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Mechanical and morphological properties of the gastrocnemius medialis muscle tendon unit after Achilles tendon rupture

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Introduction

Long term deficits in force generation of the triceps surae muscle-tendon unit (MTU) and functional limitations have been described after complete Achilles tendon (AT) ruptures (Mullaney et al., 2006). AT repair can also lead to a lengthening of the tendon (Kangas et al., 2007) and most likely places the calf muscle in a shortened position. We hypothesize a reorganization of the entire triceps surae MTU. To clarify the described deficits, this study investigates the mechanical and morphological properties of the MTU post rupture and their effect on force generation.

Methods

Eleven male subjects (age 44 ± 11 years) who underwent acute surgical repair of a complete AT rupture were analyzed 4.6 \pm 2 years after rupture. Gastrocnemius medialis (GM) tendon length, AT cross-sectional area (CSA), AT moment arm and tendon mechanical properties were determined using ultrasonography (US). Torque-angle relationship was assessed in five different ankle angles (20° dorsiflexion to 20° plantar flexion) capturing GM muscle architecture by US simultaneously. The healthy leg served as control. For all statistical analysis, $p = 0.05$ was accepted as the level of statistical significance.

Results

GM tendon is significantly longer ($13 \pm 10\%$) in the repaired leg (R) compared to the healthy control leg (C). Significant differences between R and C were observed in AT CSA ($52 \pm 11\%$) and GM fascicle length at rest ($31 \pm 9\%$). Tendon mechanical properties changed significantly between sites. While tendon stiffness increased in R compared to C ($39 \pm 14\%$), modulus of elasticity decreased ($38 \pm 104\%$). The deficit in maximum plantar flexor torque of R was $13 \pm 12\%$. Normalized torque-angle relationship showed no significant differences in dorsiflexed positions. Significant differences occurred in neutral and plantar flexed positions.

Discussion

Repaired ruptures of AT have been discussed to be more compliant 6 months after repair (McNair et al., 2013). The increased tendon stiffness in this study shows, that there must be reorganization in tendon during later stages. Force deficits in plantar flexion angles in R could be explained by a higher tendon-to-fascicle length ratio forcing fascicles to work in a disadvantageous region of their length-tension curve. Stiffer tendons are not able to compensate that effect.

References

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