Eccentric training improves tendon biomechanical properties: a rat model

Introduction

• Eccentric = treatment of choice for tendinopathies
• Prolonged program of sub-maximal eccentric contractions reduced all symptoms of tendinopathy
• A minimum of 20 training sessions appears to be necessary
• Morphological and biochemical changes in the tissue are not yet clear
Aim

- To better define the biomechanical changes that affect healthy tendinous tissue after eccentric and concentric training
Materials & methods

• The Institutional Animal Care and Use Ethics Committee of the University of Liège approved the protocol used in this study
Materials & methods

18 rats

Group U
Untrained
6 rats
No physical exercise

Group C
Concentrique
6 rats
Running on treadmill
(+15°, 17m/min, 1h, 3x/sem, 5 sem)

Group E
Eccentrique
6 rats
Running on treadmill
(-15°, 17m/min, 1h, 3x/sem, 5 sem)
Materials & methods

- Tricipital tendon
- Patellar tendon bilaterally
- Achilles tendon
Materials & methods

• Biomechanical testing up to rupture after measurement

• Histological cross-section

Haematoxylin eosin

Masson’s trichrome
Results

<table>
<thead>
<tr>
<th>Tendons</th>
<th>$U$</th>
<th>$C$</th>
<th>$E$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-training weight (g; average ± standard deviations [SD])</td>
<td>338.2 ± 2.1</td>
<td>356.4 ± 10.7</td>
<td>363.0 ± 5.7</td>
</tr>
<tr>
<td>Weight after 5 weeks of training (g; average ± SD)</td>
<td>424.4 ± 14.57</td>
<td>441.6 ± 3.3</td>
<td>467.0 ± 19.8</td>
</tr>
<tr>
<td>$A$ (mm$^2$; average ± SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Achilles</td>
<td>27.1 ± 10.9</td>
<td>19.4 ± 3.8</td>
<td>25.7 ± 9.5</td>
</tr>
<tr>
<td>Patellar</td>
<td>48.5 ± 11.5</td>
<td>36.8 ± 15.4</td>
<td>36.6 ± 6.8</td>
</tr>
<tr>
<td>Tricipital</td>
<td>45.5 ± 17.9</td>
<td>74.8 ± 16.4</td>
<td>79.1 ± 20.2</td>
</tr>
<tr>
<td>$F$ (N; average ± SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Achilles</td>
<td>61.7 ± 8.5</td>
<td>66.4 ± 8.9</td>
<td>71.5 ± 13.1</td>
</tr>
<tr>
<td>Patellar</td>
<td>61.2 ± 8.3</td>
<td>75.3 ± 10.3</td>
<td>79.3 ± 11.3</td>
</tr>
<tr>
<td>Tricipital</td>
<td>28.6 ± 9.9</td>
<td>36.5 ± 7.0</td>
<td>44.6 ± 7.6</td>
</tr>
<tr>
<td>$F/A$ (MPa; average ± SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Achilles</td>
<td>2.38 ± 1.28</td>
<td>3.58 ± 0.82</td>
<td>3.43 ± 1.61</td>
</tr>
<tr>
<td>Patellar</td>
<td>1.44 ± 0.47</td>
<td>2.40 ± 1.21</td>
<td>2.66 ± 0.33</td>
</tr>
<tr>
<td>Tricipital</td>
<td>0.38 ± 0.11</td>
<td>0.54 ± 0.20</td>
<td>0.63 ± 0.07</td>
</tr>
</tbody>
</table>

*P < 0.05. **P = 0.051.
Results
Discussion

- Improvement in the mechanical qualities:
  eccentric training > absence of training
  concentric training = absence of training

- Some studies ➔ sub-maximal eccentric exercise reduces the tendency of the tendon to degenerate by increasing the collagen fiber content and/or by reducing the neovascularisation.
Discussion

• Mechanical strength per surface area = between the three groups

→ no modification in the quality of the histological structure

→ the higher resistance relies on an increase in the tendon cross-sectional area
Discussion

• The physiological process = mechanotransduction

• = range of phenomena through which the organism converts mechanical stress into cellular responses ➔ structural changes

• = non-neural physiological process, which contributes to the maintenance of normal musculoskeletal structure in the absence of an injury, and to healing after an injury
Conclusion

- The mechanical properties of tendons in rats improve after specific training, especially following eccentric training.
- The higher resistance of trained tendons mostly results from an increase of the cross-sectional area although small modifications of the tissue architecture may also play a role.
- Our results partly explained how mechanical loading, especially in eccentric mode, could improve the healing of tendon.
Eccentric Training Improves Tendon Biomechanical Properties: A Rat Model

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ABSTRACT: The treatment of choice for tendinopathies is eccentric reeducation. Although the clinical results appear favorable, the biomechanical changes to the tissue are not yet clear. Even if the mechanotransduction theory is commonly accepted, the physiology of tendons is not clearly understood. We aimed to better define the biomechanical and histological changes that affect healthy tendon after eccentric and concentric training. This study compared the effects of two methods of training (eccentric [E] training and concentric [C] training) with untrained (U) rats. The animals were trained over a period of 5 weeks. The tricipital, patellar, and Achilles tendons were removed, measured and a tensile test until failure was performed. A histological analysis (hematoxylin and eosin and Masson's trichrome stains) was also realized. There was a significant increase in the rupture force of the patellar and tricipital tendons between the U and E groups. The tricipital tendons in the control group presented a significantly smaller cross-sectional area than the E- and C-trained groups, but none was constated between E and C groups. No significant difference was observed for the mechanical stress between the three groups for all three tendons. Histological studies demonstrated the development of a greater number of blood vessels and a larger quantity of collagen in the E group. The mechanical properties of tendons in rats improve after specific training, especially following eccentric training. Our results partly explained how mechanical loading, especially in eccentric mode, could improve the healing of tendon. © 2012 Orthopaedic Research Society. Published by Wiley Periodicals, Inc. J Orthop Res 31:119–124, 2013

Keywords: tendon; eccentric; concentric; rat
Thank you!

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