MYOKINETIC vs EMG ANALYSIS OF MUSCULAR ACTIVITY DURING GAIT

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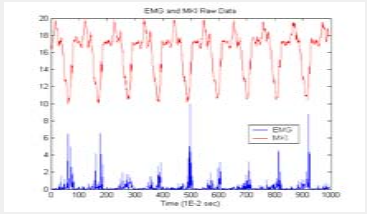
Abstract

The standard interface for registration of muscle activity is the electromyogram (EMG). We are investigating the Myokinetic Interface (MKI) as an alternative method for measuring some aspects of muscle activity, detecting activity from the muscles dynamic surface pressure. The MKI and EMG records of the leg muscles of a subject walking at 3mph were compared to numerically define the periods of muscle activity. Results showed: (1) onset times recorded by EMG and MKI are approximately equivalent, (2) muscle activation duration as measured by MKI outlasted electrical activation by 566 milliseconds, and (3) MKI compares favorably with EMG

MyoKinetic Interface.

A method of quantifying the properties of muscle activation using changes in muscle shape.



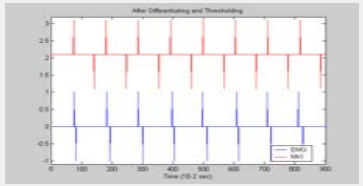
MKI (red) and EMG (blue) data from anterior thigh, normalized and unfiltered

The MKI sleeve is an adjustable array of pressure sensors aligned over the major muscles of the limb, measuring kinetic activity via the external pressure that results from a muscle contraction.

Subject dons MKI and ambulates

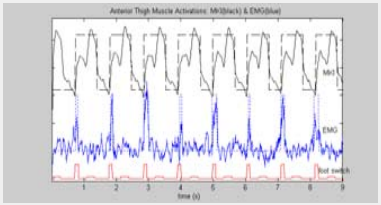
On/Off Analysis

- Normalized •Enveloped (Moving Average)
- Differentiated •Thresholded



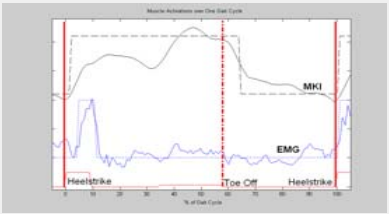
MKI and EMG, after thresholding, showing onsets and offsets

- EMG and MKI were thresholded to outline the timing of muscle activity.



On/Off Analysis of Anterior Thigh MKI and EMG with foot-switch timing

- EMG and MKI data over one cycle, defined by two consecutive heel-strikes, show relative timing.



Anterior Thigh recording over one gait cycle

Muscle Timing

The post-heelstrike timing of the onset and offset of EMG and MKI, as listed in the table, demonstrate how the two methods compare for the same motion.

	EMG (msec)(mean ± s.d.)	MKI (msec)(mean ± s.d.)
t_{on}	18.8 ± 37.6	15.0 ± 5.35
t_{off}	129 ± 24.2	691 ± 8.35
duration	110 ± 38.9	676 ± 7.44

	EMG (% of cycle)(mean ± s.d.)	MKI (% of cycle)(mean ± s.d.)
t_{on}	1.77 ± 3.54	1.41 ± 0.50
t_{off}	12.1 ± 2.28	65.1 ± 0.79
duration	10.4 ± 3.67	63.7 ± 0.70

Timing of Muscle Activity, as measured by EMG and MKI, mean ± standard deviation

Gait Cycle Repeatability

The Variance Ratio quantifies the repeatability of the wave-forms for multiple (8) gait cycles:

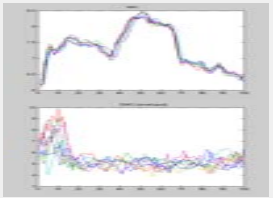
$$VR = \frac{\sum_{i=1}^{k}\sum_{j=1}^{n}(X_{ij} - \bar{X}_i)^2/k(n-1)}{\sum_{i=1}^{k}\sum_{j=1}^{n}(X_{ij} - \bar{X})^2/(kn-1)}$$

Variance Ratio of multiple gait cycles (Hwang et al)[1]

	VR
MKI	0.028
EMG(raw)	0.877
EMG(enveloped)	0.555

Variance Ratio (where identical signals → 0 and random noise → 1) for EMG and MKI

Overlays of signals from each gait cycle, (raw MKI (top) and enveloped EMG (bottom)



MKI signals are significantly more similar from cycle to cycle than EMG signals are, even after enveloping EMG

[1]Hwang, Ing-Shiou, et al. "Electomyographic Analysis of Locomotion for Healthy and Hemiparetic Subjects". Gait and Posture 18. (2003): 1-12

Electromechanical Delay

A notable issue of contention is the "electromechanical delay", the time gap between neuromuscular excitation and force production. If excitation and force are measured by EMG and MKI, respectively, the on/off analysis can both detect the delay and determine its size.

	EMG	MKI
t_{on} (msec)	18.8 ± 37.6	15.0 ± 5.35
t_{on} (% of cycle)	1.77 ± 3.54	1.41 ± 0.50

Timing of Muscle Activity Onsets, as measured by EMG and MKI, mean ± standard deviation

The data shows that the onset times are statistically equivalent. This supports the idea that there is no "electro-mechanical delay"

Discussion

•EMG and MKI record approximately equivalent onset times, supporting the idea that there is no electromechanical delay.

•MKI duration outlasted EMG by an average of 566 msec (8 gait cycles). Muscle relaxation may account for most or all of this difference.

•Gait cycle repeatability of MKI is high relative to EMG.