

# FORCE MYOGRAPHY ANALYSIS OF LEG MUSCLE ACTIVITY

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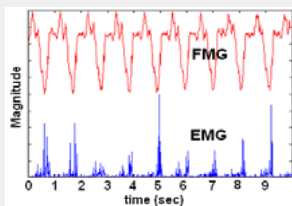
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## Abstract

The present study investigates Force Myography (FMG) as an alternative to standard electromyographic (EMG) methods for measuring key aspects of muscle activity. FMG detects the changes in the muscles' dynamic surface pressure that reflect muscular contraction. The FMG and EMG records of the leg muscles of a subject walking at 3mph and 6mph were compared to numerically define the periods of muscle activity. Results showed: (1) FMG timing is linearly related to EMG, (2) FMG compares favorably with EMG in terms of variability, (3) in isometric tasks, FMG and EMG are highly concordant.

## Force Myography.

- Quantifies the properties of muscle activation
  - detects changes in muscle shape.



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



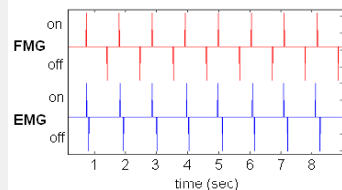
Subject dons FMG array and ambulates

- adjustable array of pressure sensors
- aligned over major leg muscles
- Measures kinetic activity
  - External, radial pressure changes
  - Result from muscle contraction

## Accurate Timing

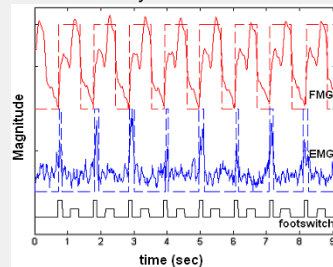
### Data Processing

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



Thresholded Rate of Change of FMG and EMG signals, showing onsets and offsets.

- EMG and FMG rates of change were thresholded to outline the timing of muscle activity.



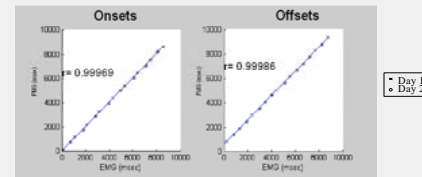
Filtered signals: FMG (top); EMG (middle); heelswitch (tall peaks) and toeswitch (small peaks) (bottom).

- Onset and Offset Timings correspond visually to original waves, confirming the accuracy of temporal data<sup>1</sup>

<sup>1</sup>Hodges, PW, et al., A comparison of computer-based methods for the determination of onset and muscle contraction using electromyography. *Electroencephalography and Clinical Neurophysiology*, 1996. 101(6): 511-519.

## Highly Correlated

- Pearson r-values > 0.99
  - 16 gait cycles from 2 days
  - correlate EMG and FMG



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

## Highly Repeatable

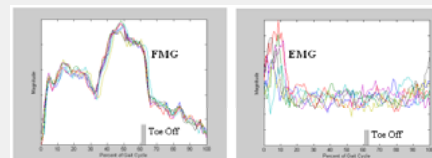
The Variance Ratio quantified the repeatability of the wave-forms for the multiple gait cycles of each trial:

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

Variance Ratio of multiple gait cycles<sup>2</sup>

	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

Variability of EMG compared to FMG

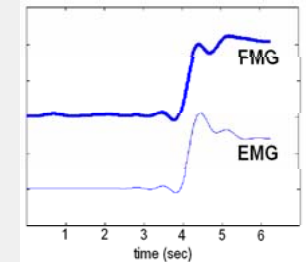


Overlays of signals from each gait cycle, raw FMG (left) and enveloped EMG (right)

<sup>2</sup>Hwang, Ing-Shiou, et al. "Electromyographic Analysis of Locomotion for Healthy and Hemiparetic Subjects". *Gait and Posture* 18. (2003): 1-12

## Waveform Similarity

- Isometric Flexion and Extension



FMG 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

- FMG provides a reasonable record of muscle activity, and could functionally substitute for EMG in some applications
- FMG duration outlasted EMG by an average of 54% of gait cycle. Muscle relaxation may account for most or all of this difference.
- Gait cycle repeatability of FMG is high relative to EMG, in terms of both fiducial point timing and the Variance Ratio.
- In isometric tasks, FMG and EMG are highly concordant.