Similar Responses to Fatigue In Men And Women Following Sustained, Isometric Forearm Flexion Tasks Anchored to RPE And Torque

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ABSTRACT

Few studies have simultaneously assessed the amplitude (AMP) and mean power frequency (MPF) of electromyographic (EMG) and mechanomyographic (MMG) signals during tasks anchored to a rating of perceived exertion (RPE) and torque to compare the changes in the neuromuscular and mechanical properties of muscle function. **PURPOSE:** The purpose of this study was to examine the effects of anchor scheme and sex on maximal voluntary isometric contraction (MVIC) torque, EMG, and MMG responses following sustained, isometric forearm flexion tasks in men and women. **METHODS:** Fourteen recreationally active adults (7 men and 7 women) performed 2, 3s forearm flexion MVICs before and after sustained, isometric forearm flexion tasks to failure (elbow joint angle = 100°) anchored to RPE = 7 (RPEFT) and the initial torque (TRQFT) that corresponded to RPE = 7. Task failure for the RPEFT was defined as RPE > 7, or torque reduced to zero. For the TRQFT, task failure was defined as the inability to maintain the target torque value. During testing, torque was recorded on a Cybex 6000 dynamometer, with the EMG and MMG signals recorded from the biceps brachii (BB). Five, separate 2 (Time: Pre-test vs. Post-test) × 2 (Anchor Scheme: RPEFT vs. TRQFT) × 2 (Sex: Men vs. Women) mixed factorial ANOVAs were performed for torque and the neuromuscular parameters (EMG AMP, EMG MPF, MMG AMP, and MMG MPF). Bonferroni corrected post-hoc dependent t-tests and independent t-tests were used when necessary. **RESULTS:** Post-hoc comparisons indicated a decrease in torque (collapsed across sex) from pre-test to post-test MVICs (45.9 ± 5.6 vs. 40.9 ± 5.9 Nm; $p < 0.001$) and that the men produced a greater MVIC than the women (58.5 ± 6.4 vs. 28.3 ± 9.8 Nm; $p < 0.001$). Furthermore, post-hoc comparisons indicated a decrease in EMG AMP (collapsed across sex) from pre-test to post-test MVICs (720.3 ± 136.6 vs. 603.2 ± 123.0 µVrms; $p = 0.003$) and that the men had a greater MMG AMP than the women (0.72 ± 0.14 vs. 0.60 ± 0.12 $m \cdot s^{-2}$). There were no changes for EMG MPF or MMG MPF. **CONCLUSIONS:** The present findings were consistent with the typical sex-specific differences in MVIC torque production during upper body tasks. Our findings indicated, however, that men and women exhibited similar fatigue-induced decreases in MVIC, regardless of anchor scheme. It is possible, that the fatigue-induced decreases in EMG AMP indicated a decrease in muscle excitation associated with reductions in central command due to peripheral factors that caused central fatigue and likely contributed to fatigue-induced decreases in MVIC. In addition, it may be that the men relied more on motor unit recruitment (based on MMG AMP) during the MVICs than the women, which suggested there may be sex-specific differences in motor unit activation strategies involved with the production of MVIC torque values during forearm flexion tasks. **PRACTICAL APPLICATIONS:** EMG and MMG can be used to examine both the neuromuscular and mechanical aspects of muscle function following fatiguing tasks utilizing different anchor schemes to provide information about the mechanisms of fatigue-induced changes in muscular strength for men and women.

INTRODUCTION

Fatigue has been commonly defined as an exercise-induced decline in torque-generating capacity of a muscle. Furthermore, it is recommended that the effects of fatigue should be quantified using a criterion relative to a reference value over a given period of time (4). The quantification of fatigue can be achieved with performance-related measures such as maximal torque production recorded before and after a fatiguing task. This method has been defined as performance fatigability (2,3). Additionally, EMG and MMG signals have been used to make inferences regarding fatigue-induced neuromuscular and mechanical changes. Few studies (1,5) have simultaneously assessed the amplitude AMP and MPF of EMG and MMG signals following fatiguing tasks anchored to a rating of perceived exertion (RPE) and torque to compare the changes in the neuromuscular and mechanical properties of muscle function. Thus, the purpose of this study was to examine the effects of anchor scheme and sex on MVIC torque, EMG, and MMG responses following sustained, isometric forearm flexion tasks in men and women.

