Advantages of the Onion-Skin scheme of motor unit firing during voluntary contractions

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Over the past five decades, the notion that higher-threshold shorter-after-hyperpolarization (AHP) motoneurons have greater firing rates than lower-threshold longer-AHP ones has been commonly accepted. This notion, here named the AHP scheme, derived from observations in electrically stimulated cat motoneurons and supports the assumption that motor unit (MU) firing rates match their mechanical properties to “optimize” force generation [1,2]. That is, lower-threshold MUs have wider and smaller force twitches that require lower firing rates to tetanize. In contrast, we have shown that earlier-recruited MUs maintain higher firing rates than later recruited ones during voluntary isometric contractions, resulting in an inverse orderly hierarchy of firing rate curves named the Onion-Skin scheme [3-5].

The purpose of this study is to use a novel model of muscle force generation [6] to compare the force characteristics produced by the two schemes during constant-force contractions in the first dorsal interosseus (FDI) and vastus lateralis (VL) muscles.

METHODS

The model used for the simulation of the MU firing rate and force behavior is a modified version of that developed by Contessa and De Luca (2013) for the FDI and VL muscle.

Mu Firing Rate and force behavior: The input excitation drives the firing behavior of all MUs in the muscle. The firing rate spectrum describes the firing behavior of MUs as a function of input excitation. The force output is the summation of the force contributions of all MUs. If a force feedback allows simulation of force sustained at given targets. The spectrum was derived from empirical data from voluntary isometric linearly-varying/constant contractions in humans [6]. AHP scheme was modeled based on the hypothesis that MU firing rates provide “optimal” force twitch fusion for all MUs [1,2].

RATING RATE: SPECTRUM: Onion-Skin

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