FORCES OF MULTI-TENDONED MUSCLE ARE AFFECTED BY MYOFASCIAL FORCE TRANSMISSION

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INTRODUCTION

Recent in situ experiments on rat extensor digitorum longus muscle (EDL) clearly indicated force transmission between muscle heads via their shared connective tissue, named myofascial force transmission (Huijing et al., 1998; Jaspers et al., 2002). It should be noted that EDL muscle was dissected free of its surrounding tissues, leaving nerve and blood supply intact, and muscle force was measured exclusively at the proximal tendon.

EDL is a multi-tendoned muscle, which consists of four heads of which the muscle fibers share a common aponeurosis and tendon proximally, but have individual aponeuroses and tendons distally. The heads are named after their insertions on the digits of the toes (II, III, IV, V).

In the present study, force transmission from head III of rat EDL muscle (EDL III) was investigated with intact inter- and extramuscular connective tissue. The aim was to determine the role of myofascial force transmission during distal length changes of EDL III.

METHODS

The distal tendon of EDL III, the proximal tendon of whole EDL and the distal tendons of EHL and TA muscles were exposed, and connected to force transducers. Connective tissue at the muscle bellies of these muscles was left intact. For several muscle-tendon complex lengths (l_{m+t}) of EDL III, isometric forces of distal EDL III, proximal EDL and distal TA+EHL were measured. Supramaximal stimulation of the peroneal nerve excited all muscles maximally and simultaneously. TA+EHL length as well as the position of the proximal tendon of EDL muscle were kept constant.

RESULTS AND DISCUSSION

ANOVA indicated significant effects of EDL III muscle-tendon complex length on active force of distal EDL III, proximal EDL, and TA+EHL. Maximal proximal EDL active force was 2.53 ± 0.10 N (Fig. 1). Substantial length changes of EDL III (Δl_{m+t} = 9 mm) caused only minor effects on proximal EDL active force: ΔF_{max} = 0.15 ± 0.03 N. Optimal active force of EDL III was 1.03 ± 0.07 N (Fig. 1). It should be noted that based on the normalized mass of EDL III the maximal contribution of EDL III to total EDL active muscle force was estimated to be 17%. As optimal active force of whole EDL does in general not exceed 3 N, EDL III force is minimally 34%. It is concluded that at optimum length a substantial part of EDL III force originates from other sources than muscle fibers from head III.

A comparison between proximal EDL and EDL III forces expressed as a function of EDL III length (Fig. 1) indicates that force changes of proximal EDL were much (= 5 times) smaller than force changes of EDL III. This is explained by myofascial force transmission between the muscle belly of EDL III and adjacent muscle bellies as well as other non-muscular surrounding structures.

Distal force of TA+EHL, kept at constant length, decreased significantly (i.e. from 5.62 ± 0.27 to 5.22 ± 0.32) with lengthening EDL III. These results indicate mechanical interactions between EDL III and the TA+EHL complex, typical for intermuscular myofascial force transmission.

It is concluded that intra-, inter- and extramuscular myofascial force transmission play an important role during length changes of one head of multi-tendoned muscle. It has been reported that it is hardly possible to move a single digit without movements of adjacent digits (e.g. Kilbreath and Gandevia, 1994). Independent digit movements may be limited by myofascial force transmission.

SUMMARY

The present results show that distal length changes EDL III cause (1) relatively high force changes of EDL III, (2) only minor force changes of proximal EDL, and (3) substantial changes of distal TA+EHL force. These mechanical interactions between the muscle belly of EDL III and its surrounding structures must be mediated by intra-, inter and extramuscular myofascial force transmission.

REFERENCES


![Figure 1: Length-distal active force (Fma) characteristics of EDL III as well as the simultaneously measured proximal EDL active force. Values are shown as mean ± SE (n = 6).](image-url)