

Motor Unit Measurement Technology for Training, Exercise and Functional Activities

Kline JC¹, Shiwani B¹, Contessa P¹, Roy SH¹, Chiodini JP¹, and De Luca G¹
¹ Delsys Inc. and Altec Inc, Natick, MA, USA

Technological Innovation in Motor Unit Measurement Technology



4 Neural Control of Muscles

Action Potentials

Motor Unit Firings

Average 20+ Motor Units

Algorithm Advantages:

- For dynamic functional activities
- Direct measure of motor unit action potentials
- No assumptions of motor unit firing behavior
- Fully automate processing and validation for all motor units³
- Proven accuracy

3 Signal Decomposition Algorithm

Accuracy (%)

95.6
94.3
97.2
93.8
96.5
94.7
95.6
93.9

Motor Unit Action Potential Trains^{1,2}

dEMG Algorithm

sEMG signal

1 Sensor Technology

Sensor Interface 5 mm

20 mm

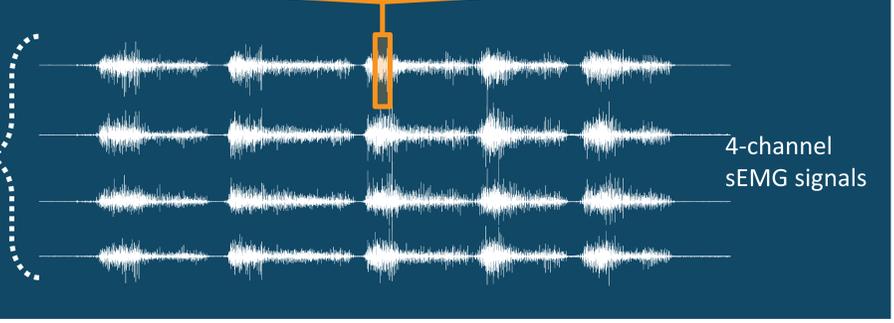
41 mm

Sensor Advantages:

- Noninvasive
- Miniaturized footprint
- Small and large muscles
- Placement takes seconds, no gel
- Designed to detect distinct motor unit action potentials

2 EMG Signal Acquisition

Record High-Fidelity sEMG Signals

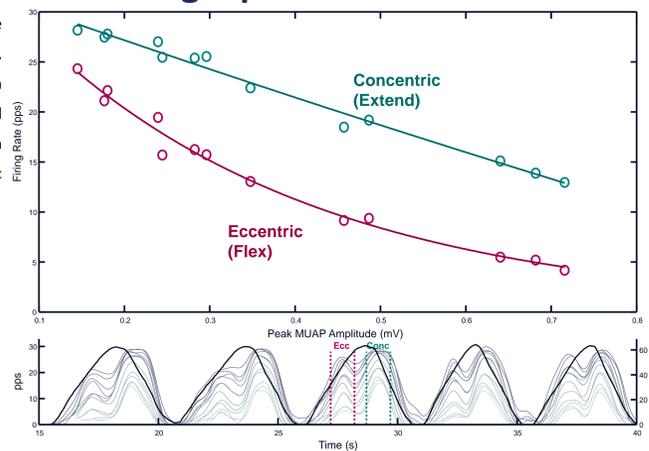


4-channel sEMG signals

Research & Clinical Applications

Rehabilitation Exercise Leg Squats

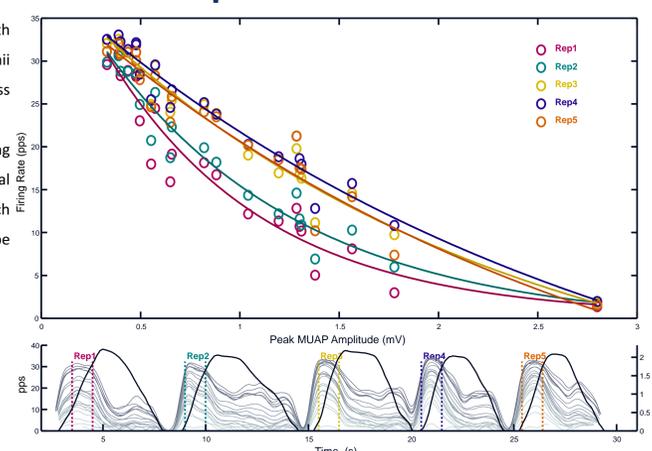
• During exercises of the quadriceps muscle group, motor unit firing rates from vastus medialis showed clear differences between concentric and eccentric changes in knee angle.



Strength Training Bicep Curls

• Firing rates during strength training of biceps brachii showed variations across different repetitions.

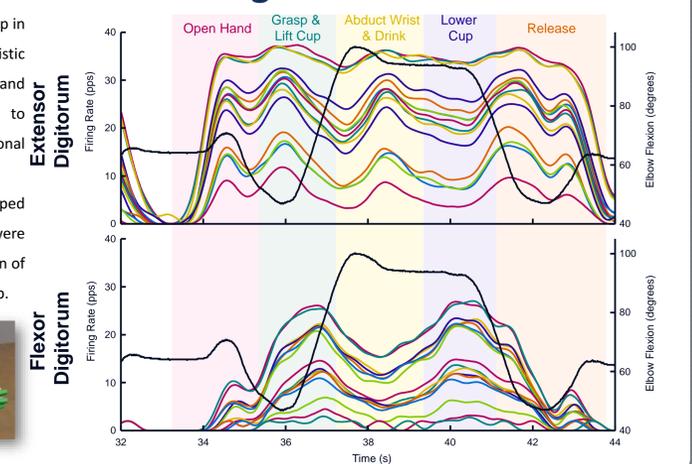
• Relationships between firing rates and biomechanical parameters of muscles such as torque and fatigue can be further investigated.



Fine Motor Control Drinking Task

• Firing rates of muscle group in the hand showed synergistic activations of extensor and flexor digitorum muscles to accomplish the functional tasks such as drinking.

• Extensor muscles that helped opening the hand were supported by the activation of flexor muscles during grasp.



Conclusions

- Hierarchical changes in motor units during dynamic activities can provide insights to the control and regulation mechanisms of activities.
- Regulation of agonist/antagonist muscles during an activity can be revealed by the correlation of firing rates in the synergist muscle pair.
- Motor unit data coupled with biomechanical information of muscle performance can delineate factors that influence motor control.

Acknowledgements

This work was funded in part by the De Luca Foundation and by the National Institute of Neurological Disorders and Stroke of the NIH under award numbers R44NS077526 and R43NS093651.

References

1. LeFever et al., IEEE, 149-157, 1982
2. De Luca et al., Neurophysiology, 96(3), 1646-1657, 2006
3. De Luca et al., Neurophysiology, 113(6), 1941-1951, 2014