METHODS

SUBJECTS: Fourteen recreationally active adults (7 men: 21.3 ± 2.1 yrs; height = 182.7 ± 5.7 cm; body mass = 94.4 ± 15.4 kg, and 7 women: 20.7 ± 2.3 yrs; height = 167.8 ± 5.9 cm; body mass = 73.5 ± 19.6 kg) volunteered to participate in this study. **PROCEDURES:** The Subjects completed two testing visits. Test visit 1 included 2, 3s pre-test forearm flexion MVICs, a sustained, isometric task to failure (RPE > 7, or torque reduced to zero) anchored to RPE = 7 (RPEFT), and 2, 3s post-test MVICs. Test visit 2 was performed in a manner identical to test visit 1, but the sustained task was anchored to the torque (TRQFT) produced during the first 1s of the RPEFT. The TRQFT was sustained to task failure (target torque could not be maintained). All muscle actions were performed at an elbow joint angle of 100°. **SIGNAL PROCESSING:** Torque (N·m) was recorded on a calibrated Cybex 6000 dynamometer. Bipolar EMG electrodes were placed over the BB with a miniature accelerometer placed between the electrodes. Surface EMG was used to record EMG AMP (µVrms) and EMG MPF (Hz) and the miniature accelerometer was used to record MMG AMP ($m \cdot s^{-2}$) and MMG MPF (Hz). The raw EMG and MMG signals were digitized at 2,000 Hz with a 12-bit analog-to-digital converter (MODEL MP150; Biopac Systems, Inc) and amplified (gain: x 1000) using differential amplifiers (EMG2-R Bionomadix, Biopac Systems, Inc. Goleta, CA, USA; bandwidth—10-500 Hz). Finally, the EMG and MMG signals were digitally bandpass filtered (fourth-order Butterworth) at 10-500 Hz and 5-100 Hz, respectively. **STATISTICS:** Five, separate 2 (Time: pre-test vs. post-test) × 2 (Anchor Scheme: RPEFT vs. TRQFT) × 2 (Sex: Men vs. Women) mixed factorial ANOVAs were performed for torque and the neuromuscular parameters (EMG AMP, EMG MPF, MMG AMP, and MMG MPF). Bonferroni corrected post-hoc dependent t-tests and independent t-tests were used when necessary.

RESULTS

MVIC Torque: Post-hoc comparisons indicated a decrease in torque (collapsed across Anchor Scheme and Sex) from pre-test to post-test MVICs (45.9 ± 5.6 vs. 40.9 ± 5.9 N·m; $p < 0.001$) and that (Collapsed across Anchor Scheme) the men produced a greater MVIC than the women (58.5 ± 6.4 vs. 28.3 ± 9.8 N·m; $p < 0.001$).

EMG AMP: Post-hoc comparisons indicated a decrease in EMG AMP (Collapsed across Anchor Scheme and Sex) from pre-test to post-test MVICs (720.3 ± 136.6 vs. 603.2 ± 123.0 µVrms; $p = 0.003$).

EMG MPF: There were no changes ($p > 0.05$) for EMG MPF from pre-test to post-test MVICs regardless of anchor scheme or sex.

MMG AMP: Collapsed across anchor scheme, post-hoc comparison indicated that men had a greater MMG AMP than women (0.72 ± 0.14 vs. 0.60 ± 0.12 $m \cdot s^{-2}$; $p = 0.002$).

MMG MPF: There were no changes ($p > 0.05$) for MMG MPF from pre-test to post-test MVICs regardless of anchor scheme or sex.

