Effects of a Sustained Task Anchored to a Low RPE on Performance Fatigability, Perceived Fatigability, and Neuromuscular Responses in Men

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Abstract

Performance fatigability (PF) and perceived fatigability are two interdependent attributes of fatigue defined as a decline in an objective measure of performance and the changes in sensations and perceptions associated with performance, respectively. Few studies have examined the torque (TRQ) and neuromuscular responses during a sustained, isometric forearm flexion task (SIFFT) anchored to a low rating of perceived exertion (RPE) and whether perceived sensations (PercSens) and psychological factors (PsychFact) influence the decision to terminate the task. **Purpose:** This study examined the composite patterns of responses (CPoR) for TRQ, electromyographic amplitude (EMG AMP), and neuromuscular efficiency (NME = normalized TRQ / normalized EMG AMP) during a SIFFT anchored to a low RPE as well as the PercSens and PsychFact that contributed to task termination (TT). **Methods:** Twelve men (mean ± SD: age = 20.9 ± 2.2 yrs.; height = 79.8 ± 5.3 cm; body mass = 80.2 ± 9.9 kg) performed forearm flexion maximal voluntary isometric contractions (MVIC) before and after a SIFFT to failure (i.e., TRQ reduced to zero) anchored to RPE = 2 to determine PF (% decline in MVIC). The EMG AMP was recorded from the biceps brachii (BB). Following the SIFFT, the subjects completed a post-test questionnaire (PTQ) to quantify the contribution of the PercSens (i.e., fatigue and pain of the BB, forearm muscles [FM], and hand muscles [HM]) and PsychFact (i.e., loss of focus [LOF] and motivation) to TT. The PTQ included 10 Likert-type items: (1) BB fatigue; (2) BB pain; (3) FM fatigue; (4) FM pain; (5) HM fatigue; (6) HM pain; (7) LOF; (8) Motivation 1 [Mot1: subject expended maximal effort]; (9) Motivation 2 [Mot2: subject perceived that the task could not be accomplished]; and (10) Motivation 3 [Mot3: subject became bored]. Polynomial regression analyses (linear and quadratic) were used to define the composite relationships for normalized TRQ, EMG AMP, and NME versus time (every 10%) during the SIFFT. Spearman's Rank Order Correlations (SROC) were used to assess the relationships among the PTQ items, time to task failure (TTF; 306.9 ± 486.4 s), and PF (7.2 ± 11.0%). **Results:** The CPoR indicated significant ($p \leq 0.05$, r = -0.776 - 0.976) linear decreases for TRQ, EMG AMP, and NME. The SROC indicated significant ($p \leq 0.05$, r_s= 0.585 - 0.942) associations for BB fatigue vs. BB pain, BB fatigue vs. FM fatigue, BB fatigue vs. HM fatigue, BB pain vs. FM pain, BB pain vs. HM fatigue, BB pain vs. HM pain, FM fatigue vs. FM pain, FM fatigue vs. HM fatigue, FM fatigue vs. HM pain, FM pain vs. HM fatigue, FM pain vs. HM pain, HM fatigue vs. HM pain, LOF vs. Mot2, LOF vs. Mot3, and Mot2 vs. Mot3. There were no significant ($p >$ 0.05, r_s = -0.263 - 0.458) associations for the PercSens and PsychFact items versus TTF or PF. **Conclusion:** The decreases in TRQ and EMG AMP were likely associated with the ability to reduce TRQ to maintain the prescribed RPE. Furthermore, the decrease in NME, which resulted from the disproportionate fatigue-induced decrease in TRQ relative to EMG AMP, suggested the presence of peripheral mechanisms of fatigue. In addition, the PercSens were related to PsychFact, however, neither were related to TTF or PF. **Practical Applications:** Practitioners may program exercises anchored to RPE as an alternative to percentages of MVIC or 1 repetition maximum loads to assess an individual's fatigue characteristics and use PTQs to examine the contribution of PercSens and PsychFact to TT.

Background

Performance fatigability and perceived fatigability are two interdependent attributes of fatigue defined as a decline in an objective measure of performance and the changes in sensations and perceptions associated with performance, respectively (Kluger et al., 2013; Enoka & Duchateau, 2016). Recent studies (Arnett et al., 2023; Smith et al., 2024) have anchored fatiguing tasks to ratings of perceived (RPE) to examine the torque and neuromuscular responses and assess the relationship between performance fatigability and perceived fatigability. Few studies, however, have examined the torque and neuromuscular responses during a sustained, isometric forearm flexion task (SIFFT) anchored to a low RPE and whether perceived sensations (PercSens) and psychological factors (PsychFact) influenced the decision to terminate the task.

