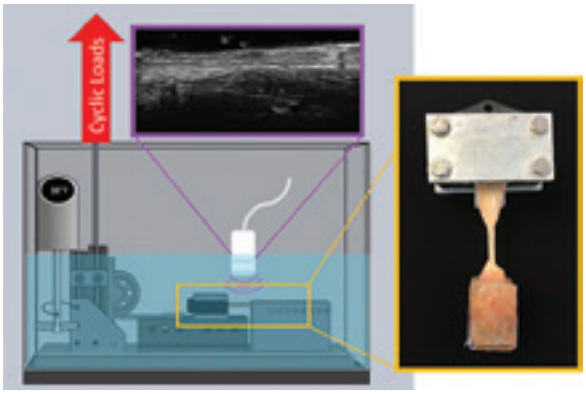

Figure 1. Tendon specimens were cyclically loaded in water bath while images were acquired using an 18MHz ultrasound probe

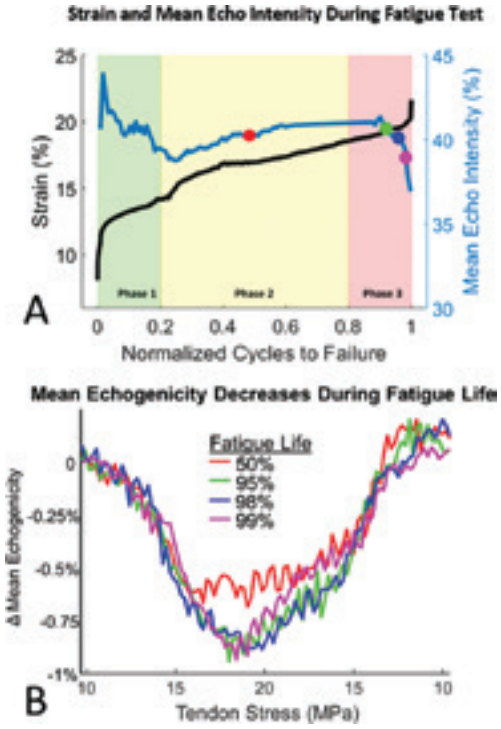

Figure 2. Change in strain and mean echogenicity during the three phases of fatigue life for Specimen 1 **(A)**. Change in mean echogenicity during one cycle at different points of fatigue life **(B)**.

Conclusions

Mean echogenicity is a promising marker for quantifying fatigue damage in Achilles tendons. Our ongoing work is focused on developing computer-based predictive tools to assess Achilles tendinopathy risk in physically active adults.

References

1. Yasui *et al.* *Biomed Res. Int.* Epub 2017 Apr 30
2. Sunding *et al.* *Knee Surg Sports Traumatol Arthrosc.* 2016. 24.6: 1988