

# Tendon Structure and Functional Performance in Achilles Tendinopathy: Does Sex Matter?

Morgan N Potter<sup>1</sup>, Kayla D Seymore<sup>2</sup>, Stephanie G Cone<sup>1</sup>, Ryan Pohlig<sup>1</sup>, Karin Gräware Silbernagel<sup>1</sup>

<sup>1</sup>College of Health Science, University of Delaware, Newark, Delaware, USA

<sup>2</sup>Division of Biokinesiology and Physical Therapy, University of Southern California, Los Angeles, California, USA

Email: [mpotter@udel.edu](mailto:mpotter@udel.edu)

## Summary

Midportion Achilles tendinopathy (AT) is a painful, overuse injury impacting lower extremity biomechanics and quality of life. To date, there is a poor understanding of sex differences with this injury. The findings of this study indicate that while sex does not moderate the relationship between tendon structure and function in patients with AT, older females showed worse performance in movements like single leg hopping.

## Introduction

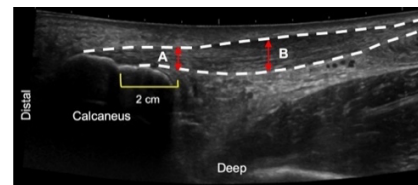
Midportion Achilles tendinopathy (AT) is a debilitating overuse injury resulting in Achilles tendon pain with movement [1]. Fusiform thickening of the Achilles tendon is common with this injury, with greater thickening relating to worse symptom severity and lower extremity (LE) functional deficits [1]. Healthy males and females differ in their Achilles tendon structure, with females having smaller Achilles tendon cross sectional area, decreased stiffness, and diminished capacity to adapt to repetitive loading [2]. Given differences in healthy Achilles tendons, it is important to evaluate if the relationship between structure and function differs between sexes when AT is present. Investigating sex differences with injury can provide a better understanding of how structural changes in midportion AT impacts function in males versus females; ultimately providing insight on the need to differentiate treatment between the sexes. The purpose of this study was to evaluate if sex modifies the relationship between Achilles tendon structure and LE function in individuals with midportion AT.

## Methods

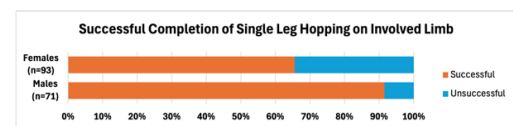
182 individuals (M=79) were included in this study. Sex, height, and weight were documented. To assess tendon structure, we used Achilles tendon thickening obtained via sagittal plane B-mode ultrasound imaging (Figure 1) [3]. LE function was evaluated through average hopping height Limb Symmetry Index (LSI=[involved limb/uninvolved limb]\*100) on the single leg hopping test. Successful performance on the hopping test requires subjects to perform 20 single leg hops at least 1 cm above the ground. Those who were unsuccessful received a 0 for hop height [4]. Total work (Work=body weight in Newtons x heel rise displacement) LSI on the single leg heel-rise endurance test was also used to evaluate LE function [4]. Multiple Regression analysis was used to determine if sex moderated the relationship of Achilles tendon structure on either of the LE function tests ( $\alpha=0.05$ ).

## Results and Discussion

Males and females did not differ in age (mean $\pm$ SD M:48 $\pm$ 13yrs, F:47 $\pm$ 13yrs,  $p=0.699$ ) or body mass index (BMI, M:29 $\pm$ 6.0 kg/m<sup>2</sup>, F:29 $\pm$ 6 kg/m<sup>2</sup>,  $p=0.585$ ). Sex did not moderate the relationship between Achilles tendon thickening and hop height LSI ( $b=0.297$ ,  $p=0.865$ ) or total work LSI ( $b=24.86$ ,  $p=0.347$ ). Additionally, nearly a quarter of individuals were unsuccessful on the hopping test on their involved limb. A secondary analysis (independent sample t-test and Chi-squared) found those in the unsuccessful group were significantly older (unsuccessful: 52 $\pm$ 12yrs, successful: 45 $\pm$ 12yrs;  $p<0.001$ ) and predominately female (unsuccessful: 32/38 [84%], successful: 61/126 [48%];  $p<0.001$ ) (Figure 2). The hopping test places high load through the calf-tendon unit, requiring repetitive use of the stretch-shortening cycle [4]. While sex does not modify the relationship between tendon structure and LE function, it is possible that age related changes to the calf-tendon unit impact functional performance differently in males versus females with AT. This female sex-specific functional deficit may indicate a need for sex-specific treatment strategies to equitably restore LE function.



**Figure 1:** Sagittal plane ultrasound image of an Achilles tendon with AT. Achilles tendon thickening = thickness at B – thickness at A.



**Figure 2:** Successful completion of single leg hopping test on involved limb by sex among those who attempted the test.

## Conclusions

While sex did not modify Achilles tendon structure-function relationships in patients with AT, greater prevalence of unsuccessful performance in single leg hopping among older females may reflect age and sex specific tendon changes. Personal factors, like menopause, should be evaluated as they relate to structure-function relationships in patients with AT.

## References

- [1] Corrigan P et al. (2020). *Orthop. J. Sports Med.*, **8**: 1-9.
- [2] Gianakos H et al. (2024). *J. ISAKOS*, **9**: 184-91.
- [3] Smitheman HP et al. (2023). *J Vis Exp*, (200)
- [4] Silbernagel KG et al. (2006). *KSTA*, **14**: 1207-17