

Matching participants for triceps surae muscle-tendon unit mechanical properties eliminates age-related differences in drop jump performance

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Introduction

Age-related declines in locomotor performance have been associated with a degeneration of the triceps surae muscle-tendon unit (MTU) capacities (Kulmala et al., 2014). However, to our knowledge, no studies have compared the motor task performance of young and older adults with similar triceps surae muscle strength and Achilles tendon stiffness. In the current study, we aimed to determine if differences in drop jump height or motor task execution strategy between young and middle-aged adults exist, when triceps surae MTU capacities (muscle strength and tendon stiffness) were matched.

Methods

The triceps surae MTU biomechanical properties of 29 middle-aged (50 - 65 years) and 26 younger (20 - 30 years) adults were assessed during isometric voluntary ankle plantarflexion contractions of the dominant leg using a custom-made dynamometer and ultrasonography (27 Hz; MyLabTMOne, Esaote; Genua, Italy) simultaneously. The resultant joint moments were calculated by means of inverse dynamics. The elongation of the tendon during contraction was assessed by digitizing the myotendinous junction of the gastrocnemius medialis muscle with a custom-made Matlab software (Matlab 2013b, MathWorks Inc., Natick, Massachusetts, USA) while taking into account the effect of potential ankle joint angular rotation during contraction (Muramatsu et al. 2001). Tendon stiffness was determined in the linear region of the force-length relationship. Following the MTU measurements, the 12 young adults with the lowest triceps surae muscle strength and the 12 middle-aged adults with the greatest muscle strength were compared. There were no significant differences between the matched young and middle-aged adults in muscle strength (young: 3.2 ± 0.4 ; middle-aged: 3.1 ± 0.5 Nm/kg), tendon stiffness (580.3 ± 121.8 ; 590.2 ± 108.4 N/mm) or tendon energy storage capacity (217 ± 63.2 ; 187.5 ± 82.7 J). The matched participants then completed a series of drop jumps. The instructions given to the subjects were "jump as high as possible with as little knee flexion as possible". In order to analyse drop jump performance and motor task execution strategy, ground contact time, average vertical ground reaction force, average mechanical power and jumping height were determined during drop jumps from different heights (13, 23, 33 and 39 cm) onto a force plate (90 x 60 cm, 1000 Hz; Kistler, Winterthur, CH). A two-way repeated measures ANOVA with age and drop height as factors was conducted in order to detect age-related differences in drop jump height and motor task execution strategy. The effect of muscle strength and tendon stiffness on drop jump height was investigated using Pearson's product-moment correlation coefficient.

Results

Younger and middle-aged adults attained comparable jumping heights independent of the drop jump height (Fig. 1). There were significant age effects on ground contact time ($p < .01$) and average vertical ground reaction force during ground contact phase ($p < .01$) (Fig. 1), with the middle-aged adults showing higher ground contact times but lower forces than the younger adults, leading to a significant age effect on mechanical power ($p < .05$). Significant ($p < .05$) correlations were found between triceps surae MTU capacities and drop jump height ($.41 \leq r \leq .81$; $p < .05$).

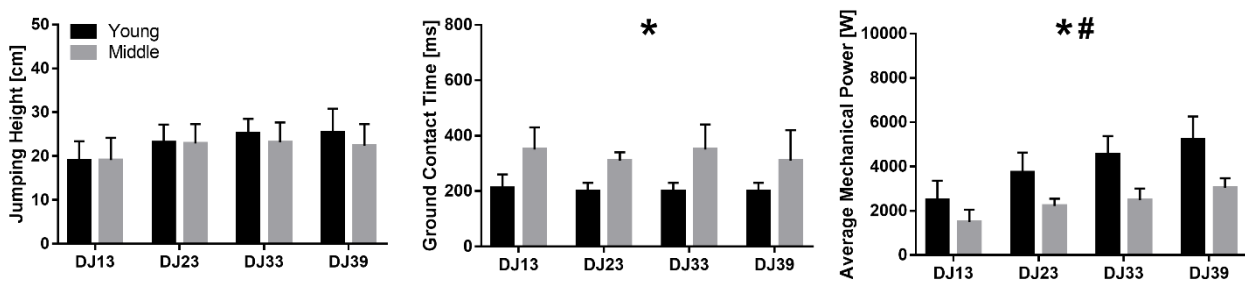


Fig. 1. Jumping height, ground contact time and average mechanical power during drop jumps from four heights in young and middle-aged subjects. *: Significant age effect ($p < .05$). #: Significant jump condition effect ($p < .05$).

Discussion

The results of the current study demonstrate that when triceps surae MTU capacities are matched, young and middle-aged adults show comparable performance (jump height) of a jumping task. However, the motor strategies used to achieve these similar performances differ, with the middle-aged adults demonstrating longer ground contact times, lower ground reaction forces and hence lower average mechanical power. Muscle strength and tendon stiffness appear to play an important role in jumping performance and countering the degeneration of these properties may help prevent the decline in locomotor function seen with ageing. Finally, the results suggest that neuromuscular factors other than maximum isometric strength and tendon stiffness may influence motor task execution strategy during jumping, such as the power generating capacity of the triceps surae muscle.

References

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