MYOFASCIAL FORCE TRANSISSION IS MORE IMPORTANT AT LOW-FREQUENCY STIMULATION

H.J.M Meijer[1], G. C. Baan[1] and P.A. Huijing[1, 2]
[1] Instituut voor Fundamentele en Klinische Bewegingswetenschappen, Vrije Universiteit, Amsterdam, NL
[2] Integrated Biomechanical Engineering for Restoration of Human Function, Faculteit Construerende Technische Wetenschappen, Technische Universiteit Twente, NL
Email: h.meijer@fbw.vu.nl

INTRODUCTION

In addition to myotendinous force transmission, force exerted by the sarcomeres can be transmitted between the muscle and surrounding inter- and extramuscular connective tissue, *i.e.* myofascial force transmission [1]. Proof of such epimuscular force transmission is a difference in force exerted at the origin and insertion of a muscle [2]. For fully activated muscle, myofascial force transmission has been shown to be important for muscle properties. However during *in vivo* motion, firing frequency may vary (in rat EDL muscle between 10 and 60 Hz [3]). Therefore, effects of submaximal stimulation frequencies on myofascial force transmission were investigated for fully recruited rat extensor digitorum muscle (EDL).

METHODS

Male Wistar rats were anaesthetized and the anterior crural compartment was exposed. Proximal and distal tendons of the extensor digitorum muscle (EDL) and the tied distal tendons of the complex of tibialis anterior and extensor hallucis longus (TAEHL) were severed and connected to force transducers. Fully recruited EDL and TAEHL muscles were stimulated at 10, 20, 30 and 100 Hz. The TAEHL complex was kept at constant length, and length-force characteristics after distal lengthening of EDL were determined at the distal and proximal tendons.

RESULTS AND DISCUSSION

At lower firing frequencies, significant proximo-distal EDL force differences exist, indicating epimuscular force transmission (e.g. Fig. 1). Maximal absolute EDL proximo-distal active force differences were highest at 100 Hz ($F_{dist-prox}$ =0.4 N). However, the percentual difference (Fig. 2) was highest at 10 Hz (F = 30 $\%F_{dist}$). Firing frequency dependent shifts of EDL optimum muscle length were found, although proximally and distally assessed effects of firing frequency differed quantitatively. After distal EDL lengthening, TAEHL distal isometric active force decreased progressively with a peak decrease at 100Hz ($F_{from\ initial}$ = - 0.25 N). However, the highest percentual decrease was found for 10 Hz stimulation ($F_{from\ initial}$ = - 40%).

CONCLUSIONS

Myofascial force transmission becomes more important at lower submaximal firing frequencies: with a decreasing firing frequency, relatively more force is transmitted myofascially relative to the myotendinous path. Evidently, at progressively lower firing frequencies, the stiffness of epimuscular myofascial paths of force transmission decreases less than the stiffness of serial sarcomeres and myotendinous pathways. It is therefore concluded that low firing frequencies as encountered *in vivo,* enhance the relative importance of epimuscular myofascial force transmission with respect to the myotendinous force transmission.

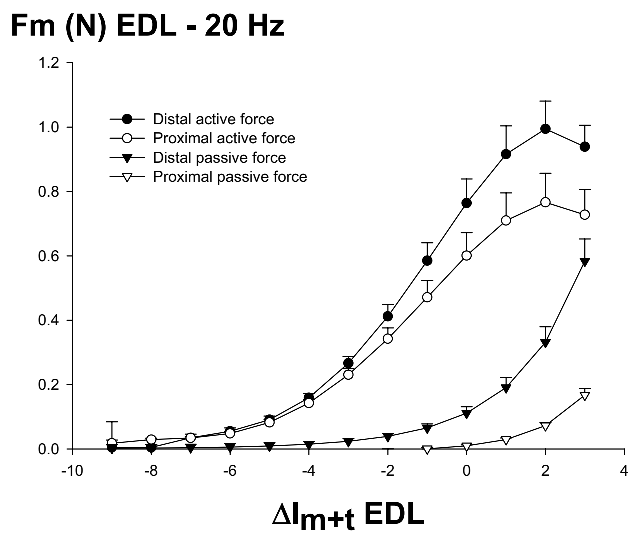

Figure 1: EDL proximal and distal length force characteristics at 20 Hz, as a function of EDL muscle-tendon complex length, increased by distal EDL lengthening (l_{m+t} EDL dist), expressed as deviation from 100 Hz distal optimum length. Error bars represent standard errors.

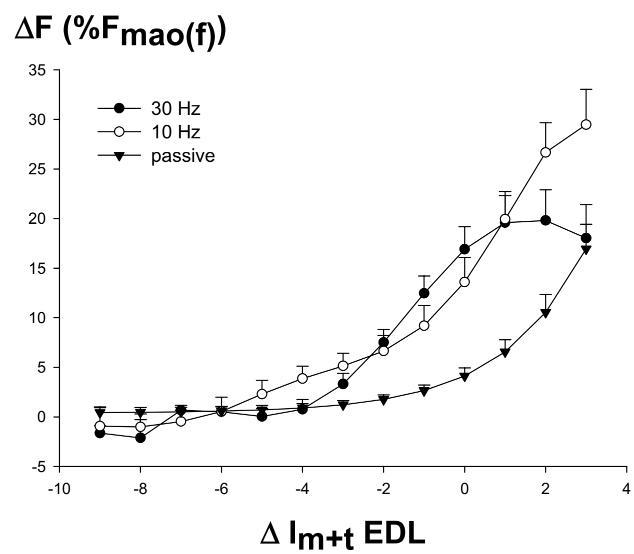

Figure 2: Effects of firing frequency and EDL muscle-tendon complex length on the proximo-distal difference in active force, normalized for distal optimum active force ($F_{mao\ (f)}$), and passive force (normalized for distal 100 Hz optimum force). Error bars represent standard errors.

REFERENCES

1. Huijing, PA, et al.. *J. Exp. Biol.* **201,** 682 – 691, 1998.
2. Huijing, PA, et al.. *Acta Physiol. Scand.* **173,** 297 – 311, 2001.
3. Hennig, R. et al.. *Nature* **314,** 164 – 166, 1985.