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M-wave properties during progressive motor unit activation by transcutaneous neuromuscular stimulation: effect of the stimulation waveform / MINETTO M.A; BOTTER A; MESIN L.; MERLETTI R. - (2007). ((Intervento presentato al convegno INTERNATIONAL SFEMG COURSE AND QUANTITATIVE EMG CONFERENCE tenutosi a LJUBLJANA, SLOVENIA, nel 2-6 GIUGNO 2007..

Availability:

This version is available at: 11583/1919715 since:

Publisher:

Published

DOI:

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M-wave properties during progressive motor unit activation by transcutaneous neuromuscular stimulation: effect of the stimulation waveform

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The detection of surface EMG signals during electrical stimulation allows the assessment of the peripheral properties of the neuromuscular system.

M-waves were detected from the biceps brachii muscle of 10 healthy male subjects by a linear adhesive array of 8 electrodes, which was located between the stimulation electrode and the distal tendon and was aligned to the direction of the muscle fibers. Three different monophasic waveforms of 304- μ s duration were applied (in randomized order) to the stimulating electrode: triangular, rectangular, and sinusoidal. For each waveform, linearly increasing stimulation intensities from 0 mA to the supramaximal current in 10 s were applied. Five minutes of rest were given to the subjects after each contraction. Moreover, a simulation analysis was used to interpret the experimental results.

Average rectified value (ARV) and conduction velocity (CV) were estimated from signals obtained from both experimental and simulated staircase contractions.

From the experimental and model analysis, it was found that: 1) M-wave ARV and CV estimates significantly increased with the current level for all stimulation waveforms, 2) at the same peak current level, the higher the injected charge and stimulation energy, the higher the M-wave ARV and CV estimates, and 3) at the same charge and energy levels, the estimates of M-wave ARV and CV were not affected by stimulation waveform.

In conclusion, motor unit recruitment tended to be from low to high CV with increasing electrical stimulation and depended only on charge and energy of the pulse and not on the waveform used.