Performance Fatigability, Perceived Fatigability, and Neuromuscular Responses During a Fatiguing Task Anchored to a High Rating of Perceived Exertion

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ABSTRACT

BACKGROUND: Few studies have assessed the interaction between performance fatigability (PF) and perceived fatigability during a fatiguing task anchored to a high rating of perceived exertion (RPE). In addition, assessing fatigue-induced changes in electromyographic amplitude (EMG AMP) and neuromuscular efficiency (NME) may provide insight into the motor unit activation strategies that modulate torque (TRQ) production during a fatiguing task. **PURPOSE**: The present study examined the composite patterns of responses for TRQ, EMG AMP, and NME during a sustained, isometric forearm flexion task anchored to RPE=8, as well as the perceived factors that contributed to task termination. **METHODS**: Twelve men (mean±SD: age=20.9±2.2 yrs) completed forearm flexion maximal voluntary isometric contractions (MVICs) before and after a sustained, isometric forearm flexion task to failure (defined as TRQ reduced to zero) anchored to RPE=8. The EMG AMP was recorded from the biceps brachii (BB), and neuromuscular efficiency (NME) was calculated by dividing normalized TRQ by normalized EMG AMP. A post-test questionnaire (PTQ) with 10 Likert-type items was used to quantify the contributions of perceived sensations (i.e., pain and fatigue in the BB, forearm muscles [FM], and hand muscles [HM]) and psychological factors (i.e., loss of focus and motivation) to the decision to terminate the task. Motivation was divided into three subtypes: Motivation 1 [M1: gave maximal effort], Motivation 2 [M2: perceived that the task could not be accomplished], and Motivation 3 [M3: became bored]. Polynomial regressions (linear and quadratic) were used to define the composite relationships for normalized TRQ, EMG AMP, and NME versus time (every 10%) during the sustained task. Spearman's Rank Order Correlations (SROC) were used to assess the relationships among the PTQ items, time to task failure (TTF), and PF (% decline in MVIC from pre-test to post-test). **RESULTS**: The composite patterns of responses indicated significant negative TRQ (p<0.001, r=-0.969), EMG AMP (p=0.002, r=-0.857), and NME (p<0.001, r=-0.969) versus time relationships throughout the fatiguing task. The mean (±SD) values for TTF and PF were 255.5 s (±166.3 s) and 23.5% (±13.7%), respectively. The SROC indicated significant (p≤0.05, r_s=0.611-0.904) associations for FM fatigue vs. FM pain, FM fatigue vs. HM fatigue, FM fatigue vs. HM pain, FM pain vs. M3, FM pain vs. HM fatigue, FM pain vs. HM pain, HM fatigue vs. HM pain, and M2 vs. focus. There were no associations (p>0.05, r_s=-0.419-0.565) among BB fatigue, BB pain, M1, TTF, and PF. **CONCLUSIONS**: The present findings indicated that the decreases in TRQ and EMG AMP during a sustained, isometric task anchored to RPE=8 were likely due to the ability to voluntarily reduce TRQ to maintain the target RPE. In addition, the fatigue-induced decrease in NME during the task was likely due to excitation-contraction coupling failure that resulted from peripheral fatigue. Neither the perceived sensations or psychological factors were related to TTF or PF, but perceived sensations and psychological factors were interrelated. **PRACTICAL APPLICATION**: When performing an isometric task to failure anchored to RPE=8, individuals modulate their ability to continue the task by lowering their torque to maintain their target RPE. Furthermore, a PTQ with Likert-type items may be a simple way for practitioners to assess factors related to perceived fatigability.

BACKGROUND

Previous researchers have provided various definitions for muscular fatigue. Therefore, unified taxonomies have been proposed by Kluger et al. (2013) and Enoka and Duchateau (2016), which characterized fatigue as an interaction between two interdependent aspects: performance fatigability and perceived fatigability. Few studies have assessed the interaction between these two aspects of fatigue during a sustained, isometric task anchored to a high rating of perceived exertion (RPE), which is a scale used to rate the subjective intensity experienced during an exercise (Robertson and Noble, 1997). In addition, assessing fatigue-induced changes in electromyographic amplitude (EMG AMP) and neuromuscular efficiency (NME) may provide insight into the motor unit activation strategies that modulate torque (TRQ) production during a fatiguing task.

Thus, the purpose of this study was to examine the composite patterns of responses for TRQ, EMP AMP, and NME during a sustained, isometric forearm flexion task anchored to an RPE value of 8 (RPE=8), as well as the perceived factors that contributed to task termination via a post-test questionnaire (PTQ).

METHODS

Subjects: Twelve men (mean ± SD: age = 20.9 ± 2.2 yrs.; height = 179.8 ± 5.3 cm; body mass = 80.2 ± 9.9 kg) volunteered to participate in this study. All subjects were recreationally active (≥ 3 d·wk^{-1} of resistance and/or aerobic exercise) and free of upper body pathologies that would affect performance. The subjects visited the laboratory on one occasion for testing. **Procedures**: Subjects performed the following isometric forearm flexion actions with their dominant arm at an angle of 100° on an isokinetic dynamometer: (1) a warm-up consisting of 4, 3 s submaximal contractions (50-75% of max effort), (2) 2, 3 s pre-test maximal voluntary isometric contractions (MVICs), (3) a fatiguing task, and (4) 2, 3 s post-test MVICs. The fatiguing task was sustained at RPE=8 until task termination, which was defined as torque reduced to zero. After, subjects completed a PTQ with 10 Likert-type items to quantify the contributions of perceived sensations (i.e., pain and fatigue in the biceps brachii [BB], forearm muscles [FM], and hand muscles [HM]) and psychological factors (i.e., loss of focus and motivation) to the decision to terminate the task. Motivation was divided into three subtypes: Motivation 1 [M1: gave maximal effort], Motivation 2 [M2: perceived that the task could not be accomplished], and Motivation 3 [M3: became bored]. **Signal Acquisition**: The EMG AMP was collected from a bipolar EMG electrode arrangement placed over the biceps brachii. The raw signal was digitized at 2000 samples per second using a 12-bit-analog-to-digital converter (Model MP150; Biopac Systems, Inc., Goleta, CA, USA) and digitally band-pass filtered (fourth-order Butterworth) at 10–500 Hz. Neuromuscular efficiency was calculated by dividing normalized TRQ by normalized EMG AMP. **Statistical Analysis**: Polynomial regressions (linear and quadratic) were used to define the composite relationships for normalized TRQ, EMG AMP, and NME versus time (every 10%) during the sustained task. Spearman's Rank Order Correlations (SROC) were used to assess the relationships among the PTQ items, time to task failure (TTF), and performance fatigability (% decline in MVIC from pre-test to post-test).

