O92- Effects of eccentric and plyometric trainings on Achilles tendon mechanical properties

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Tendons are able to change their mechanical properties by several adaptative mechanisms in response to chronic training. The aim of eccentric contraction is to store and then to dissipate potential elastic energy, while during plyometric actions the energy is restituted during a concentric contraction. This difference could lead to specific adaptations in tendon stiffness and dissipative properties. The effects of fourteen weeks of standardized eccentric and plyometric trainings on Achilles tendon stiffness and dissipative properties were assessed. No significant change in Achilles tendon mechanical properties was found after eccentric training ($P > 0.05$) while plyometric training increased tendon stiffness and reduced dissipation capacity of the tendon ($P < 0.05$). These specific adaptations of Achilles tendon mechanical properties to eccentric and plyometric training are discussed and appeared to be consistent with functional implication of Achilles tendon in both eccentric and plyometric actions.
Keywords: Tendon, Eccentric training, Plyometrics, Stiffness, Dissipative properties.

INTRODUCTION

Tendons are able to change their mechanical properties by several adaptative mechanisms in response to mechanical stress (Wang, 2006). Within these mechanical properties, the tendon stiffness has been of particular interest. In contrast and surprisingly, changes in dissipative properties of the tendon have received lower attention in the literature. It is generally thought that when tissues are too stiff, they cannot absorb sufficient energy associated with loading, and subsequently are more likely to be injured (McNair and Stanley, 1996). It has also been shown that for optimal performance in gait activities, tendon stiffness is important (Kubo et al., 2007), as it directly affects elastic energy storage-recoil processes and muscular tension transmission (Komi, 1992). The difference in use of elastic energy by the tendon during eccentric and plyometric actions (i.e., dissipation and recoil respectively) could induce different adaptations in tendon mechanical properties. Effects of plyometric training on mechanical properties of tendon were already assessed in a previous study (Fouré et al., 2010). The aim of the present study was then to determine effects of 14 weeks of eccentric training on mechanical properties of the Achilles tendon and to compare qualitatively adaptations induced by both eccentric and plyometric trainings.

METHODS

Twenty-six males were assigned to the eccentric (ECC, $n = 11$) and control group (CONT, $n = 15$) and were tested before and after the 14 weeks of training. Eccentric training protocol were standardized and designed from previous studies (Mahieu et al., 2008; Fouré et al., 2010).

Subjects were lying prone with thighs, hips and shoulders secured by adjustable lap belts and held in position. The linear array probe mounted on an externally fixed bracket was strapped onto the skin of subjects to obtain longitudinal ultrasonic images of the distal myotendinous junction of the medial *gastrocnemius* (Figure 1).

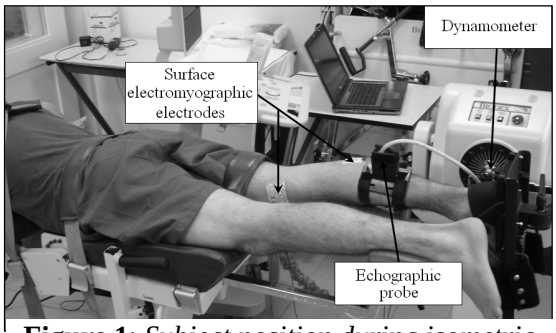

Figure 1: *Subject position during isometric contraction.*

The stiffness and dissipative properties of the Achilles tendon were determined during a constant increase in isometric torque in plantar flexion, from a relaxed state to 90% of MVC within 5 s, followed by a constant decrease in isometric torque, from 90% of MVC to the rest state within 5 s. The tendon stiffness (S_{AT}) was calculated as the slope of the tendon force-length relationship between 50% and 90% of the MVC. Areas under loading and unloading curves were calculated and represent the potential elastic energy stored and recoiled energy respectively. From these parameters, a dissipation coefficient (DC) was calculated (Fouré et al., 2010). Two-way multivariate analyses of variance (ANOVA) (group × time) were performed to assess the statistical significance of changes in mechanical parameters.

RESULTS AND DISCUSSION

A significant increase of 24.1% in S_{AT} was found for the plyometric group (PLYO, n=9) (Fouré et al., 2010). No change in S_{AT} was found for ECC and CONT groups ($P > 0.05$) (Table 1). Effects of eccentric and plyometric trainings on tendon stiffness were similar to previous studies (Kubo et al., 2007; Fouré et al., 2010). In the present study no significant change was shown for ECC and CONT groups ($P < 0.05$, Table 1) while a decrease of 35.0% in DC was determined for PLYO group (Fouré et al., 2010).

Table 1: Mean values of the Achilles tendon stiffness (S_{AT}) and dissipative coefficient (DC) for eccentric (ECC), plyometric (PLYO) and control (CONT) groups. Mean ± standard deviation.

	ECC		**PLYO**		**CONT**	
	Pretest	**Posttest**	**Pretest**	**Posttest**	**Pretest**	**Posttest**
S_{AT} (N/mm)	*215.8 ± 55.0*	*251.1 ± 109.2*	*224.7 ± 92.2*	*284.3 ± 139 .0 **	*265.5 ± 143.2*	*259.9 ± 129.9*
DC (%)	*27.8 ± 13.7*	*26.3 ± 11.2*	*36.9 ± 11.3*	*23.6 ± 9.3**	*32.4 ± 12.7*	*34.7 ± 13.6*

*Significant change between pretest and posttest: *P < 0.05.*

Plyometric training enhances the muscular tension transmission *via* an increase in tendon stiffness and a decrease in DC. Thus, long-term plyometric training induced changes in mechanical properties of tendinous structures, which improve muscle tension transmission and the storage-recoil of elastic energy, but may also increase the risk of muscle or tendon injuries. In contrast, eccentric exercises, which are highly used in strength and rehabilitation programs, seem to be a more secure manner to increase muscular strength and, in the same time, protect muscle and tendon structures from injuries though an upward trend in S_{AT} and non change in DC.

CONCLUSIONS

In spite of the high stress imposed to tendon during eccentric exercises, the lack of change in tendon mechanical properties (i.e., S_{AT} and DC) could contribute to protect tendon and muscle structures. Plyometric training enhances the muscular tension transmission through an increase in stiffness and a reduction in energy dissipated by the tendon. Specific adaptations of mechanical properties of Achilles tendon after 14 weeks of plyometric and eccentric training have a major effect in functional behaviour in both clinical interventions and physical activities.

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