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Population Coding of Neural Drive in Human Motor Units during Voluntary Isometric Contractions

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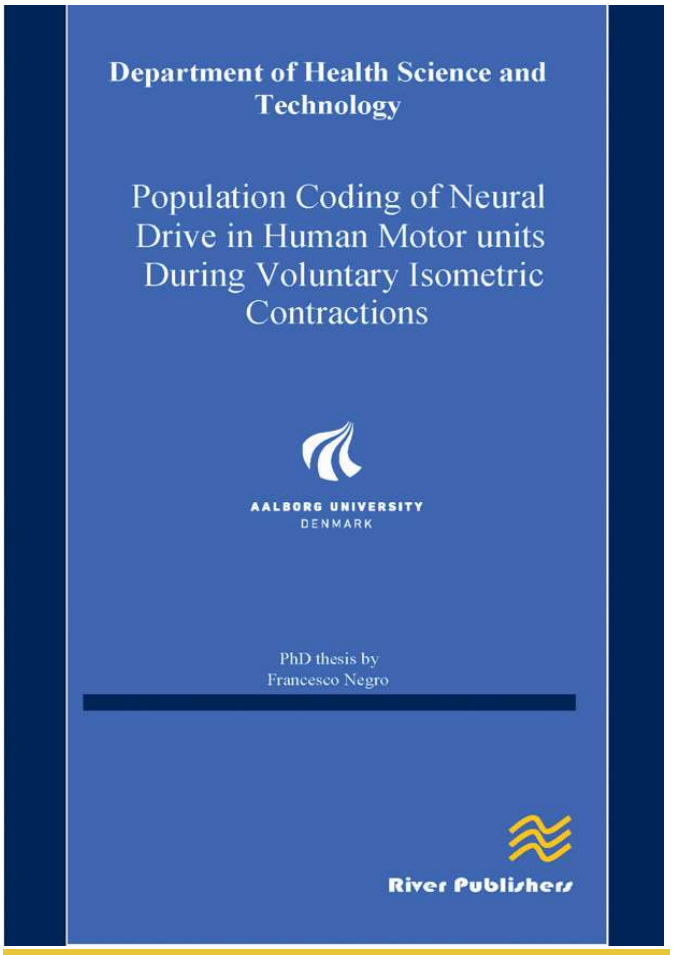
Population Coding of Neural Drive in Human Motor Units during Voluntary Isometric Contractions The execution of a movement is the result of a complex interaction between populations of neurons in the central nervous system. Nowadays, we have a detailed knowledge of the mechanisms of functioning of single neurons in vitro, but we lack a broader view of the network connections. The identification of the physiological mechanisms that are responsible, at the macro level, for the generation of movements is important to understand how to reestablish damaged pathways. This book focuses on the analysis of populations of motor units in vivo in humans to extract information about the synaptic control signals involved in the production of isometric movements. Moreover, it investigates the limitations of the current techniques for the estimation of the neural drive to the muscles. The first study (STUDY I) investigated the possibilities of separating the contributions of individual motor units from the surface electromyographic (EMG) signal. The work demonstrated that the use of multichannel electrodes can effectively improve the detection of populations of motor units from the surface EMG. Therefore, the second study (STUDY II) used a combination of surface and intramuscular EMG electrodes to increase the motor unit sample size for the investigation of the low-frequency neural signals to the muscles during isometric contractions.

The results demonstrated that a low-dimensional control signal can be extracted by the concurrent observation of a relatively large pool of motor unit spike trains. This low-dimensional signal is the effective drive to the muscle since it is directly translated into force, as demonstrated experimentally in STUDY I. Three additional studies clarified the relation between the neural drive to muscles and cortical oscillations. STUDY III investigated the variability in the estimation of the corticomuscular coherence, a common technique for assessing supraspinal control, when EMG signals from several locations over the muscle are used. Since the results demonstrated strong limitations of this technique, STUDY IV focused on estimating the corticomuscular coherence directly from the spike trains of motor units and analyzing the transmission of cortical oscillations to the motoneuron pool. It was shown that the central nervous system can transmit cortical oscillations to the motoneuron pool in a partly linear way by projecting common input to the entire motoneuron population. Despite linear transmission is achieved in this way, it is unclear if linear methods concurrently analyzing EEG and EMG can reveal it in a robust way, a topic that was investigated in the last study of the thesis. STUDY V used a realistic computational model of populations of motoneurons to identify factors of influence in EMG/EEG coherence analysis. The results showed that the interaction of common synaptic activities from muscle afferents and supraspinal centers on the motor neuron pool may influence each other and underestimate the real corticospinal interactions.



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