Thus, the purpose of this study was to examine the composite patterns of responses for torque, electromyographic amplitude (EMG AMP), and neuromuscular efficiency (NME = normalized TRQ / normalized EMG AMP) during a SIFFT anchored to a low RPE as well as the PercSens and PsychFact that contributed to task termination.

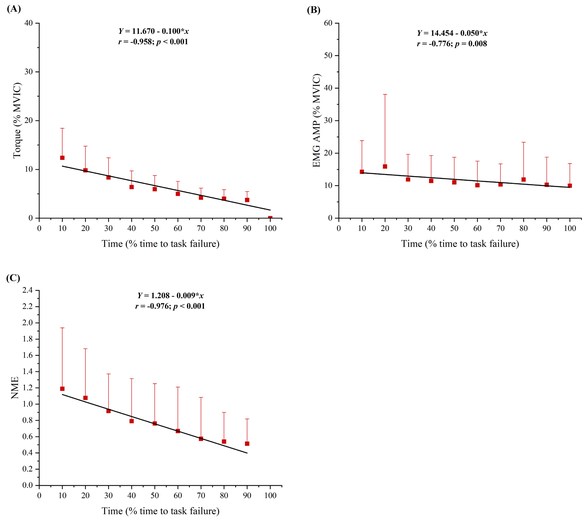

Figure 1. Time course of changes (mean ± SD) for the normalized (% of pre-test MVIC) torque and neuromuscular values for the sustained, isometric forearm flexion task anchored to RPE = 2 (SIFFT) at an elbow joint angle of 100°. Regression analyses represent torque and electromyographic amplitude values from 10-100% time to task failure and neuromuscular efficiency values from 10-90% time to task failure. (A) Torque, (B) Electromyographic amplitude (EMG AMP), and (C) Neuromuscular efficiency (NME).

Methods

Subjects: Twelve men (mean ± SD: age = 20.9 ± 2.2 yrs.; height = 79.8 ± 5.3 cm; body mass = 80.2 ± 9.9 kg) who were recreationally active and free of any upper body pathologies that would affect performance participated in this study. The subjects visited the laboratory on one occasion for testing. **Procedures:** Subjects performed a standardized warm-up (4, 3 s submaximal [50 – 75% max effort] isometric forearm flexion muscle actions), 2, 3 s pre-testing forearm flexion maximal voluntary isometric contractions (MVIC), a SIFFT anchored to RPE = 2 at an elbow joint of 100° to task failure (i.e., TRQ reduced to zero), and 2, 3 s post-testing MVICs. Following the SIFFT, the subjects completed a post-test questionnaire (PTQ) to quantify the contribution of the PercSens (i.e., fatigue and pain of the biceps brachii [BB], forearm muscles [FM], and hand muscles [HM]) and PsychFact (i.e., loss of focus [LOF] and motivation) to task termination. The PTQ included 10 Likert-type items: (1) BB fatigue; (2) BB pain; (3) FM fatigue; (4) FM pain; (5) HM fatigue; (6) HM pain; (7) LOF; (8) Motivation 1 [Mot1: subject expended maximal effort]; (9) Motivation 2 [Mot2: subject perceived that the task could not be accomplished]; and (10) Motivation 3 [Mot3: subject became bored]. **Signal Processing:** The EMG AMP was recorded from the BB. The raw EMG signal was digitized at 2000 samples per second with a 12-bit analog-to-digital converter (MODEL MP150; Biopac Systems, Inc, Goleta, CA, USA) and digitally bandpass filtered (fourth-order Butterworth) at 100 - 500 Hz. **Analyses:** Polynomial regression analyses (linear and quadratic) were used to define the composite relationships for normalized TRQ, EMG AMP, and NME versus time (every 10%) during the SIFFT. Spearman's Rank Order Correlations were used to assess the relationships among the PTQ items, time to task failure (TTF; 306.9 ± 486.4 s), and performance fatigability (7.2 ± 11.0%). A p-value ≤ 0.05 was considered statistically significant.

