

Computer simulation study on the influence of motor unit distribution within the muscle cross-sectional area on the generation of surface myoelectric signals.

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Abstract

The surface myoelectric signal represents the superposition of action potentials from the motor units arranged within a given muscle. The electrical signal generated by each motor unit undergoes a space-time filtering that depends directly on its position relative to the electrodes on the surface of the skin. Therefore, mathematical models that represent the generation of myoelectric signals must take into account the positioning and distribution of motor units within the muscle cross-sectional area. The present study is aimed at investigating the influence of motor unit distribution on the generation of the surface myoelectric signal. A phenomenological mathematical model was used to represent motor unit action potentials recorded from a pair of electrodes in a differential bipolar configuration. Different muscle cross-sectional morphologies were tested to evaluate their influence on the magnitude of the myoelectric signal.

Key words:

Surface electromyography, Mathematical modeling, Motor unit

Introduction

The myoelectric or electromyography signal (EMG) represents the superposition of the electric potentials generated by the depolarization of the sarcolemma during muscle contraction (Merletti & Farina, 2016). In this study, the objective was to investigate, from a computational point of view, the effects of motor unit positioning and distribution within the muscle on the generation of surface EMG (sEMG) signals.

Results and Discussion

The motor unit action potentials (MUAPs) were modeled by first- and second-order Hermite-Rodriguez functions (Lo Conte et al., 1994). MUAP attenuation due to the volume conductor was represented by an exponentially decaying function [Cisi & Kohn (2008); Fuglevand et al. (1992)]. Motor unit territory centers (MUTC) were randomly distributed (uniform distribution) within the muscle cross-sectional area. sEMG signals were generated by the recruitment of 100 motor units, whose discharge times followed a Gamma stochastic point process (10 Hz mean firing rate). Different cross-sectional morphologies were adopted to investigate their influence on sEMG amplitude (Figure 1). Data in Table 1 show that motor unit distribution has an impact on EMG RMS amplitude. Signals with higher amplitude were obtained when motor units were distributed within a pizza-like cross-sectional area.

Table 1. sEMG RMS amplitude. Mean and standard-deviation values obtained from 2000 simulations performed with different muscle cross-sectional morphologies.

Morphology	Mean (μV)	Standard-Deviation (μV)
Ellipse	164.74	66.27
Pizza	217.42	85.09
Ring	152.03	61.60

Conclusions

From the results presented in the section above we conclude that the morphology of muscle cross-sectional area and motor unit distribution are important features influencing sEMG signal amplitude. Therefore, future

studies using mathematical models of EMG should carefully take into consideration these factors so as to achieve results with higher biological plausibility.

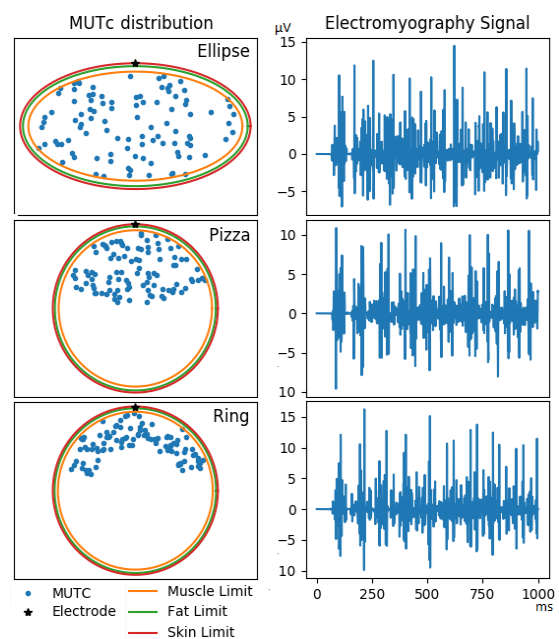


Figure 1. Influence of motor unit distribution within different muscle cross-sectional morphologies (ellipse, pizza or ring – graphs in the left panels) on the generation of sEMG (graphs in the right panels).

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