EXAMINATION OF NEUROMUSCULAR RESPONSES DURING ISOMETRIC, FATIGUING HANDGRIP HOLDS AT CRITICAL FORCE

Minyoung Kwak, Pasquale J. Succi, Brian Benitez, Haley C. Bergstrom
University of Kentucky, Department of Kinesiology and Health Promotion, Lexington, KY

INTRODUCTION

- In theory, critical force (CF) is the highest force that can be maintained for an extended period of time without fatigue.
- At or below the CF, it has been suggested that exercise is not limited by alterations in muscle blood flow that arise from increases in intramuscular pressure and occlusion of vascular beds during muscle contractions.
- The amplitude (AMP) and mean power frequency (MPF) of the electromyographic (EMG) and mechanomyographic (MMG) signals have been used to examine motor unit activation strategies.
- The EMG AMP and EMG MPF reflect muscle excitation (i.e., motor unit recruitment, firing rate, and synchronization) and action potential conduction velocity along the sarcolemma, respectively.
- The MMG AMP and MMG MPF reflect motor unit recruitment and the global firing rate of the unfused, active motor units, respectively.

PURPOSE

- This study examined the EMG and MMG AMP and MPF responses during isometric handgrip holds to failure (HTF) at the CF.

METHODS

- 10 men (Mean±SD, age=24±8years, height=177.5±8.1cm, weight=76.8±13.1kg)
- Handgrip HTF at 30%,40%,50%,60% MVIC to determine CF.

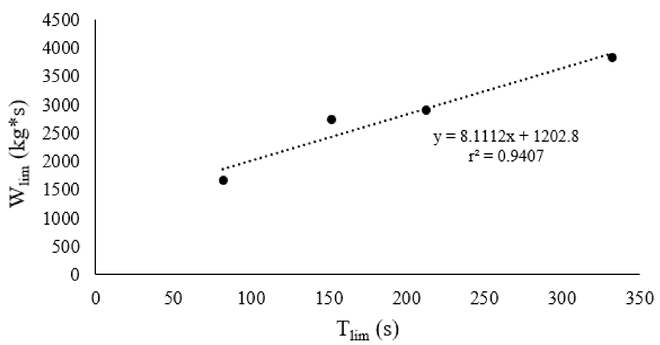

Figure 1. The total work (W_{lim}) versus time to exhaustion (T_{lim}) relationship used to determine the critical force (CF) for one representative subject. The CF was the slope of W_{lim} versus T_{lim} relationship.

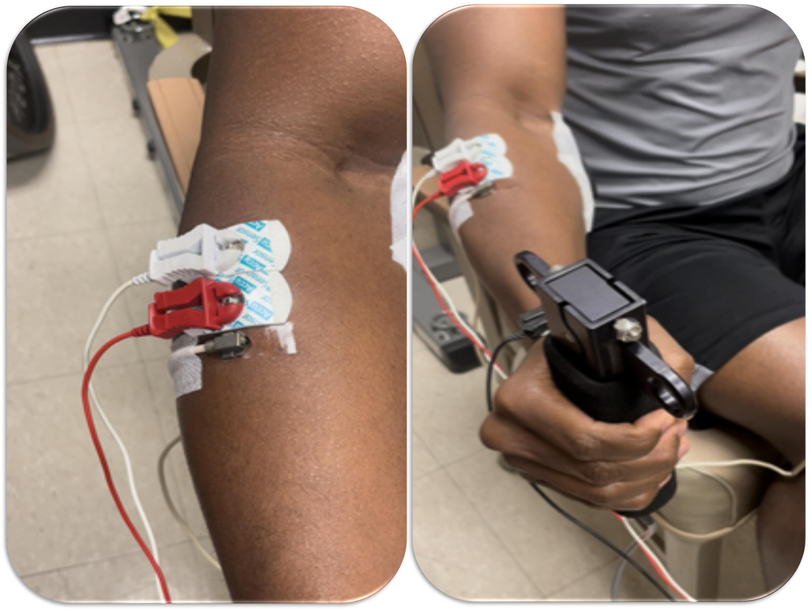

Figure 2A) Electromyographic (EMG) electrodes were placed in a bipolar arrangement on the brachioradialis of the dominant arm, and the mechanomyographic accelerometer was placed 20mm below the EMG electrodes using double-sided adhesive tape. **Figure 2B)** Isometric handgrip dynamometer was used to measure force production.

