Achilles Tendon Injury: Predisposing Factors in Men between 30 and 50 Years of Age

Kathryn Antle [1,3], David Hawkins [1,2,3]

[1] Biomedical Engineering Graduate Group
[2] Section of Neurobiology, Physiology and Behavior, dahawkins@ucdavis.edu,
[3] Human Performance Laboratory
University of California, Davis CA 95616

INTRODUCTION

The Achilles tendon plays an important role in human locomotion and if injured can severely affect a person's movement capability and quality of life (Mazzone and McCue, 2002). Based on previous research findings and basic biomechanical principles, we hypothesized that people susceptible to Achilles tendon injury would have (1) a larger active muscle to tendon stiffness ratio than other individuals, (2) a larger maximum tendon stress and strain experienced during a maximum isometric ankle plantar flexion than other individuals, and (3) a muscle tendon unit (MTU) stiffness that deviates by more than 1 standard deviation relative to normative MTU stiffness values.

METHODS

The hypotheses were tested by quantifying and comparing the triceps surae muscle group and Achilles tendon mechanical properties between two groups of physically active male subjects, 30-50 years of age: one group experiencing pain in the midsubstance of the Achilles tendon, in one leg, during and after physical activity within the past year (n=5) and another group that had no prior history of Achilles tendon injuries (n=9). It was assumed that the asymptomatic leg of the injured group would have MTU properties reflective of the injured MTU prior to injury and could be compared to uninjured controls. Subjects performed controlled isometric and eccentric ankle plantar flexion efforts in a custom testing chamber while force and muscle-tendon image data were collected simultaneously using a force transducer and a Hitachi EUB 6500 Ultrasound System (Hitachi Corporation) with dual EUP L53 linear probes. Force data were used to determine forces in the gastrocnemius-soleus-Achilles complex (GSATC). For the analysis, the posterior aspect of the lower leg was categorized into four regions: M_P - muscles proximal to the gastrocnemius muscle-tendon junction (MTJ), M_T - total muscle comprised of muscles proximal to the soleus MTJ, T_T - total tendon located between the osteotendinous junction (OTJ) and gastrocnemius MTJ, and T_F - free tendon located between the OTJ and soleus MTJ. Ultrasound images were digitized to determine muscle and Achilles tendon deformation during loading and Achilles tendon cross-sectional area. The average active muscle to tendon stiffness ratio, the Achilles tendon stress and strain during a maximum isometric ankle plantar flexion effort, and the MTU stiffness were calculated and compared between the uninjured control group and the asymptomatic leg of the Achilles tendon injured group.

An unpaired t-test was used to test the first and second hypotheses. The third hypothesis was tested by comparing individual MTU stiffness values to the range of MTU stiffness

values obtained from the uninjured group. A p-value of 0.05 was considered statistically significant while a p-value between 0.05 and 0.2 was considered marginally significant.

RESULTS

Hypothesis 1 (Injured individuals have a larger stiffness ratio of active muscle and tendon than uninjured individuals) was rejected. There were no significant differences ($p>0.38$) in the uninjured group M_P:T_T (n=7, 0.88 $\pm$ 0.76) and M_T:T_F (n=5, 0.49 $\pm$ 0.25) stiffness ratios compared to the injured asymptomatic group M_P:T_T (n=5, 0.95 $\pm$ 0.58) and M_T:T_F (n=3, 0.69 $\pm$ 0.25) stiffness ratios.

Hypothesis 2 (Injured individuals have a larger maximum tendon stress and strain experienced during a maximum isometric ankle plantar flexion than uninjured individuals) was partially supported. There was a statistical trend ($p=0.170$) between the mean T_T strain for the uninjured group (n=9, 1.80 $\pm$ 0.81 %) compared to the injured asymptomatic group (n=5, 2.69 $\pm$ 1.51 %). There was no statistical difference ($p=0.215$) in T_F strain of the uninjured group (n=9, 1.67 $\pm$ 1.45 %) compared to the injured asymptomatic group (n=4, 4.21 $\pm$ 3.71 %). There were no significant differences ($p>0.75$) in the uninjured group mean T_T (n=9, 14.9 $\pm$ 5.5 MPa) and T_F (n=9, 18.0 $\pm$ 6.8 MPa) stress values compared to the injured asymptomatic group mean T_T (n=5, 16.5 $\pm$ 13.8 MPa) and T_F (n=4, 22.2 $\pm$ 11.4 MPa) stresses.

Hypothesis 3 (Injured individuals have a muscle tendon unit (MTU) stiffness that deviates by more than 1 standard deviation relative to normative MTU stiffness values) was not supported. The MTU stiffness for the uninjured group (n=7) ranged from 66.6-131.3 N/mm. Two injured subjects had MTU stiffness values that fell outside of the $\pm$ 1 standard deviation range of the normal uninjured data, with values of 57.1 N/mm and 299.6 N/mm. Three subjects had values that fell within the normal range: MTU stiffness values of 67.0, 113.2, and 83.3 N/mm respectively.

DISCUSSION

The Achilles tendon plays a vital role in human locomotion and is commonly injured in physically active people 30-50 years of age. Identifying injury risk factors is an important first step for developing injury prevention interventions. Based on the results of this study, physically active people having a total tendon strain exceeding 2.4% during MVC may be at risk for an Achilles tendon injury. However, there was considerable variation in the data suggesting that identifying a person at risk for injury based on one or two MTU mechanical properties may not be realistic. We believe that quantifying Achilles tendon loading during daily activities and combining the loading history with the MTU mechanical properties may prove more useful in predicting injury risk than only quantifying MTU mechanical properties; the combination of data would provide a more complete biomechanical profile.

ACKNOWLEDGEMENTS

This research was supported by the UCD and Humanities Fellowship.

REFERENCES

Mazzone, M. F. and T. McCue (2002). *American Family Physician* 65: 1805-1810.