

MYOKINETIC ANALYSIS OF MUSCLE ACTIVITY DURING GAIT

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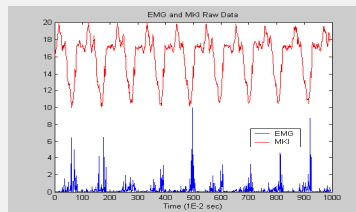
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Abstract

The present study investigates the Myokinetic Interface (MKI) as an alternative to standard electromyographic methods for measuring key aspects of muscle activity. MKI detects the changes in the muscles' dynamic surface pressure that reflect muscular contraction. 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) MKI timing is linearly related to EMG, (2) MKI compares favorably with EMG in terms of variability, (3) in isometric tasks, MKI and EMG are highly concordant.

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

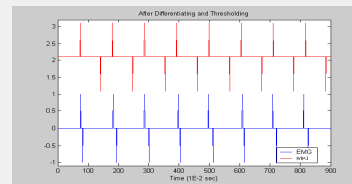


The MKI sleeve is an adjustable array of pressure sensors aligned over the major muscles of the limb, measuring kinetic activity via the external pressure that results from a muscle contraction.

Subject dons MKI and ambulates

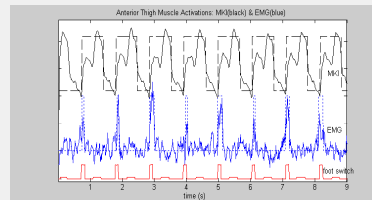
On/Off Analysis

- 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

- Fiducial Point Timing

- Post-heelstrike Mean Timing

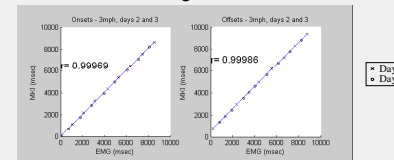
- In two trials, EMG and MKI timing was virtually identical, and in the other two, MKI consistently lagged after EMG

- Standard Deviation

- For all trials and statistics, the standard deviation of EMG was significantly larger than that of MKI, often by an order of magnitude

Linear Regression

The recordings of MKI and EMG over entire trials are compared step-by-step, resulting in very precise linear regressions, all with Pearson's r-values greater than 0.99



Linear Regressions for 3 mph: Onsets (left) and Offsets (right)

Gait Cycle Repeatability

The Variance Ratio quantified the repeatability of the wave-forms for the multiple gait cycles of each trial:

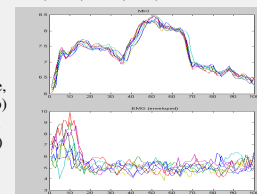
$$VR = \frac{\sum_{i=1}^k \sum_{j=1}^k (X_{ij} - \bar{X})^2 / (k(n-1))}{\sum_{i=1}^k \sum_{j=1}^k (X_{ij} - \bar{X})^2 / (kn-1)}$$

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

| | 3 mph | | 6 mph | |
|------------|-------|-------|-------|-------|
| | Day 1 | Day 2 | Day 1 | Day 2 |
| Unfiltered | 13.1 | 40.7 | 10.1 | 6.3 |
| Filtered | 12.0 | 54.4 | 9.6 | 9.1 |

$$\text{Inconsistency Ratio} = \text{VR}(\text{EMG}) / \text{VR}(\text{MKI})$$

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

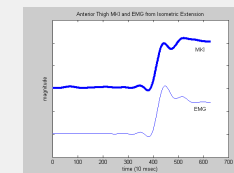


MKI signals are significantly more similar from cycle to cycle than EMG signals

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

Isometric Contraction

In isometric flexion and extension tasks, MKI and EMG records had strong concordance in both timing and morphology.



MKI and EMG in Isometric Extension

| | Trial 1 | Trial 2 |
|-----------|---------|---------|
| Extension | 0.97 | 0.96 |
| Flexion | 0.72 | 0.91 |

Correlation Coefficients for Isometric Tasks

Discussion

- EMG and MKI record features of muscle activity with similar fidelity, resulting in high Pearson r-values.

- MKI duration outlasted EMG by an average of 80% of foot-contact time. Muscle relaxation may account for most or all of this difference.

- Gait cycle repeatability of MKI is high relative to EMG, in terms of both fiducial point timing and the Inconsistency Ratio.

- In isometric tasks, MKI and EMG are highly concordant.