# HUMAN ACHILLES TENDON PLASTICITY IN RESPONSE TO CYCLIC STRAIN: EFFECT OF STRAIN DURATION

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## Introduction

Tendons are able to adapt their mechanical [Kubo, 2002] and morphological [Kongsgaard, 2007; Arampatzis, 2007] properties in response to long-term cyclic loading (i.e. tendon strain). From a mechano-biological point of view the rate, duration, magnitude and frequency of strain on connective tissues can induce cellular responses inducing tendon adaptation. In this regard, intervention studies of our group showed that a high strain magnitude (4.5-5.0%) is necessary to induce significant adaptations of mechanical and morphological tendon properties. Further, training at high strain magnitude with lower strain frequency (0.17 Hz) induced superior adaptational effects compared to a higher frequency (0.5 Hz) [Arampatzis, 2007, 2010]. However, the controlled modulation of applied strain duration has not been investigated thus far. Therefore, the purpose of the present study was to examine the effect of strain duration on Achilles tendon plasticity.

## Methods

Twelve male participants (30±3 y., 177±7 cm, 73±5 kg) exercised isometric plantar flexions inducing high strain (4.5-5.0%) on the Achilles tendon. One leg trained at short strain duration (4x 3s load, 3s relaxation) and the other leg at long strain duration (1x 12s) for 5 sets, 4 days per week for 14 weeks. The loading volume (i.e. integral of moment over time) was equal in both legs. Thirteen age-matched subjects served as control group with no training. Before and after the interventions the maximum plantar flexion moment was measured by means of a dynamometer, the Achilles tendon elongation by ultrasound and the cross-sectional area (CSA) using magnet resonance imaging.

## Results

The Achilles tendon stiffness, elastic modulus and mean tendon CSA increased significantly ($p<0.05$) following the training with long and short strain duration (Fig 1.). No significant differences were found between both intervention outcomes.

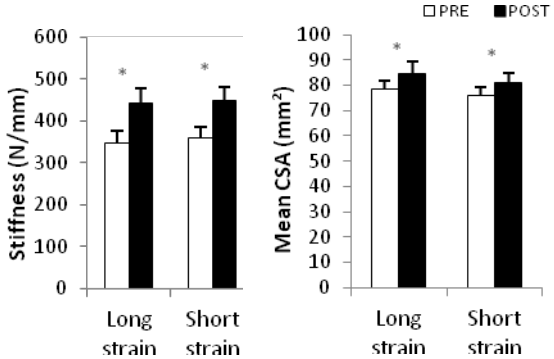


*Figure 1: Mean values and standard error of mean (error bars) of the Achilles tendon stiffness and mean CSA prior and after training intervention with long and short strain duration. * significant difference between pre and post ($p<0.05$).*

## Discussion

Both, short and long strain duration training interventions with high strain magnitude induced adaptations of the mechanical and morphological Achilles tendon properties (increase of tendon stiffness, elastic modulus and mean CSA). However, the results suggest that within the examined range a longer strain duration does not have beneficial effects compared to a shorter duration. In combination with our previous work [Arampatzis, 2007, 2010] we can argue that strain magnitude seems to be the most important stimulus for tendon adaptation. The findings provide evidence for human Achilles tendon plasticity in response to mechanical loading in vivo and give valuable information with regard to the improvement of human locomotor performance and tendon injury prevention.

## References

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