# Control properties of motor units: unique to muscle, common to subjects

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### ABSTRACT

the advent of a high-yield surface EMG signal decomposition technology, it has become possible to study the control properties of numerous (up to 40) simultaneously active motor units. For this purpose, six healthy human subjects of comparable age (21  $\pm$  0.632 yr) and physical fitness were selected to perform isometric contractions of the vastus lateralis (VL), first dorsal interosseus (FDI), and tibialis anterior (TA) muscles at the 20%, 50%, 80% and 100% maximal voluntary contraction (MVC) force levels. Electromyographic (EMG) signals were collected during the contractions with surface array sensors and decomposed into the constituent action potentials with new decomposition algorithms. The firings of over 1,200 motor unit action potential trains were obtained with an accuracy greater than 85% (up to 40 motor units per contraction). From these decomposed firings, the recruitment thresholds and mean firing rates of the active motor units were calculated and analyzed. The results strongly suggest a hierarchical relationship between the recruitment thresholds and firing rates which remains constant relative to the level of force. This relationship is slightly variable between subjects and more distinctly variable across muscles. These results support the theory that a basic control scheme is encoded in the physical properties of a muscle which responds consistently to a common excitatory input from the central nervous system.

#### EQUIPMENT



**RIGHT:** Surface array EMG sensor used to collect contraction data. Five pins (0.5 diameter) protrude mm from the housing, spaced at the corners of a 3.6x3.6 mm square.

**LEFT:** Experiment chair immobilizes joints for isometric study of the FDI, TA, and VL. Computer collects data (EMG, force) and provides live feedback to the subject.





are separated into individual action potential trains. **BELOW**: Firing rates of the same motor units plotted as functions of contraction time.

Both are plotted concurrently with the force traced by the subject.

## **EXPERIMENTAL RESULTS**





#### **Motor Unit Behavior**

Average sustained firing rate of motor units, plotted versus recruitment threshold, in contractions of increasing target force level (20, 50, 80, 100% MVC).

LEFT: examples o<sup>-</sup> individual data.

**RIGHT**: combined data of all subjects.

Equations below were derived via regression parameters (slope and intercept at target levels) from combined data.