- The EMG and MMG AMP and MPF values were normalized to their respective pre-MVIC values at the start of the hold and every 10% of T_{lim} (0%-100%).
- One-way repeated measures ANOVAs ($p \leq 0.05$) and post-hoc t-tests with Bonferroni corrected alpha level ($p<0.005$) were used to examine EMG and MMG AMP and MPF across time.

RESULTS

- The absolute (kg) and relative (%MVIC) CF values were 7.8±2.5kg, and 19.5±4.6%, respectively, and the T_{lim} was 639.8±340.6 seconds.
- The results of the one-way repeated measures ANOVAs indicated significant differences across time for EMG AMP ($F=7.453$, $p<0.001$, $\eta^2=0.453$), EMG MPF ($F=7.069$, $p<0.001$, $\eta^2=0.440$), MMG AMP ($F=16.208$, $p<0.001$, $\eta^2=0.643$), and MMG MPF ($F=8.178$, $p<0.001$, $\eta^2=0.476$).

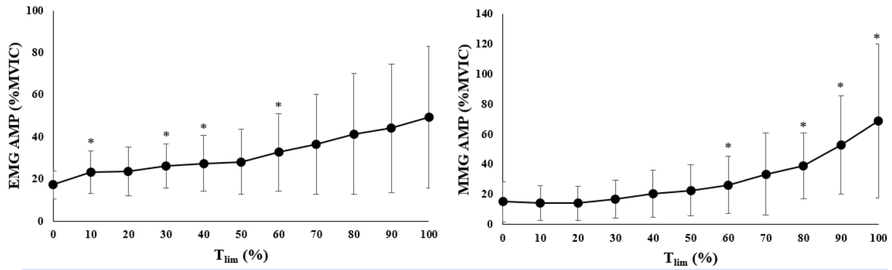

Figure 3A) There were increases, relative to the initial value (0% T_{lim}), at 10%, 30%, 40% and 60% T_{lim} for EMG AMP. **Figure 3B)** There were increases, relative to the initial value (0% T_{lim}), at 60%, 80%, 90% and 100% T_{lim} for MMG AMP.

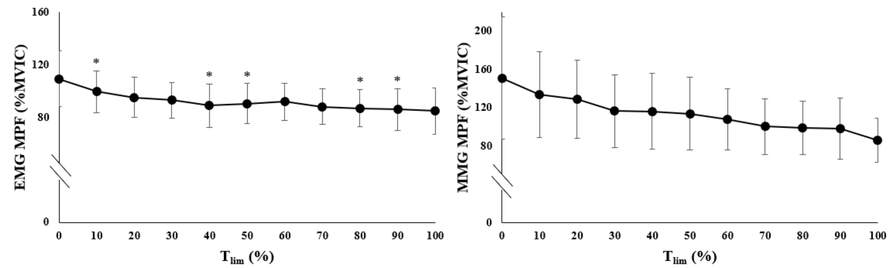

Figure 4A) There were decreases, relative to 0% T_{lim}, at 10%, 40%, 50%, 80%, and 90% for EMG MPF. **Figure 4B)** There was no differences at any time points (p=0.006-0.065) for MMG MPF.

CONCLUSIONS

- Across time, there were fatigue-induced decreases in action potential conduction velocity (EMG MPF) and increases in muscle excitation (EMG AMP) that may have reflected the recruitment of higher threshold motor units (MMG AMP), but no change in the global firing rate (MMG MPF) of the unfused, activated motor units.
- The neuromuscular responses during the HTF at CF suggested that CF overestimated the highest force that can be maintained without fatigue.

PRACTICAL APPLICATIONS

- The CF may be useful in defining work parameters for tactical and industrial occupations.
- Identifying the underlying mechanisms of fatigue could be beneficial to prevent hand/wrist-related musculoskeletal disorders and injuries derived from repetitive and prolonged handgrip contractions.