SHIFT OF THE OPTIMUM FASCICLE LEGNTH AFTER ECCENTRIC EXERCISE ON THE ASCENDING LIMB OF THE FORCE-LENGTH RELATIONSHIP IN HUMAN ANKLE DORSIFLEXOR *IN-VIVO*

[1] Hae-Dong Lee, [2]Seung-Jae Kim, [3]Dae-Yeon Lee, [4]Toshiyuki Kurihara and [4]Yasuo Kawakami
[1]Chungnam National University, [2]Hanseo University, [3]Korea University, and [4]Waseda University
Email: xbridge1997@cnu.ac.kr

INTRODUCTION

Eccentric contraction is defined as lengthening of a muscle while active. Unlike isometric and concentric contractions, eccentric contraction, performed on the descending limb of the force-length relationship in particular, induces muscle damage. One of mechanical damage indicators is a shift of the optimum muscle length of the force-length relationship, which is accounted for by the "popping sarcomere" theory [1]. However, lack of information on the shift of the optimum muscle length, not joint angle, for in-vivo human skeletal muscles makes it intangible.

The purpose of this study was to test a hypothesis that an exercise involving maximum eccentric contractions on the ascending limb does not influence the optimum joint angle and fascicle length of in-vivo human skeletal muscle, i.e., eccentric exercise-induced muscle damage is muscle length-dependent.

METHODS

Twelve subjects performed 120 maximum eccentric ankle dorsiflexions (10-repetitionin × 12 sets) on a dynamometer (Con-Trex® Multi Joint Testing Module, Switzerland). One group (n = 6, ECC_S) performed the exercise at short muscle length (ankle ROM between -5° to 15°) and the other group (n = 6, ECC_L) did it at long muscle length (ankle ROM 10° to 30°). Before (Pre) and immediately after (Post) the exercise, the torque-angle and force-length relationships (FLR) were measured along with electromyography (EMG) of the tibialis anterior (TA) were obtained. The force-length relationships of the TA were determined using the fascicle lengths measured from the visible portion of the ultrasound images and the muscle force estimated from [measured torques / moment arm lengths [2]] × [measured pennation angle]. The optimum joint angle and fascicle length was determined using a fitted curve on the FLR by a 3rd polynomial equation.

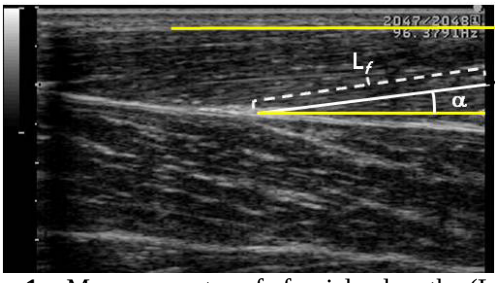

Figure 1: Measurements of fascicle length (L_f) and pennation angle (α) from ultrasound image of the tibialis anterior.

RESULTS AND DISCUSSION

Following the eccentric exercise, the peak isometric torque dropped to 75 ± 3% and 83 ± 3% for ECC_S and ECC_L, respectively, compared with the baseline values. The optimum joint angle shifted from 9.0 ± 1.8° to 13.9 ± 1.5° for ECC_S and from 6.7 ± 2.9° to 9.8 ± 2.9° for ECC_L, without significant difference between the groups. The optimum fascicle length also shifted toward the longer length (Fig. 2). Overall, the optimum length altered following the eccentric exercise from 39.3 ± 2.0 mm to 43.9 ± 3.3 mm, without significant difference between the groups.

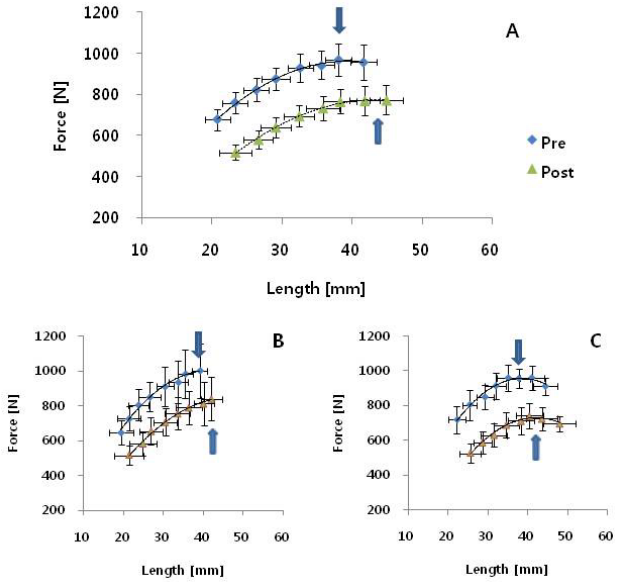

Figure 2: Force-length relationships before and after the eccentric exercise for overall (A), ECC_S (B) and ECC_L (C).

CONCLUSIONS

The popping sarcomere theory explains that the shift of the optimum length is primarily due to eccentric contraction-induced muscle damage on the descending limb of FLR. Despite of the fact that the TA fascicle works predominantly on the ascending limb of the FLR [2], the current study observed a shift of optimum TA fascicle length toward the longer length, rejecting our hypothesis. The results of this study provide evidence that this phenomenon is not fully accounted for by the popping sarcomere theory [1], suggesting further investigation for other mechanisms such as fatigue [3].

ACKNOWLEDGMENT

Korean Research Foundation Grant by the Korean Government (MOEHRD, Basic Research Promotion Fund) (KRF-2007-314-G00015)

REFERENCES

1. Morgan DL et al. *J Appl Physiol*. **87**:2007-2015, 1999.
2. Maganaris CN et al. *Clin Biomech (Bristol , Avon)*. **14**:661-666, 1999.
3. Butterfield TA et al. *J Biomech.* **38**:1932-1937, 2005.