Effect of long-term exercise-induced changes of the triceps surae muscle-tendon unit properties on maximal walking velocity in the elderly

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Keywords: aging, maximal walking velocity, tendon stiffness, muscle strength

Introduction

Deterioration in muscle strength and tendon stiffness in the elderly has been associated with modified motor task execution and reduced walking performance (Beijersbergen et al. 2013, *Ageing Res Rev* 12: 618-627; Reeves et al. 2009, *J Electromyogr Kinesiol* 19: 57-68). Using resistance training to counteract these degradations improves muscle function, and results in more effective and safer gait in the elderly (Karamanidis et al. 2014, *PLoS One* 9, e99330). In particular, the triceps surae (TS) muscle-tendon unit (MTU) properties have been proven to be important determinants for the walk-to-run transition velocity (Neptune & Sasaki 2005, *J Exp Biol* 208, 799–808), which emphasizes the relevant role of intrinsic MTU properties in gait performance. The objective of the current study was to examine if the enhanced capacities of the TS MTU mechanical and morphological properties as a result of training would improve gait velocity in the elderly.

Methods

Thirty-four female adults (60-75y) were recruited for either a long-term (1.5 years; n=12) experimental group or a control group (no physical exercise intervention; n=13). The experimental group underwent a 1.5 years high AT strain cyclic loading exercise intervention, previously shown to increase muscle strength and tendon stiffness (Arampatzis et al. 2007, *J Exp Biol* 210, 2743-2753). Maximal walking velocity, defined as walking with a double support phase, was analyzed using a motion capture system (120Hz; Vicon Motion Systems, Oxford, UK) and two force plates (60 x 40 cm, 1080 Hz; Kistler, Winterthur, CH). TS MTU mechanical properties were assessed using simultaneous dynamometry and ultrasonography (Esaote MyLab Five; Esaote Biomedica, Genoa, IT). TS morphological properties were examined in an unloaded prone position by using ultrasonography. A linear regression analysis was used to examine the relationship between TS MTU properties and maximal walking velocity, and a two-way repeated measures ANOVA was used to identify potential differences between values at baseline, after 14 weeks and after 1.5 years of exercise intervention.

Results

Using all the participating subjects (n=34), a significant correlation was found between the TS MTU mechanical and morphological properties and maximal gait velocity ($0.40 < r < 0.64$; $P < 0.05$). The experimental group showed higher TS muscle strength, tendon stiffness, and higher soleus and gastrocnemius medialis muscle thickness and pennation

angle after 14 weeks of exercise intervention in comparison to baseline ($P < 0.05$). Continuing the exercise intervention until 1.5 years resulted in no further significant increment in the analyzed parameters. However, while no significant changes in the calculated maximal gait velocity were identified after 14 weeks of the exercise intervention, there was a significant ($P < 0.05$) 6% increase in the maximal gait velocity after continuing the exercise intervention for 1.5 years in comparison to the baseline values. The control group showed no statistically significant differences in TS MTU mechanical and morphological properties or in the maximal gait velocity at the 14 weeks and 1.5 years measurement time points relative to baseline.

Discussion

The current study supports previous forward simulation models (Neptune & Sasaki 2005) showing that TS MTU properties are significant determinants of gait performance. However, it seems that 14 weeks of physical exercise intervention is not sufficient to fully utilize the changes in TS MTU properties during walking at maximal velocities. When considering the differences in maximal walking velocity between younger and older adults from the literature (younger approximately 10% faster; Bierbaum et al. 2011, *J Biomech* 44: 1921–1926), then the current observed changes (6% increase in maximal walking velocity) in the analysed older female adults after 1.5 years of exercise may be functionally relevant. The maintenance of the TS MTU capacities despite continuing the physical exercise intervention until 1.5 years indicate that neuronal components were responsible for the observed changes in the maximal walking velocity. Additionally, possible exercise-induced alterations in locomotion mechanics will be discussed.

Literature

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