

SARCOMERE NUMBER ADAPTATION IN THE RABBIT TIBALIS ANTERIOR AFTER CHRONIC ECCENTRIC EXERCISE

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INTRODUCTION

It has been well documented that a bout of eccentric exercise causes subsequent pain and discomfort within days of the exercise. However subsequent eccentric exercise fails to produce the same discomfort. One proposed theory used to explain this repeated-bout effect links fiber damage produced through the popping of weak sarcomeres on the descending limb of the force-length relationship (FLR) to a subsequent increased serial sarcomere number within the fibers. This would result in a rightward shift of the FLR, allowing the adapted muscle fibers to operate over the ascending limb and plateau of the FLR with subsequent exercise bouts (Proske and Morgan, 2001). This mechanism is based on damage as a precursor to adaptation, and thus should only occur with eccentric exercise performed on the descending limb of the FLR. Although studies have shown a significant increase in serial sarcomere number with an *in-vivo* animal model (Lynn et al., 1998) as well as a controlled eccentric training protocol (Koh and Herzog 1998), pre and post-exercise FLRs have not been reported. The purpose of this study was to assess the adaptation of the ankle dorsiflexors in conjunction with the FLR, before and after a chronic eccentric exercise protocol.

METHODS

Nerve cuff electrodes were implanted bilaterally on the peroneal nerves of nine

adult New Zealand white rabbits. The left nerve cuff electrode was attached to a custom made subcutaneous electrical interface that allowed the formation of temporary connections to an external stimulator (Koh and Leonard, 1996). The interface was connected to a stimulator, and the anesthetized rabbits were placed supine in a sling with their left foot attached to a foot plate connected to the cam of a servo motor. Supra-maximal stimulation was determined (voltage $3\times$ α -motoneuron threshold, 150 Hz) and the isometric FLR of the ankle dorsi-flexors was assessed on day one. Subsequently, an eccentric exercise bout of 5 sets of 10 repetitions was performed (stimulus train duration = 500 ms) from a tibiotarsal joint angle of 70° - 105° at $70^{\circ} \text{ sec}^{-1}$. The eccentric exercise protocol was repeated 3 times per week for 6 weeks, with at least 48 hours rest between bouts. One week after the last exercise bout, the FLR was repeated, and the rabbits were euthanized 48 hours later. Left and right tibialis anterior (TA) muscles were excised, weighed and processed. Six fascicles were teased from the superficial and deep layers of the central third, and placed on glass slides. Fascicle and sarcomere lengths were measured and analyzed.

RESULTS AND DISCUSSION

Seven rabbits were used in the final analysis. Mean weight of the TA between trained ($6.19 \pm .591\text{g}$) and contralateral control ($5.10 \pm .579\text{g}$) limbs using a paired t-test showed a significant training effect of the

exercise protocol ($p < .001$). The FLR showed no rightward shift after the 6 week training protocol (Fig.1). There was a small (3.6%) but significant increase in serial

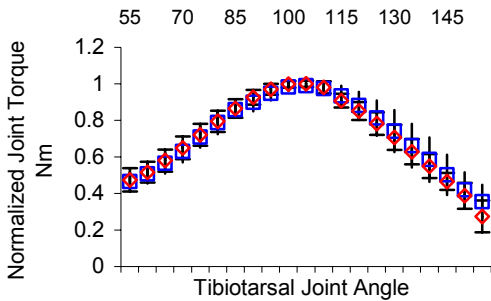


Figure 1. Isometric FLR pre (\diamond) and post (\square) exercise (mean \pm SD)

sarcomere number in the superficial fibers of the central portion of the exercised TA ($p < .05$). Sarcomere number was not significantly different between the deep fibers of the trained and control TA (Fig. 2). Normalizing sarcomere number to 1 mm

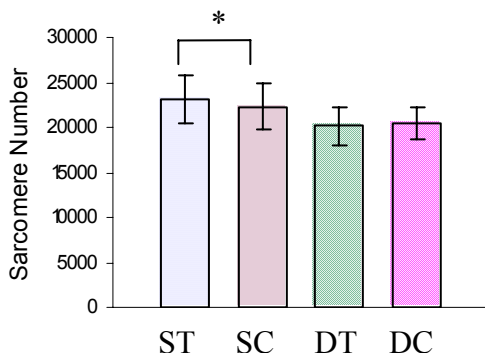


Figure 2. Graph of serial sarcomere numbers for superficial trained (ST), superficial control (SC), deep trained (DT), and deep control (DC) fascicles. (Mean \pm SD)

Table 1. Values are Mean \pm SD

	Sarcomere # / mm (density)		Fascicle Length (mm)	
	TA Superficial	TA Deep	TA Superficial	TA Deep
trained	479.09 \pm 20.97	467.71 \pm 33.57	48.44 \pm 7.40	43.51 \pm 6.33
control	474.84 \pm 28.56	461.98 \pm 32.55	47.37 \pm 7.69	44.20 \pm 4.46
difference	4.25	5.73	1.07	-0.69
P- value	.443	.253	.042*	.530

of fascicle length showed the actual number of sarcomeres/mm (density) remained unchanged with no significant differences between the measures. Superficial fascicle lengths were significantly longer (2%), compared to the controls ($p < .05$) (table1), suggesting sarcomere density remains constant, and fascicle lengths increase in response to chronic eccentric exercise.

SUMMARY

Although there was a significant increase in serial sarcomere number, this appeared to be due to an increasing fascicle length, as sarcomere numbers per length of fascicle (density) remained unchanged. The exercise protocol was performed through a ROM consistent with the ascending limb and plateau of the FLR, which may account for the small increase in sarcomere number and lack of shift in the FLR. Future studies using eccentric exercise over a greater ROM may help explain these findings.

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