Results

The composite patterns of responses indicated significant linear decreases for torque ($p < 0.001$, r = -0.958), EMG AMP ($p = 0.008$, r = -0.776), and NME ($p < 0.001$, r = -0.976). The Spearman's Rank Order Correlations indicated significant ($p \leq 0.05$) associations for BB fatigue vs. BB pain ($r_s = 0.663$), BB fatigue vs. FM fatigue (r_s = 0.694), BB fatigue vs. HM fatigue ($r_s = 0.654$), BB pain vs. FM pain ($r_s = 0.675$), BB pain vs. HM fatigue ($r_s = 0.720$), BB pain vs. HM pain ($r_s = 0.648$), FM fatigue vs. FM pain ($r_s = 0.788$), FM fatigue vs. HM fatigue ($r_s = 0.763$), FM fatigue vs. HM pain ($r_s = 0.617$), FM pain vs. HM fatigue ($r_s = 0.689$), FM pain vs. HM pain (r_s = 0.585), HM fatigue vs. HM pain ($r_s = 0.942$), LOF vs. Motivation 2 ($r_s = 0.703$), LOF vs. Motivation 3 ($r_s = 0.691$), and Motivation 2 vs. Motivation 3 ($r_s = 0.822$). There were no significant ($p > 0.05$, r_s = -0.263 - 0.458) associations for the PercSens and PsychFact items versus TTF or PF.

Conclusion

The decreases in torque and EMG AMP were likely associated with the ability to reduce torque to maintain the prescribed RPE. Furthermore, the decrease in NME, which resulted from the disproportionate fatigue-induced decrease in torque relative to EMG AMP, suggested the presence of peripheral mechanisms of fatigue. In addition, the PercSens were related to PsychFact, however, neither were related to TTF or performance fatigability.

Table 1. Spearman's Rank Order Correlations (r_s) for the time to task failure (TTF) values and performance fatigability (PF = % change in maximal torque from pre-test to post-test MVIC assessments) from the sustained, isometric forearm flexion task anchored to RPE = 2 (SIFFT) and the 10 Likert-type items from the post-test questionnaire provided after the SIFFT.

	BB Fatigue	BB Pain	FM Fatigue	FM Pain	HM Fatigue	HM Pain	LOF	Motivation 1	Motivation 2	Motivation 3	TTF	PF
BB Fatigue	1.000											
BB Pain	0.663*	1.000										
FM Fatigue	0.694*	0.539	1.000									
FM Pain	0.497	0.675*	0.788**	1.000								
HM Fatigue	0.654*	0.720**	0.763**	0.689*	1.000							
HM Pain	0.520	0.648*	0.617*	0.585*	0.942**	1.000						
LOF	0.294	0.287	0.241	0.449	-0.017	-0.120	1.000					
Motivation 1	0.210	-0.027	0.172	0.000	0.309	0.242	-0.442	1.000				
Motivation 2	-0.186	0.033	0.085	0.233	-0.092	-0.204	0.703*	-0.308	1.000			
Motivation 3	-0.173	-0.216	0.106	0.155	-0.360	-0.443	0.691*	-0.311	0.822*	1.000		
TTF	-0.074	0.249	0.167	0.458	0.253	0.306	-0.167	0.159	-0.015	0.017	1.000	
PF	0.315	-0.256	0.278	0.137	-0.121	-0.263	0.289	0.397	-0.015	0.309	-0.210	1.000

Regarding contribution to the decision to terminate the task, the 10 Likert-type items (Biceps brachii fatigue, Biceps brachii pain, Forearm Muscles fatigue, Forearm Muscles pain, Hand Muscles fatigue, Hand Muscles pain, Loss of Focus, Motivation 1, Motivation 2, and Motivation 3) were rated on a 5-point (1 - 5) Likert-type scale with definitions associated with the following numbers: 1 = strongly disagree; 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.
MVIC = maximal voluntary isometric contraction; PF = [((pre-test MVIC - post-test MVIC) / pre-test MVIC) x 100], LOF = loss of focus.
* $p < 0.05$, $r_s = 0.584$
** $p < 0.01$, $r_s = 0.724$

Practical Applications

Practitioners may program exercises anchored to RPE as an alternative to percentages of MVIC or 1 repetition maximum loads to assess an individual's fatigue characteristics and use PTQs to examine the contribution of PercSens and PsychFact to task termination.

References

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