MECHANICAL PROPERTIES OF SINGLE MOTOR UNITS FROM HUMAN EXTENSOR CARPI RADIALIS MUSCLE BASED ON MECHANOMYOGRAM AND FORCE

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INTRODUCTION

The purpose of the study was to test whether the contractile properties of individual motor units (MU) are reflected in the surface mechanomyogram (MMG) during voluntary low force muscle contractions in human and if the MU firing rate plays a role on the MMG signal. Furthermore, it was investigated if the MMG can be used to estimate the electromechanical delay from exitation to contraction without the influence of the series elastic elements and the compliance of the tendon delaying the longitudinal force transfer.

METHODS

Seven subjects were seated with the elbows flexed 90° and the forearms pronated. The subjects performed a maximal voluntary contraction (MVC) followed by a weak contraction of the extensor carpi radialis muscle (ECR) against a force tranducer applied proximal to the metacarpophalangeal joint until stable activity of a MU was evoked. Visual and auditory feedback was given to keep the MU active as long as possible up to 20 minutes. A piezoelectric accelerometer was used for detection of the MMG. The accelerometer was placed on the belly of the ECR muscle and surface electromyography (SEMG) was recorded by bipolar surface electrodes placed on each side of the accelerometer. Intramuscular electromyography (IEMG) was recorded by a quadripolar needle electrode. The IEMG signals were decomposed into individual MU action potential trains (MUAPT) using a computer algorithm based on signal shape recognition (Olsen et al 2001). For each MU time for discharges were used to spike triggered averaging (STA) of the MMG, SEMG, and the force. Data are given as the peak to peak amplitude of the STA SEMG and MMG signals and the increment of the STA force. The IEMG-MMG and the IEMG-force delays were calculated as the time between the triggering discharge and the first peak in the STA MMG and force. To study the influence of the firing rate on the averaged MMG signal, STA of the MMG was performed only using action potentials separated from the two adjacent discharges with time period corresponding to frequency bands of <9, 9-11, 11-13, and 13–15 Hz.

RESULTS AND DISCUSSIONS

Mean force during the contractions ranged from 2.4 to 5.7 % MVC. A total of 28 MU were identified with number of discharges ranging from 630 to 20482. By STA of force, SEMG and MMG a distinct and comparable shape could be identified for all 28 MU in the SEMG response and for 24 MU in the MMG as well as the force response. SEMG amplitude was as a mean 35, range (6-95) µV, MMG amplitude 35 (3-157) mm/s^2 and force 214 (38-1445) mN.

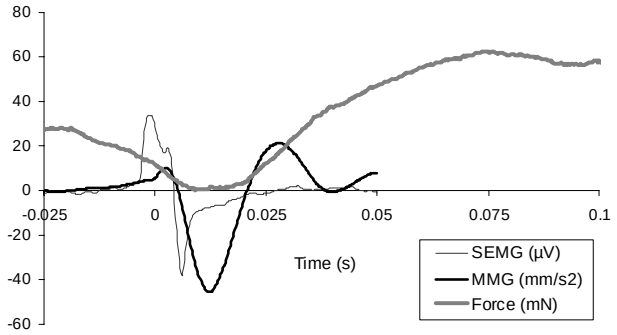

Figure 1: An example of averaged SEMG, MMG and force triggered from a MUAPT with 7333 discharges. All traces are time aligned corresponding to triggering MU discharge.

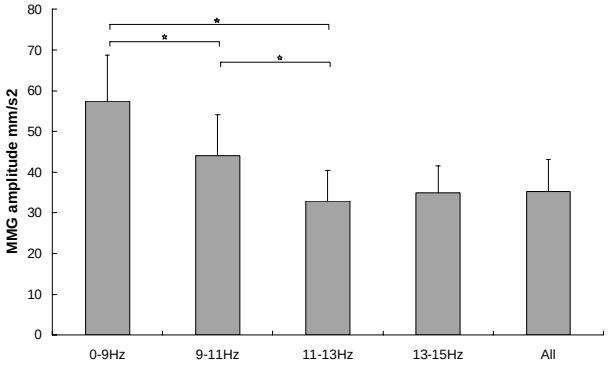

Figure 2: STA MMG amplitude in frequency bands.

The STA MMG amplitude was significantly lower in the 11-13 Hz band than the amplitude at lower firing rates but further increase in firing rate did not seem to have an influence (see Figure 2). The average IEMG-MMG delay was 12 (4-26) ms and always shorter than the IEMG-force delay, which was on average 57 (36-82) ms. The IEMG-MMG time delay was not influenced by the firing rate.

SUMMARY

The present results show that contractile properties of the active MU may be extracted by STA of the MMG. These properties are depending on the firing rate, especially in the lower end of the physiological range. In contrast, the IEMG-MMG time delay was not influenced by the firing rate and presents an estimation of the time delay between the electrical stimulation and the lateral movement of the muscle fibres during force development, which is independent of the compliance of the series elastic elements and the tendon.

REFERENCES

Olsen, H.B. et al (2001. *Acta Physiol Pharmacol Bulg*; **26**, 73-78