Influence of Motor Unit Characteristics and Behavior on Surface EMG, Force, and Their Association

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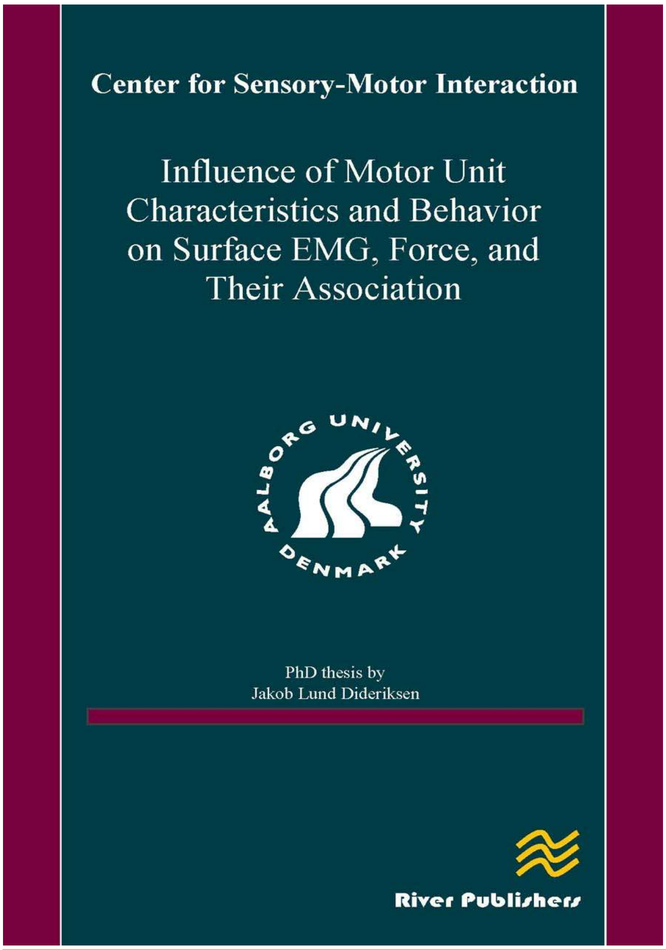
Human voluntary movement occurs when muscles generate force in response to patterns of activation from the neural system. The force generated by individual muscles however is difficult to measure experimentally. Therefore, the surface EMG signal is often used as a surrogate measure for the relative muscle force in spite of the differences in the mechanisms underlying these two signals. This PhD thesis focuses on the limitations the association.

To investigate the relation between these two signals, a computational model of adaptations occurring in the neuromuscular system during sustained contractions and the resulting muscle force and surface EMG signal was developed. Simulations of the metabolic accumulation in the muscle was used to control the rate of change for the various neuromuscular adaptations, while a control algorithm estimated the excitatory drive to the muscle needed to maintain a desired contraction level. Using the model, first, the influence of muscle fatigue on the association between contraction level and average rectified surface EMG amplitude was analyzed. Next, the relation between the temporal variability in the surface EMG envelope and the force was assessed.

The simulations indicated that the presence of muscle fatigue potentially introduces a large bias in the relation between the amplitudes of force and surface EMG. This bias is difficult to predict since it depends on multiple adjustments in the neuromuscular behavior. Furthermore, there was little correlation between the surface EMG envelope and the force variability. This lack of correlation was due to the filtering effects related to the process of force generation. These filters implied that only the variability of the common neural input to the motor neuron population was transmitted to force and were not present in the generation of the surface EMG signal.

These results indicate significant limitations in the ability of the surface EMG signal to reflect the characteristics of the force generated by the muscle. Therefore, using this signal as an estimator for force should be done with caution and at a qualitative level only.



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