THE INFLUENCE OF DIFFERENT MECHANICAL STIMULI AND GROWTH ON THE MECHANICAL PROPERTIES OF THE ACHILLES TENDON IN THE FEMALE RAT

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INTRODUCTION

Even though tendon injuries rank among the most frequently occurring sport injuries [1], the adaptation of the tendon to exercise is not well investigated. It is known that different kinds of physical activity create different mechanical stimuli on biological materials leading to different adaptation effects. This has been shown for example for bone tissue [2] but had not yet been investigated for the tendon. Therefore, the aim of this study is to analyze the effect of running exercise, which creates single impacts with short rest periods between the impacts (~2.4 Hz)[3] in contrast to vibration strength training, that creates close following impacts; and growth on the mechanical and morphological properties of the rat Achilles tendon.

METHODS

Forty-two female Sprague Dawley rats of 11 weeks age (233 ± 20g) were divided into four groups: a basis control group (BC, n=10) that was killed at the beginning of the study; a non-active age matched control group (AMC, n=10); a voluntary wheel running group (RT, n=10) that was single housed and had free access to a running wheel; and a vibration strength training group (VST, n=12). The VST group trained voluntarily in a rat squat machine, where the rats had to lift a weight to reach a special food. When the weight was lifted a vibration plate (25 Hz) under the rat's feet was activated. Three rats of the VST group had to be excluded from the study, because they did not use the squat machine frequently enough. After a 12 week training period the rats were killed by decapitation and the Achilles tendon was dissected. The left Achilles tendons were at first cyclically tested with 30 cycles up to 10 N. With the last cycle the hysteresis and creep (in % of the original length) were determined. Afterwards the tendons were tested until failure to determine the ultimate load, ultimate load per body mass, stiffness and deformation. The right Achilles tendons were embedded in paraffin and will be sectioned and stained to determine the cross sectional area. The significance of difference between the groups was determined by an one-way ANOVA. All statistical tests were evaluated using $\alpha < 0.05$.

RESULTS AND DISCUSSION

The average running distance of the rats in the RT group was 9.6 ± 2.9km/day. The animals of the VST group lifted the weight (250 - 450g at the end of the study) for 161 ± 112s/day. At the end of the study the AMC group (327 ± 31g) was significantly heavier than RT group (283 ± 25g, $p = 0.010$). There was no significant difference between the VST group (305 ± 36g) and the other two groups concerning the body mass. Regarding the mechanical properties of the Achilles tendon, no significant differences could be found between the groups (Table 1). But if the ultimate load is adjusted according to body mass, the BC group revealed significantly ($p \leq 0.001$) higher values than the AMC and the VST group. Thus, neither vibration strength training nor growth cause an increase in the ultimate load of the tendon but rather the ultimate load per body mass decreases. Running training seems to compensate an age related decrease of the ultimate load per body mass. These results indicate that the kind of mechanical stimulus has an influence on the mechanical properties of the Achilles tendon but that the tendon is predominantly influenced by growth effects in younger adult rats. These results are in line with the hypothesis of Smith et al. [4] who formulated that once an optimised tendon is formed during skeletal maturity no more distinct adaptation will occur.

REFERENCES

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Table 1: Mechanical properties of the Achilles tendon. Values presented are means ± SD. *Values significantly ($p \leq 0.001$) different to the BC group

Group		Achilles Tendon					
		F_{max} [N]	F_{max}/mass [N/kg]	Stiffness [MPa]	Deformation [mm]	Hysteresis [%]	Creep [%]
BC	[n=10]	47.1 ± 5.1	203 ± 25	40.5 ± 8.7	2.10 ± 0.41	20.8 ± 5.4	0.25 ± 0.06
AMC	[n=10]	45.0 ± 9.6	138 ± 27*	49.9 ± 11.4	1.59 ± 0.48	18.4 ± 5.8	0.28 ± 0.09
RT	[n=10]	47.7 ± 9.1	169 ± 35	49.5 ± 11.0	1.67 ± 0.56	17.4 ± 3.4	0.28 ± 0.04
VST	[n=9]	42.0 ± 9.4	137 ± 38*	42.8 ± 14.1	1.65 ± 0.40	16.6 ± 2.6	0.25 ± 0.06