

# THE EFFECTS OF A SINGLE 30 MINUTE RUNNING BOUT ON THE MECHANICS OF THE HUMAN ACHILLES TENDON AND ITS IMPLICATIONS FOR INJURY

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## INTRODUCTION

Strain induced tendinopathies are common in long tendons of the distal limb in human and equine athletes such as the human Achilles and superficial digital flexor tendon (SDFT) in horses [1]. This is likely due to the elastic nature of such tendons and their role as energy stores during locomotion, which exposes them to large strains of up to 12% in horse SDFT [2] and 5% in the human Achilles [3]. Mathematical modelling and in-vivo measurement of temperature rises in equine SDFT during galloping suggested that increased core temperature due to stored energy lost as heat (hysteresis) might be responsible for the degenerative lesions commonly present in the core of injured tendons [2]. The same model predicted that human Achilles core temperature could reach 43 °C during running but, this calculation was based on limited in-vivo measurements and assumptions of the properties and mechanics of the human Achilles [2]. The aim of this study was to make in-vivo measurements of human Achilles tendon properties and behaviour before, during and after running and to model maximum temperature in the core of the tendon. It was hypothesised that Achilles tendon properties would be unaffected by a single bout of running and that core temperature rise would be insufficient to be a likely factor in tendon pathology, due to lower tendon strain in humans than in horses.

## METHODS

Twelve males performed a single 30 minute bout of running on a treadmill at 12 kmph. Before and after the run the participants performed a series of hops on a force plate (AMTI) operating at 200 Hz. Kinematic data were obtained at 200 Hz during running and hopping from motion analysis markers (CODA) placed on estimated joint centres. Inverse dynamic analysis was used to calculate sagittal plane ankle moments during hopping.

Real-time B-mode ultrasound (8 MHz) images of the gastrocnemius muscle tendon junction were collected (50 Hz) synchronously with motion analysis data to calculate the length of the Achilles tendon [4] during the hops and during the first, fifteenth and final minutes of the run. Length changes during hopping were combined with tendon forces calculated from ankle joint moments, to calculate the stiffness of the Achilles before and after the run. Cross-sectional area of the tendon was measured from transverse ultrasound images. Tendon strain during running was calculated relative to Achilles length when standing. Tendon core temperature was predicted for a steady-state using standard heat transfer equations.

## RESULTS & DISCUSSION

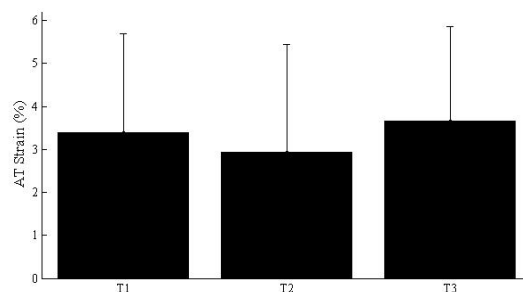
No significant differences were found in stiffness pre and post run (Table 1). This is supported by the fact that tendon elongation during ground contact did not change

over the course of the run (Figure 1) and standing length of the tendon did not differ after the run (Table 1).

**Table 1:** Mean ( $\pm$  sd) tendon properties pre and post run

	Pre	Post
Stiffness ( $\text{N}\cdot\text{mm}^{-1}$ )	163 $\pm$ 41	147 $\pm$ 52
Cross-sectional Area ( $\text{mm}^2$ )	43 $\pm$ 8	41 $\pm$ 8
Standing Length (mm)	301 $\pm$ 16	300 $\pm$ 14

Group average strain during running was 3%. Using this value, group average stiffness and a mid-range hysteresis value from the literature of 20% [4, 5], a steady state tendon core temperature of 39 °C was predicted.



**Figure 1:** Achilles tendon strain (group mean  $\pm$ sd) at the 3 time points during the run

Whilst this value is not as high as that reported in horse SDFT, it is still a high temperature for biological tissues to be exposed to. Also, this temperature may be an underestimate due to underestimated strain (relative strain may be less than true strain) and not including any rise in peripheral tendon temperature in the model. Studies exposing tendon fibroblasts to thermal assault in-vitro have shown high survival rates after 10 minutes at 45 °C [6]. However, this is a short time compared to that which human athletes might typically run for. Also, it may be the tendon matrix metabolism that is affected by heat, not the actual fibroblasts [6].

## CONCLUSIONS

A single bout of running has no affect on the properties or behaviour of the human Achilles tendon. The predicted rise in temperature was small compared to that in equine SDFT and maybe insufficient to cause pathological degeneration. This may be due to lower strains experienced by the human Achilles.

## REFERENCES

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