MORPHOLOGICAL AND FUNCTIONAL MUSCLE ADAPTATION AFTER ECCENTRIC EXERCISE LOADING

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Introduction

Exercise loading can affect the radial and longitudinal growth of skeletal muscles. Although there are many studies in the literature on radial muscle adaptation, there is little information about longitudinal muscle adaptation in humans. It is believed that eccentric loading might be an adequate mechanical stimulus for longitudinal muscle growth [Proske and Morgan, 2001; Butterfield and Herzog, 2006]. Therefore, the purpose of this study was to investigate the effect of loading magnitude, muscle lengthening velocity and muscle length range during eccentric loading on longitudinal adaptation of the vastus lateralis muscle.

Methods

Fifty-three participants voluntarily participated in this study. They were randomly divided into two experimental groups and one control group. The experimental groups performed eccentric training of the knee extensors using an isokinetic dynamometer (Biodex 3) for 10 weeks, 3 days per week and 5 sets per training day. The control group did not experience any specific training. Thirty-one participants successfully completed the intervention. We investigated four different exercise protocols, where the magnitude of the eccentric stimulus, the muscle lengthening velocity and the muscle length where the eccentric stimulus has been applied were modified. The first group (n=10) exercised the knee extensors of one leg (protocol 1) at 65% of the maximum voluntary contraction (MVC) and the second leg (protocol 2) at 100% MVC. The angular velocity of the eccentric contractions was 90°/s and the range of motion from 25° to 100° knee angle in both protocols. The second group (n=10) exercised one leg at 100% MVC, 90°/s angular velocity and a range of motion between 25° and 65° (i.e. short muscle length, protocol 3). The other leg was exercised at 100% MVC, 240°/s angular velocity (i.e. high muscle lengthening velocity) and range of motion between 25° and 100° (protocol 4). In the pre-post measurements we examined the fascicle length of the vastus lateralis from 20° to 90° knee angle and the moment-angle relationship of the knee extensors.

Results

We found a significant increase ($p<0.05$) of fascicle length of the vastus lateralis muscle compared to the control group, yet only in the leg trained with protocol 4 (i.e. high muscle lengthening velocity). The increase (~14%) in fascicle length was similar for the whole range of the knee angle. However, A shift in optimum angle in the moment-angle relationship to the right (i.e. greater muscle lengths) has not been identified. During the training in protocol 4 the fascicle lengthening velocity of the vastus lateralis was ~2 times higher compared to the other three protocols. Furthermore, the highest strain velocity of the fascicles has been located in the phase where the moment decreased. All protocols resulted in an increase of maximum joint moment over the whole range of motion, with a superior increase in protocol 2.

Discussion

Exercise protocol 4 was the only one that showed clear longitudinal changes in fascicle length. These findings give evidence that not every eccentric exercise loading causes an increase in fascicle length and that the lengthening velocity of fascicle seems to be the most important factor for longitudinal muscle adaptation. Although the underling mechanisms regarding the longitudinal adaptation of the muscle (i.e. increase of sarcomeres in series) are not well known, we can argue that a high lengthening velocity of the fascicles might be necessary to trigger a homeostatic perturbation in muscles to induce longitudinal plastic changes.

References

Butterfield and Herzog, *Pflügers Arc Eur J Phys*, *451*:688–700, 2006.

Proske and Morgan, J Physiol 537: 333-345, 2001.