INTER-OPERATOR RELIABILITY OF FINE-WIRE ELECTROMYOGRAPHY IN THE EVALUATION OF ECCENTRIC ELBOW FLEXOR ACTIVITY

Sarah M. Barron[1*], Tamara Ordonez Diaz[1], Maximillian T. Diaz[1], Federico Pozzi[2], and Jennifer A. Nichols[1]
[1]J. Crayton Pruitt Family Department of Biomedical Engineering, University of Florida, Gainesville, FL
[2]Department of Physical Therapy, University of Florida, Gainesville, FL
email: *sgormley@ufl.edu

Introduction

Objective assessments of muscle weakness and fatigue are important in both clinical practice and research studies. Electromyography (EMG) can provide measurements of muscle function and thus, is an excellent tool for identifying and treating muscle dysfunction. To enable comparison of data across clinical practices (different clinicians) and in complex, multi-site research studies (different experimenters), the inter-operator reliability of various EMG methods has been demonstrated. For example, surface EMG (sEMG) has shown good reliability during strength exercises [1]. However, sEMG cannot be used for deep muscles or small superficial muscles, where crosstalk is problematic. These muscle types are prevalent in the upper extremity and require use of fine-wire EMG (fEMG). Studies assessing the inter-operator reliability of fEMG are limited. These studies, focused on motor unit information, had multiple operators run decomposition algorithms on data collected following a single electrode insertion [2]. Therefore, the reliability of fEMG amplitude parameters, which provide valuable functional information but can be affected by electrode location, is not fully understood. The purpose of this study was to assess the inter-operator reliability of fEMG amplitude parameters in the upper extremity following electrode insertion by different experimenters.

Methods

5 healthy subjects [3 female, 23.2 ± 2.3 years] (mean ± SD) and 3 experimenters were involved in this IRB-approved study. The experimenters were doctoral students who have each undergone training in fEMG electrode insertion and have between 1-3 years of experience in evaluating muscle activity with EMG. Each experimenter inserted fEMG electrodes into the brachialis, biceps brachii, and brachioradialis of each subjects' dominant arm using anatomical landmarks and ultrasound to determine insertion sites. Experimenter insertion order was randomized, and previous experimenter's electrodes were removed prior to subsequent insertions to avoid location bias. Following each experimenter's insertions, subjects performed 2 sets of 5 bicep curls (6 total sets) with a 10-lb kettle bell while EMG data were sampled at 3000 Hz. 3 curls from each set of 5 were analyzed. EMG processing followed standard methods [3]. Briefly, the signals were filtered using a 20-450 Hz Butterworth bandpass filter and rectified. Root mean squared (RMS) values were calculated using a 100-ms time-averaging window. The EMG envelope for each trial was normalized to the peak concentric activation value occurring within the trial. This within-task normalization approach was chosen, as individuals in clinical settings may have trouble achieving maximum effort [4]. The normalized peak eccentric activation from each curl within the trial was then calculated. Inter-operator reliability was assessed by calculating the intraclass correlation coefficient (ICC: two-way random effects) of the eccentric peaks between experimenters. ICC values between 0.5 and 0.75 indicate moderate reliability, 0.75 and 0.9 good reliability, and greater than 0.9 excellent reliability [5].

Results and Discussion

Across muscles, fEMG demonstrated good reliability (ICC = 0.761, CI [0.661, 0.835]). Within-muscle analyses demonstrated moderate to good reliability. The biceps had the highest ICC (0.887, CI [0.793, 0.942]), followed by the brachioradialis (0.644, CI [0.347, 0.819]) and brachialis (0.573, CI [0.217, 0.783]), respectively. Though the brachialis (deepest muscle) had the lowest reliability, the difference across experimenters in mean peak eccentric EMG was <15% for all subjects, and <7% when averaged across subjects (Fig. 1). Past studies have demonstrated higher ICC values (ranging from 0.77-0.94) for individual muscle sEMG amplitude parameters during strength exercises [1] than the brachioradialis/brachialis fEMG in this study. Though the lower inter-operator reliability exhibited may reflect true operator variability, it has been shown that fEMG is more variable within-subject than sEMG with a constant electrode location [6]. Lower ICC values may also reflect a lack of variability among sampled subjects or a small sample size [5].

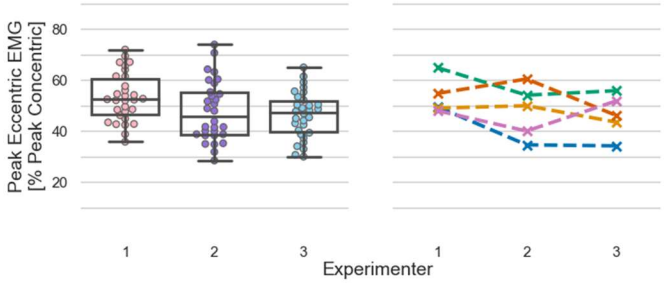

Figure 1: Peak eccentric brachialis EMG, expressed as % peak concentric. [L]: Boxplots and individual data from each experimenter across all subjects. [R]: Within-subject averages for each experimenter across trials/repetitions. Unique colors represent separate subjects.

Significance

This study demonstrates that fEMG amplitude parameters have good inter-operator reliability across the elbow flexors. This is an essential step in validating that fEMG can be compared across clinical practices and research sites. Though fEMG amplitude parameters can be used to assess relative muscle weakness across time, frequency information is necessary to evaluate muscle fatigue. The reliability of fEMG frequency should therefore be assessed in future studies.

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References

[1] Danneels et al., 2001. *Man Ther.* 6(3):145-153. [2] Calder et al., 2008. *J Neurosci Methods.* 168(2):483-493. [3] Konrad, 2006. The ABC of EMG. [4] Halaki et al., 2012. Normalization of EMG Signals. [5] Koo et al., 2016. *J Chiropr Med.* 15(2):1550163. [6] Jacobson et al., 1995. *J Electromyogr Kinesiol.* 5(1):37-44.