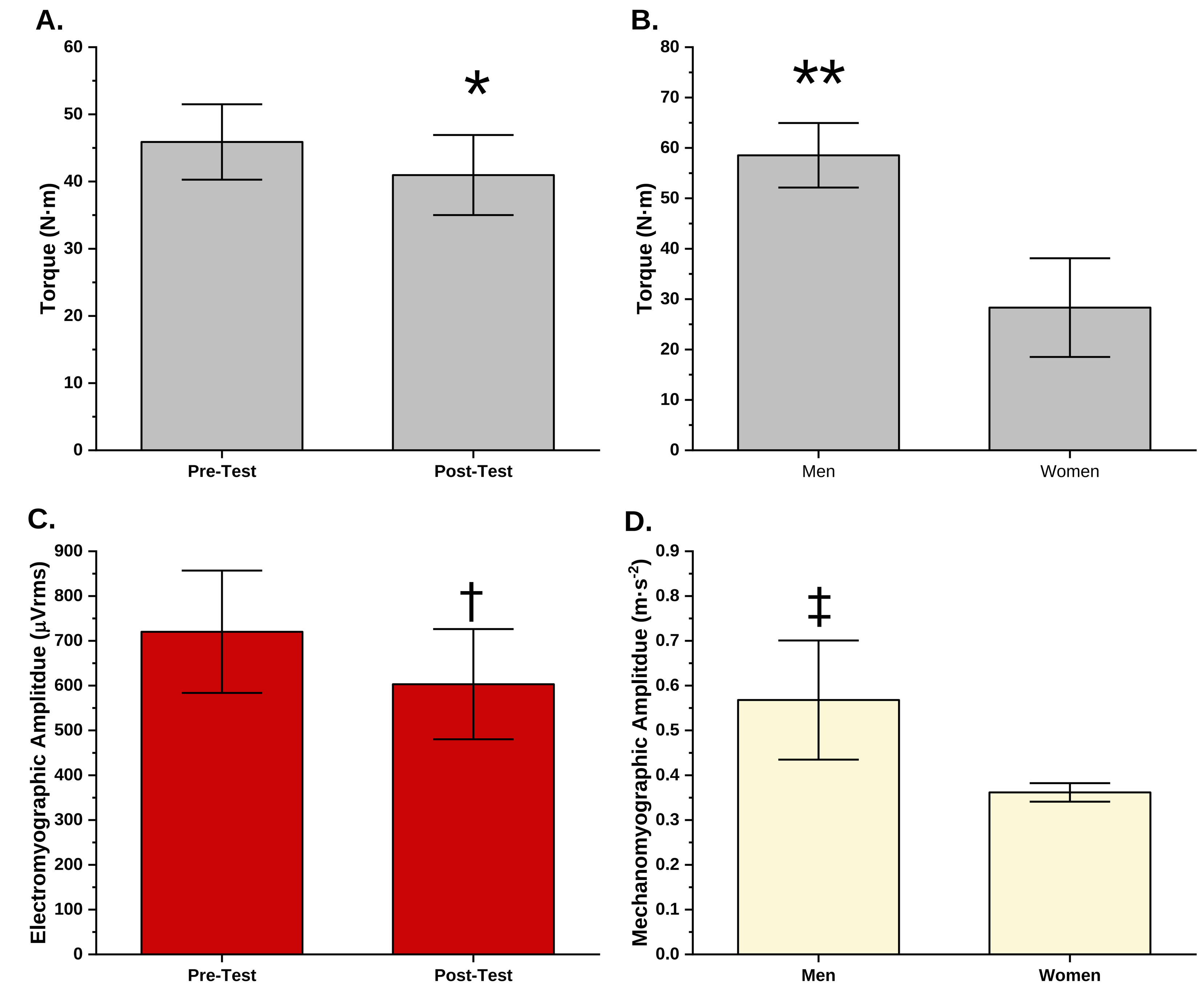

Figure 1. A. Mean (± SD) torque values during the pre-test and post-test maximal voluntary isometric contraction (MVIC) assessments (Collapsed across Anchor Scheme and Sex). * Pre-Test (45.9 ± 5.6 N·m) > Post-Test (40.9 ± 5.9 N·m) at $p < 0.001$. **B.** Mean (± SD) torque values during the pre-test MVIC assessments for men and women (Collapsed across Anchor Scheme). ** Men (58.5 ± 6.4 N·m) > Women (28.3 ± 9.8 N·m) at $p < 0.001$. **C.** Mean (± SD) Electromyographic Amplitude (EMG AMP) values during the pre-test and post-test MVIC assessments (Collapsed across Anchor Scheme and Sex). † Pre-Test (720.3 ± 136.6 µVrms) > Post-Test (603.2 ± 123.0 µVrms) at $p = 0.003$. **D.** Mean (± SD) Mechanomyographic (MMG) AMP values during the pre-test MVIC assessments for men and women (Collapsed across Anchor Scheme). ‡ Men (0.72 ± 0.14 $m \cdot s^{-2}$) > Women (0.60 ± 0.12 $m \cdot s^{-2}$) at $p = 0.002$.

CONCLUSION & PRACTICAL APPLICATIONS

The present findings were consistent with the typical sex-specific differences in MVIC torque production during upper body tasks. Our findings indicated, however, that men and women exhibited similar fatigue-induced decreases in MVIC, regardless of anchor scheme. It is possible, that the fatigue-induced decreases in EMG AMP indicated a decrease in muscle excitation associated with reductions in central command due to peripheral factors that caused central fatigue and likely contributed to fatigue-induced decreases in MVIC. In addition, it may be that the men relied more on motor unit recruitment (based on MMG AMP) during the MVICs than the women, which suggested there may be sex-specific differences in motor unit activation strategies involved with the production of MVIC torque values during forearm flexion tasks. Electromyography and MMG can be used to examine both the neuromuscular and mechanical aspects of muscle function following fatiguing tasks utilizing different anchor schemes to provide information about the mechanisms of fatigue-induced changes in muscular strength for men and women.

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