# Achilles Tendinopathy and Achilles Tendon Rupture Differentially Affect Achilles Tendon Loading During Gait

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## Summary

Achilles tendon injuries including tendinopathy and rupture result in long-lasting, well-documented changes in tendon tissue structure and quality and deficits in lower limb function. However, there is a lack of information on how lower limb function deficits relate to changes in actual Achilles tendon loading. Here we present data from wearable biomechanical sensors indicating that Achilles loading in walking varies between healthy, tendinopathic, and previously ruptured Achilles tendons, with the greatest side-to-side differences found with Achilles tendinopathy.

## Introduction

The Achilles tendon is one of the most injured tendons due to the complex and continual stress it withstands during locomotion [1]. Achilles tendinopathy (AT) is an overuse injury causing pain, morning stiffness, and functional impairments [2]. Acute Achilles tendon rupture (ATR) occurs when the tendon is overloaded to failure [3]. AT and ATR can take months or years to rehabilitate and cause lasting changes in tendon structure and function [1], [3]. Shear wave tensiometry is a novel approach to predict dynamic tendon loading during walking by tracking shear wave propagation in tendons [4]. Here we applied shear wave tensiometry to assess biomechanical changes in Achilles tendon loading during walking following Achilles tendon injury.

## Methods

Data was collected bilaterally in an IRB approved protocol on 15 participants: 5 healthy (2M, 3F, 40±17.3 yrs), 5 AT (2M, 3F, 53.8±8.8 yrs, 5/5 actively symptomatic), and 5 ATR (3M, 2F, 33.4±11.1 yrs, 22±13.7 mos. since injury). The tensiometer, consisting of a mechanical tapper (SparkFun Electronics, 100Hz) and two mini accelerometers (PCB Piezotronics, 50 kHz), was secured to location of pathology on the involved Achilles tendon (2cm proximal to heel on dominant limb in controls) and at the same height on the contralateral limb. Participants walked at a self-selected speed on a treadmill and three 10 second data collections were performed. The speed of the treadmill was increased by 20% and three more 10 second data collections were performed. Custom MATLAB code was used to process accelerometer data and extract normalized stride averages for each leg and walking speed. A modified Chi-squared method was used for statistical comparison of curves.

## Results and Discussion

Shear wave speed varied significantly between tendons, with tension in the involved limb being greater than uninvolved limb for both AT ($p<.001$, ~100% average increase at pushoff) and ATR ($p<.001$, ~20% average increase at pushoff) groups, with no side-to-side difference found in the healthy population ($p=0.953$). Wave speed was also found to differ between the involved limb of each injured group and the healthy population ($p<0.001$), with no difference between AT and ATR involved limbs ($p=0.977$). Walking speed did not significantly alter shear wave speed in any group (Fig. 1).

These results indicate asymmetries in walking mechanics of both injured groups for comparable portions of the gait cycle, with AT displaying the greatest magnitude of asymmetry, with two-fold differences in peak wave speed between sides. A 20% increase in gait speed did not impact load, suggesting greater changes may be needed to induce changes in loading.

## Conclusions

This work shows long term functional impacts of Achilles tendinopathy and Achilles tendon rupture. Despite well-known differences in structural changes to the tendon, the two injury groups demonstrated asymmetric loading following two different types of Achilles tendon injuries. Further research into these injured populations measuring isolated movements and accounting for tendon thickness should be done to better understand the reason for and impacts of the asymmetries found in this study.

## References

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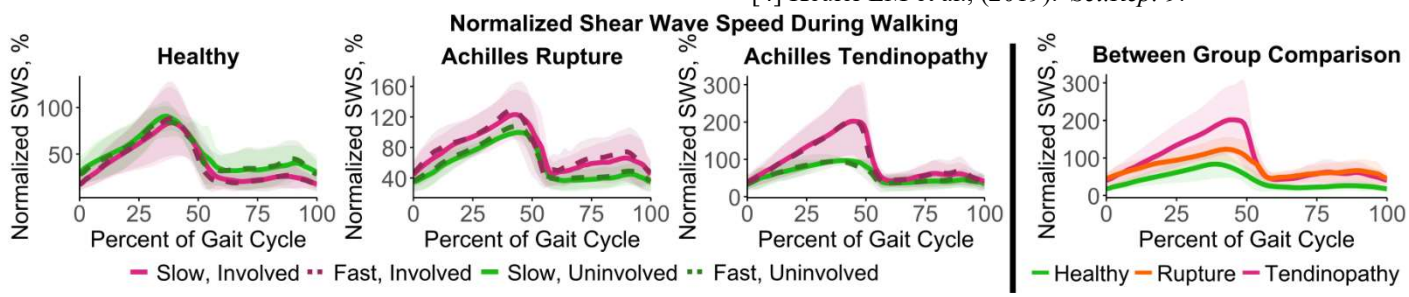


**Figure 1.** Shear wave speed data, normalized to the peak level of uninvolved/nondominant limb at a self-selected speed is shown for healthy, AT, and ATR groups with side-to-side comparisons (left) and for the involved/dominant limbs between groups at self-selected speed (right).