ESTIMATION OF MUSCLE FIBER CONDUCTION VELOCITY FROM TWO-DIMENSIONAL SURFACE EMG RECORDINGS IN DYNAMIC TASKS

Farina Dario1, Falla Deborah
(Center for Sensory-Motor Interaction (SMI) 1, Denmark)

Background: Muscle fiber conduction velocity reflects fiber membrane properties and their change with fatigue, pathological conditions, and exercise. Most studies investigating muscle fiber conduction velocity have utilized a static contraction paradigm where the posture and force are maintained constant over the task. In most applied fields, e.g. sport medicine, this paradigm is of limited interest, but methodological obstacles have often impeded the assessment of muscle fiber conduction velocity in dynamic contractions. Moreover, it has been shown that the average conduction velocity of muscle fibers may vary substantially in different regions of the muscle which may be due to spatial dependency of muscle fiber properties and motor unit recruitment. Thus in many applications it would be preferable to extract conduction velocity from a large muscle region. This could be achieved using two-dimensional, high-density EMG recordings, however currently there are no reports on the application of these systems in fast dynamic tasks.

Aim: The purpose of this study was to develop and apply a new method for the estimation of muscle fiber conduction velocity from short epochs of 2-D EMG recordings during dynamic tasks.

Methods: Surface EMG signals were collected from the biceps brachii muscle of four subjects with a grid of 5x13 electrodes during horizontal elbow flexion/extension movements (range 120°-170°) at the maximum speed, repeated cyclically for 2 min. Action potentials propagating between the innervation zone and tendon regions could be detected during the dynamic task. A maximum likelihood method for conduction velocity estimation from the 2-D grid using short time intervals (50-100 ms) was developed and applied to the experimental signals. The method provides estimates which are global in space and local in time, representative of the entire muscle yet able to track fast changes over the execution of a task. In this study, conduction velocity was estimated from windows of 60-ms duration for each cycle, at the time instants corresponding to 165 degrees of elbow flexion.

Results: Conduction velocity estimated from each of the five columns of the grid was largely variable across columns (average range 3.6-4.3 m/s). The standard deviation of the residual of the regression line of conduction velocity estimates with respect to time decreased from (range) 0.20 – 0.33 m/s using one column of the electrode grid for the estimate to 0.02 – 0.15 m/s when combining 5 columns of the electrode grid with the proposed method.

Conclusion: In this study we demonstrated that it is possible to record two-dimensional EMG signals during fast dynamic contractions and estimate average muscle fiber conduction velocity from these recordings in short signals epochs. The use of two-dimensional recordings for estimating conduction velocity increases the accuracy of the estimates with respect to using less detection locations. The proposed technique provides the means for assessing fast changes in membrane fiber properties during the execution of dynamic tasks at high speed.

Supported by the Danish Technical Research Council (26-04-0100) and by the National Health and Medical Research Council of Australia (ID 351678).

Keywords: Neuromuscular System