A Finite Element Model for Describing the Effect of Muscle Shortening on Surface

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A FINITE ELEMENT MODEL FOR DESCRIBING THE EFFECT OF MUSCLE SHORTENING ON SURFACE EMG

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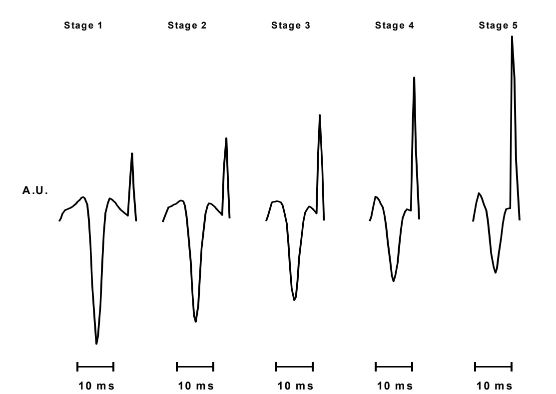
AIMS: A finite element model for the generation of single fibre action potentials in a muscle undergoing various degrees of fibre shortening is developed. The effect of the volume conductor shortening on surface EMG parameter is assessed.

METHODS: The muscle is assumed fusiform with muscle fibres following a curvilinear path described by a Gaussian function. Different degrees of fibre shortening are simulated by changing the parameters of the fibre path and maintaining the volume of the muscle constant. The conductivity tensor is adapted to the muscle fibre orientation. In each point of the volume conductor, the conductivity of the muscle tissue in the direction of the fibre is larger than that in the transversal direction. Thus, the conductivity tensor changes point-by-point with fibre shortening, adapting to the fibre paths. An analytical derivation of the conductivity tensor can be obtained. The volume conductor is then studied with a finite element approach using the analytically derived conductivity tensor.

RESULTS: Five contraction levels were simulated. The geometrical changes in the muscle, which imply changes in the conductivity tensor, determined important variations in action potential shape, thus affecting its amplitude and frequency content (Figure). The relative weights of the travelling components and of the end end-onf - fibre component changed with shortening (Figure). Average rectified value (ARV) and mean power spectral frequency (MNF) estimated from the simulated single fibre surface potentials are were influenced by muscle shortening, mainly due to the change in the distance between the sources and the detection electrodes with shortening. For example, for a channel placed between the innervation zone and a tendon and fiberfibre under the detection point and 6.25 mm deep, the standard deviation of ARV and MNF for signals from a fibre under the detection channel, at the five simulated levels of shortening and 6.25 mm deep at the tendon level are (respectively)were -279% and 8746% for a (monopolar detection), and 20-48% and -74% for a (single differential) channel (percentages referred to the ARV or MNF values at the maximal level of shortening)with respect to the values with the muscle 46.6% shortened. The variations of ARV and MNF are strongly dependentd on the position of the fibre within the muscle.



EXAMPLE OF MONOPOLAR POTENTIALS FOR DIFFERENT SHORTENING LEVELS (RELAXED, 13.3%, 26.7%, 40%, 46.6%), FOR A FIBRE UNDER THE DETECTION ELECTRODE (PLACED BETWEEN THE INNERVATION ZONE AND THE TENDON), 6.25 MM DEEP AT THE TENDON LEVELINTO THE MUSCLEE.

CONCLUSIONS: The model provides a new tool for interpreting surface EMG signal features with changes in muscle geometry, as it happens during dynamic contractions.