IN VIVO TENDON STIFFNESS VS. CONTRACTION SPEED IN TRICEPS SURAE MUSCLES

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INTRODUCTION

We have measured contraction velocity dependency of tendon stiffness during isometric contractions. The question of velocity dependency of tendons is relevant to researchers since theoretical models along with *in vitro* experiments have demonstrated that the shape of the stress-strain curve depends on strain rate [1]. In practice, tendon mechanical properties *in vivo* are often investigated at slower-than-natural stretching speeds, which could potentially induce systematic changes in tendon mechanical parameters as compared to more natural stretching speeds.

METHODS

Tendon stiffness at different speeds was deduced from 12 healthy non-competitive runners who volunteered for the study. The test was carried out in seated position in custom-built ankle dynamometer, where subjects produced isometric ramp-up contractions (up to 80% force level) at three different target speeds: SLOW (duration 3.5sec), MID (1.5sec) and FAST (0.5sec).

Ankle plantar flexion force as well as medial gastrocnemius (MG) tendon elongation was analysed from each trial. To calculate tendon elongation, heel displacement and MG myotendinous junction (MTJ) displacement were recorded. MTJ displacement was recorded with ultrasonography (125Hz) assisted by video camera to account for probe movement. MTJ movement was tracked by computer algorithm to remove contribution of possible biased human observations [2].

Due to large inter-individual variation in plantar flexion force and tendon strain, we have used normalised force and strain for each subject. Force was normalised to maximum voluntary contraction (MVC) force (expressed as %) and strain to maximum measurable strain. Tendon stiffness was calculated as the slope of the normalised force vs. strain curve in the linear region (20-60% of MVC).

RESULTS AND DISCUSSION

In total, 70 normalised force-strain curves were analysed. Figure 1 shows tendon stiffness against contraction speed, and it demonstrates that tendon stiffness was independent of contraction speed (r^2=0.048). Velocity dependency of tendon compliance could also shift the normalized force-strain curve to the right. This possibility was examined by plotting tendon strain at 60% force level against contraction speed (figure 2). There was no indication that tendon compliance depended on contraction speed (r^2=0.028).

The results suggest that tendon mechanical properties, even if determined during slow ramp contractions, might be comparable to natural locomotion. The fastest force production speed here, 80% of MVC/500ms, is roughly equivalent to that of walking [3].

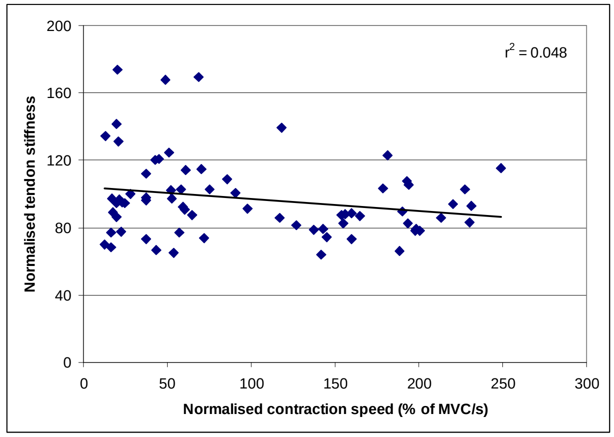

Figure 1: Normalised tendon stiffness (calculated from range 20-60% of MVC force) vs. normalised contraction speed (N=70).

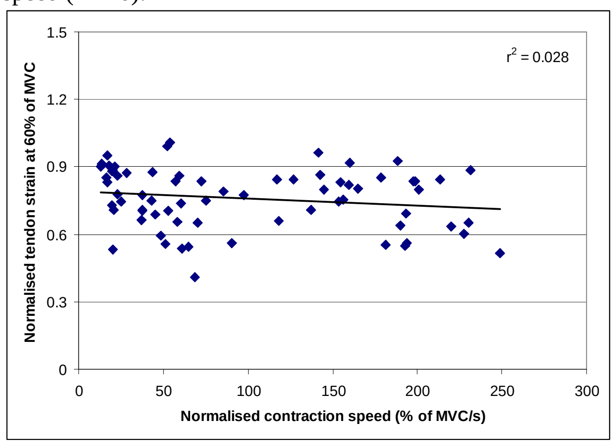

Figure 2: Normalised tendon strain at 60% of MVC force vs. normalised contraction speed (N=70).

CONCLUSIONS

Our data suggest that tendon stiffness is independent of contraction velocity. The same is true for tendon strain at the 60% force level. Our observations are in line with previous findings that tendon stiffness does not change with stretches related to a frequency band of 0.2-11Hz [4]. Therefore, slow and fast ramp contractions are equally suitable for defining tendon mechanical properties.

REFERENCES

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