RESULTS

The composite patterns of responses indicated significant negative linear TRQ (p < 0.001, r = -0.969) (Figure 1), EMG AMP (p = 0.002, r = -0.857) (Figure 2), and NME (p < 0.001, r = -0.969) (Figure 3) versus time relationships throughout the fatiguing task. The mean ± SD values for TTF and performance fatigability were 255.5 ± 166.3 s and 23.5 ± 13.7%, respectively. The SROC indicated significant (p < 0.05) associations for FM fatigue vs. FM pain (r_s = 0.904), FM fatigue vs. HM fatigue (0.726), FM fatigue vs. HM pain (0.679), FM pain vs. M3 (0.611), FM pain vs. HM fatigue (0.630), FM pain vs. HM pain (0.632), HM fatigue vs. HM pain (0.856), and M2 vs. focus (0.690). There were no associations (p > 0.05, r_s = -0.419 – 0.565) among BB fatigue, BB pain, M1, TTF, and performance fatigability.

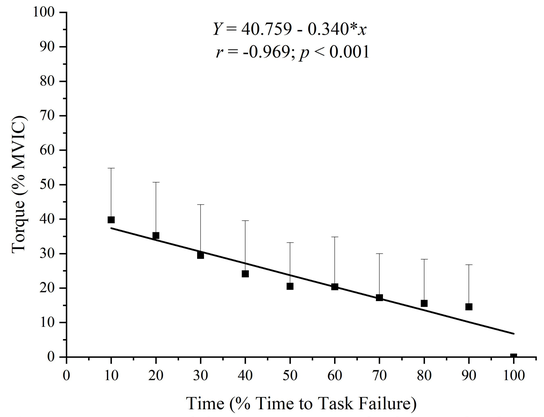

Figure 1. Time course of changes (mean ± SD) for the normalized (% of pre-test MVIC) torque values. The regression analysis represents the torque values from 10-100% of time to task failure.

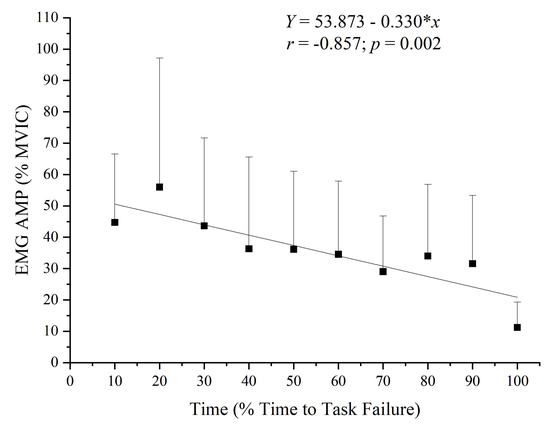

Figure 2. Time course of changes (mean ± SD) for the normalized (% of pre-test MVIC) electromyographic amplitude (EMG AMP) values. The regression analysis represents the EMG AMP values from 10-100% of time to task failure.

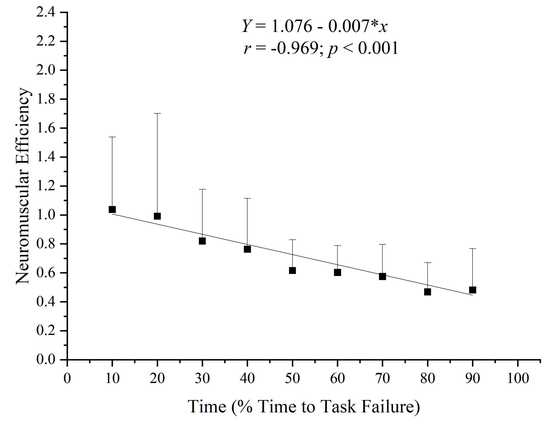

Figure 3. Time course of changes (mean ± SD) for the neuromuscular efficiency values. The regression analysis represents the NME values from 10-90% of time to task failure.

CONCLUSIONS

The present findings indicated that the decreases in TRQ and EMG AMP during a sustained, isometric task anchored to RPE=8 were likely due to the ability to voluntarily reduce TRQ to maintain the target RPE. In addition, the fatigue-induced decrease in NME during the task was likely due to excitation-contraction coupling failure that resulted from peripherical fatigue. Neither the perceived sensations or psychological factors were related to TTF or performance fatigability, but perceived sensations and psychological factors were interrelated.

PRACTICAL APPLICATIONS

When performing an isometric task to failure anchored to RPE=8, individuals modulate their ability to continue the task by lowering their torque to maintain their target RPE. Furthermore, a PTQ with Likert-type items may be a simple way for practitioners to assess perceived sensations and psychological factors contributing to task termination.

References

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