MATCHING TRICEPS SURAE MUSCLE STRENGTH AND TENDON STIFFNESS ELIMINATES AGE-RELATED DIFFERENCES IN DROP-JUMP PERFORMANCE

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We aimed to determine the influence of triceps surae (TS) muscle strength and Achilles tendon (AT) stiffness on age-related changes in locomotor performance and motor task execution strategy during a drop jump (DJ) task. After matching 12 young and 12 middle-aged adults for TS muscle strength and AT stiffness, all subjects performed a series of DJs from different starting heights. Matched young and middle-aged adults showed similar DJ performance but the middle-aged adults showed significantly longer ground contact times, lower values in maximum vertical ground reaction force during the support phase and lower mechanical power, independent of starting height. These results suggest that leg extensor muscle strength and tendon stiffness are the primary drivers of age-related changes in locomotor performance, but not motor task execution strategy selection during jumping.

KEY WORDS: muscle-tendon unit, ageing, locomotion, jumping mechanics

INTRODUCTION: Age-related changes in locomotor performance and motor task execution strategy have been associated with reduced leg-extensor muscle-tendon unit capacities in old age (Karamanidis & Arampatzis, 2005; Kulmala et al., 2014). However, it remains unclear if leg-extensor muscle strength and tendon stiffness are the primary drivers of these alterations seen with ageing, or if other factors also play a role. We aimed to determine if potential age-related differences in drop jump (DJ) performance and motor task execution strategy would be eliminated in a group of younger and middle-aged adults when triceps surae (TS) muscle strength and Achilles tendon (AT) stiffness were matched.

METHODS: Ankle plantarflexion moments and AT stiffness of both legs were assessed in 12 younger (20-30y) and 12 middle-aged (50-65y) adults during isometric plantarflexion contractions using dynamometry and ultrasonography synchronously. Tendon elongation during the loading phase was assessed by visualising the myotendinous junction of the gastrocnemius medialis muscle and stiffness of the AT was determined in the linear region of the force-length relationship. There were no significant differences between the matched young and middle-aged adults in maximal ankle plantarflexion moment (young: 3.2±0.4; middle-aged: 3.1±0.5 Nm/kg) and AT stiffness (580.3±121.8 vs. 590.2±108.4 N/mm). On a second occasion, the matched participants performed a series of DJs from different starting heights (13, 23, 33 and 39 cm) onto a force plate. A two-way ANOVA (factors: age, starting height) was performed in order to detect any age or starting height effects on DJ height and

motor task execution strategy. The effect of TS muscle strength and AT stiffness on DJ height was investigated by using Pearson's product-moment correlation coefficient.

RESULTS: There was no significant age effect for DJ performance, meaning that matched younger and middle-aged adults achieved similar DJ heights, independent of starting height (Fig. 1). Concerning DJ mechanics, there were significant age effects ($p<.05$) on ground contact time, maximum vertical ground reaction force and mechanical power, with the middle-aged adults showing higher ground contact times (Fig. 2A), but lower forces (Fig. 2B) and lower mechanical power (Fig. 2C) for all starting heights. Significant correlations were found between DJ performance and TS muscle strength and AT stiffness ($.41\leq r\leq.81$; $p<.05$) for all starting heights.

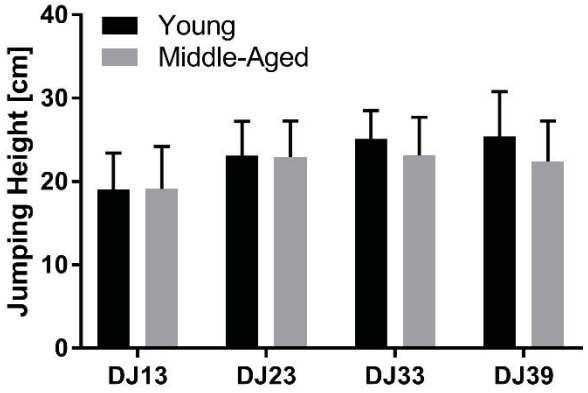

Figure 1: Jumping height during drop jumps from four different starting heights in matched young (*n* = 12) and middle-aged (*n* = 12) subjects. There was no significant subject group effect, independent of starting height.

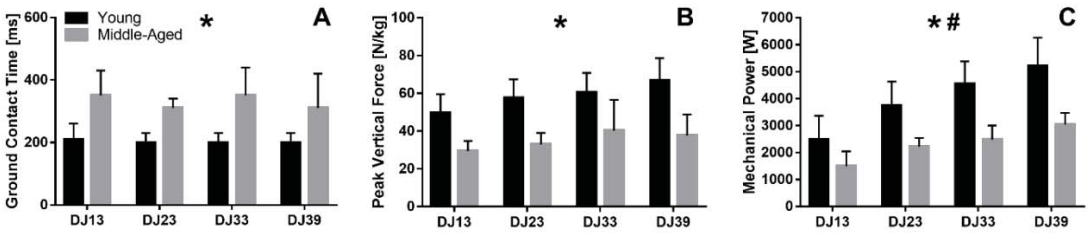

Figure 2: Ground contact times (A), maximum vertical ground reaction forces (B) and mechanical power (C) during drop jumps from four different starting heights in matched young (*n* = 12) and middle-aged (*n* = 12) subjects. *: Significant age effect ($p<.05$). #: Significant starting height effect ($p<.05$).

DISCUSSION: The results of the current study demonstrate that matching younger and middle-aged adults for TS muscle strength and AT stiffness eliminates age-related differences in the performance of a jumping task, independent of starting height and hence, task demand. However, the age groups used different motor task execution strategies, as measured by ground contact time, ground reaction forces and mechanical power for all starting heights, indicating that while changes in leg extensor muscle strength and tendon stiffness may be the primary drivers of deteriorated locomotor performance in older age, they may not be major contributors to motor task execution strategy during jumping.

CONCLUSION: Jumping performance appears to be unaffected when leg extensor muscle strength and tendon stiffness are maintained with age and therefore, countering the degeneration of these properties may help prevent the decline in locomotor performance seen with ageing.

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