Muscle and tendon adaptation in young and older adult athletes: A combined longitudinal and cross sectional investigation

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Introduction

Muscles and tendons are mechanosensitive, showing adaptive changes in response to mechanical loading (Arampatzis et al., 2007: J Exp Biol 210, 2743-2753). However, different time courses of muscle and tendon adaptation in response to training, as recently shown in adolescent subjects (Mersmann et al., 2016: J Appl Physiol 121, 893-899), may cause discordance within the muscle-tendon unit (MTU), increasing injury risk. In the current study, we aimed to examine triceps surae muscle strength and tendon stiffness in young adult elite sprinters and jumpers over one season, in order to detect potential discordance between muscle and tendon adaptation due to athletics training. Furthermore, we aimed to examine the effect of habitual athletics training on triceps surae MTU mechanical properties in young and older athletes, using a cross-sectional design.

Methods

Eleven healthy younger elite sprinters and jumpers (23 ± 3 years), 12 master athletes (66 ± 7 years), 12 recreationally active young controls (26 ± 3 years) and one young adult elite athlete, 10 months after unilateral Achilles tendon reconstruction participated in the study. All young adult athletes (11 healthy and the one unilateral Achilles tendon reconstruction patient) underwent regular (every 2 – 4 weeks) measurements over one season (longitudinal investigation). In order to analyse triceps surae muscle strength and tendon stiffness of both legs, subjects performed maximal isometric voluntary ankle plantarflexion contractions on a dynamometer. The gastrocnemius medialis tendon displacement was synchronously assessed using ultrasonography. To examine potential discordance between muscle and tendon adaptation due to athletics training, we examined the changes of both structures and calculated the coefficients of variation (CV) over one season. A one-way analysis of variance with subject group as a fixed factor and Bonferroni *post hoc* tests were used to investigate possible differences in MTU mechanical properties between subject groups.

Results

Within one season, similar patterns of relative changes in muscle strength and tendon stiffness were seen in the young elite athletes, with CVs of 8.7 ± 2.3 % (strength) and 12.7 ± 4.8 % (stiffness) over all analysed data points (on average, 16 per athlete). For the post tendon reconstruction athlete, the affected leg showed no observable increases in muscle strength or tendon stiffness over one season (average value over all data points: 1.8 ± 0.2 Nm/kg; 503.7 ± 90.7 N/mm), and remarkably lower muscle strength but similar tendon stiffness compared to the non-affected leg (3.4 ± 0.2 Nm/kg; 496.8 ± 33.1 N/mm). Healthy young elite athletes showed significantly ($p < .05$) higher muscle strength (4.0 ± 0.5 Nm/kg) and tendon stiffness (687.2 ± 115.1 N/mm) than both other subject groups, with no significant differences between young recreationally active controls and master athletes

(young controls: 3.2 ± 0.3 Nm/kg and 557 ± 70.2 N/mm; master athletes: 2.7 ± 0.6 Nm/kg and 574.2 ± 93.2 N/mm). When examining the age effect on muscle-tendon properties, relative differences were greater in muscle strength (33 %) than in tendon stiffness (17 %) in young, compared to older elite athletes.

Discussion

The results of our longitudinal investigation provide evidence for a concordant adaptation of muscle and tendon due to athletics training over one season within our analysed sample of healthy young adult elite sprinters and jumpers. Fifteen months after Achilles tendon reconstruction, we found no increases in triceps surae muscle strength or tendon stiffness due to athletics training in the elite athlete's affected leg, which had lower muscle strength and similar tendon stiffness values compared to the non-affected leg. Thus, Achilles tendon rupture and reconstruction may be a major risk factor for irreversible discordance within triceps surae MTU. Finally, the results provide evidence that habitual athletics training over the lifespan may effectively counteract age-related decreases in muscle strength and tendon stiffness and that tendons may not be any less adaptable to mechanical loading than skeletal muscles in old age.