# *IN VIVO* MUSCEL FIBER KINETICS DURING TETANIC CONTRACTION

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## INTRODUCTION

The muscle fiber force is a function of muscle fiber length (MFL), muscle fiber shortening velocity (MFV) and active state (AS) [1, 2]. However, little is known how these factors determine the time-course of muscle fiber force in human muscles *in vivo*. The present study aimed to investigate the time-course of muscle fiber kinetics during isometric tetanic contractions. For this aim, we measured MFL and MFV, and estimated the time-course of the force generating capacity (FGC) determined from each of MFL, MFV and AS.

## METHODS

Six healthy male volunteers participated in this study as subjects. The subject was seated with the knee joint fully extended. To change the initial length of MFL, three ankle joint angles (30, 10 and -10 deg; 0 deg is an anatomical position) were chosen . Isometric tetanic contractions (2s at 50Hz) were evoked by percutaneous supramaximal electrical stimulations to the common peroneal nerve. The ultrasound apparatus (SSD-6500SV, Aloka, Japan) having a 10 MHz linear-array probe was used to measure the sequence of longitudinal ultrasonic images (96.4Hz) of the tibialis anterior muscle at the level of 40 % of the lower leg length. From the serial images, MFL, MFV and pennation angles were measured using an image analysis software. Muscle fiber force was estimated using measured dorsi-flexion torque, moment arm length and pennation angle. FGC related to MFL and MFV were estimated from force-length and force-velocity relationships. FGC related to AS was calculated using the following equation:

$$F_{exp}=P_0 \cdot FGC_{F-L(MFL)} \cdot FGC_{F-V(MFV)} \cdot FGC_{F-AS(AS)}$$

where $F_{exp}$=estimated muscle fiber force, $P_0$=maximal force at optimum length, FGC **a** (**b**)=force generating capacity related to **a** as function of **b**. F-L, F-V and F-AS mean force-length, force-velocity and force-active state relationships, respectively.

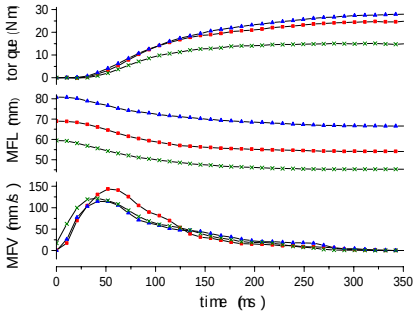


**Figure 1**: Time-courses of dolsi-flexion torque, muscle fiber length (MFL) and muscle fiber shortening velocity (MFV). (average of six subjects) [ 30deg, ■10deg, ×-10deg]

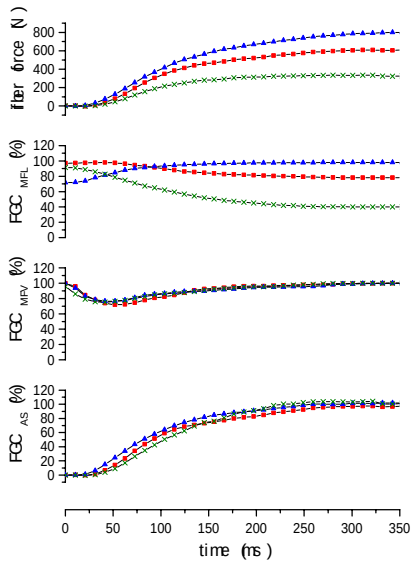


**Figure 2**: Time-courses of fiber force and force generating capacity of each muscle fiber length (MFL), muscle fiber shortening velocity (MFV) and active state (AS). (average of six subjects) [ 30deg, ■10deg, × -10deg]

## RESULTS AND DISCUSSION

The time courses of the measured dorsi-flexion torque, MFL and MFV are shown in Figure 1, and the estimated time-courses of FGC for each of MFL, MFV and AS in Figure 2. For MFL, the magnitude of FGC changed by as much as 27% at the initial phase of contraction (~100 ms). The shapes of the time-course curves were considerably different between joint angle conditions (maximal difference; 31%). For MFV, the magnitude of FGC decreased rapidly at the initial phase (maximal change; 28%) and then increased gradually in all joint angle conditions. For AS, although the magnitude of FGC increased gradually from 0 to 100% in all joint angle conditions, the shape of the time-course curve differed among joint angle conditions (~17%). These findings suggest that the time-course of muscle fiber force developed during tetanic contraction of the tibialis anterior muscle is determined by summation of various changes of the time-course of FGC as a function of MFL, MFV and AS, and that, when the joint angle is changed, it is influenced mostly by the force-MFL and force-AS relationships rather than the force-MFV relationship.

## REFERENCES

1. Bobbert MF and Ingen schenau JV. *J Biomech* **23**, 105-119. 1990.
2. van Zandwijk JP et al. *Biol Cybern* **79**, 121-130, 1998.