DOPPLER MYOGRAPHY: ULTRASONIC LOCALIZATION OF ACOUSTIC MYOGRAPHIC SIGNALS

[1]Stephen F Levinson, [2]Hiroshi Kanai and [2]Hideyuki Hasegawa
[1]University of Rochester Department of Orthopaedics, Rochester, NY
[2]Tohoku University Department of Electronic Engineering, Sendai, Japan; email: levinson@ece.rochester.edu

INTRODUCTION

Skeletal muscles generate low-frequency sounds when they contract. These sounds originate from resonant vibrations of muscle fibers and their frequency is related to fiber length and tension. Although more than 2 decades have passed since acoustic myography (AMG) was first described, clinical applications have been limited to neuromuscular junction monitoring during anesthesia [1, 2]. With few exceptions, AMG has provided little more information than surface electromyography (EMG).

Recent improvements in ultrasonic Doppler technology have made it possible to detect sub-micron displacements. Indeed, the measurement of heart sounds propagating in myocardial tissue has been reported [3]. We hypothesize that a similar technique can be used to detect and possibly image skeletal muscle vibrations. This could lead to a biomechanical analog of needle EMG and could provide a noninvasive alternative.

METHODS

As many different terms appear in the literature, we will refer to the *phenomenon* of muscle fiber vibration as AMG, the recording of AMG signals at the skin surface as phonomyography (PMG) and the recording of AMG using Doppler ultrasound as Doppler myography (DMG).

We conducted a single subject exploration of DMG by placing an ultrasound transducer over the flexor forearm group. Doppler signals were obtained during active grasp and the range gate was adjusted to be within the flexor digitorum superficialis (FDS). Surface EMG and PMG signals were simultaneously recorded. Grip strength was measured using a grip dynamometer (Figure 1).

RESULTS AND DISCUSSION

Simultaneous recordings were obtained for a variety of grip strengths. Vibrations are evident in the DMG recordings, however, translational motion was also observed (Figure 2). As with EMG, it is likely that filters will need to be implemented to remove unwanted components from the DMG signal. Additional experiments will be required to determine the optimum ultrasound parameters and configuration. Still, we believe that this is an important first step and that, with additional research, DMG could become a clinically useful test. The addition of real-time imaging capabilities could lead to a powerful new diagnostic tool.

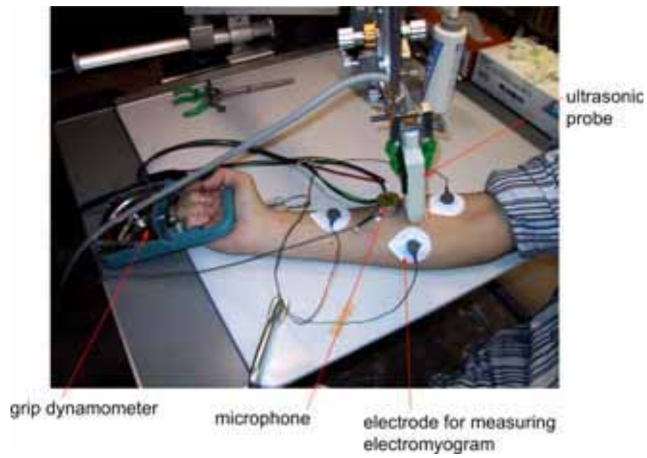

Figure 1: Apparatus for simultaneous measurement of surface electromyogram (EMG), phonomyogram (PMG) and Doppler myogram (DMG) in the forearm during grasp. Grip strength is measured using a grip dynamometer.

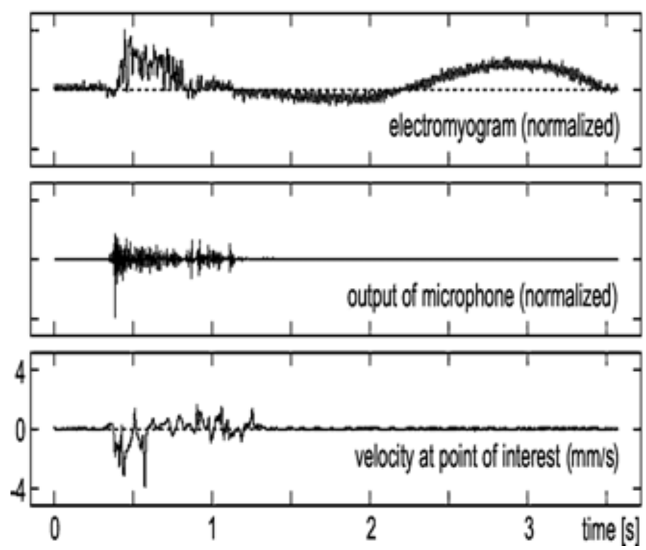

Figure 2: Simultaneous recordings of surface EMG (top), PMG (middle) and DMG (bottom) signals in the flexor digitorum superficialis during 24 kg of grasp.

REFERENCES

1. Barry DT, et al., Acoustic myography: a noninvasive monitor of motor unit fatigue. *Muscle & Nerve* **8:** 189-94, 1985.
2. Hemmerling TM, et al., Phonomyography and mechanomyography can be used interchangeably to measure neuromuscular block at the adductor pollicis muscle. *Anesthesia & Analgesia* **98:** 377-81, 2004.
3. Kanai H, et al., Transcutaneous measurement and spectrum analysis of hart wall vibrations. *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control* **43:** 791-810, 1996.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support of the University of Rochester School of Medicine and Dentistry.