

KNEE EXTENSOR TORQUE REDUCTION DURING CONSTANT PERCEIVED EXERTION ISOMETRIC CONTRACTIONS

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INTRODUCTION

The quality of motor performance relies heavily upon the sensation of force/exertion that accompanies a muscular contraction. When producing a muscular contraction to a constant level of perceived exertion, a reduction in the generated torque naturally ensues (1). However, the magnitude of this decrease in muscle generated torque, as a function of perceived exertion level, is yet to be conclusively established. The objective of the present study was to evaluate knee extensor torque and activation during sub-maximal voluntary contractions guided by perceived exertion.

METHODS

Forty-eight healthy young adults (23 men, 22.8 ± 2.6 years, 80.1 ± 13.4 kg, 176.0 ± 7.0 cm, and 25 women 21.9 ± 3.6 years, 64.6 ± 7.7 kg, 166.9 ± 7.1 cm) with no history of lower leg injury, neurological or cardiopulmonary conditions participated.

Subjects participated in two evaluation sessions, separated by approximately 1 week. All subjects were assessed for knee extensor torque during five brief (5 s) maximal voluntary contractions (MVC), during both sessions at a fixed knee angle (90°) on an isokinetic dynamometer (Biodex Medical Inc, Shirley, NY). During the second session, subjects performed, in addition to and following the MVC's, 9 sub-maximal contractions to 10-90% MVC (10% increments, random order). The subjects were provided visual feedback from a computer monitor and were required to match a target line for 5 seconds. The visual feedback of their torque production was then removed, and the subjects were instructed to continue contracting their knee extensors to maintain a constant level of perceived exertion for 10 seconds. A minimum rest period of 2 minutes separated all sub-maximal contractions.

Immediately following each sub-maximal contraction (total duration = 15 s), subjects were asked to provide a numerical rating of their perceived exertion from the Borg category-ratio scale (CR-10).

Surface electromyograms (EMG) were recorded (1000 Hz, 20-500 Hz bandpass filtered) from the vastus medialis (VM), rectus femoris (RF) and vastus lateralis (VL) muscles. Following full wave rectification of the raw signals, EMG activity was integrated (IEMG) over the middle 3 seconds of each contraction. The EMG's from the sub-maximal contractions were normalized to the MVC's. Following the removal of the visual feedback, the change in knee extensor torque across the 10 s contraction was examined by the slope, normalized to the three highest (averaged) MVC's ($\%MVC \cdot s^{-1}$).

RESULTS AND DISCUSSION

The results demonstrated a significant increase ($F_{8,368} = 407.7$, $p < 0.001$) in ratings of perceived exertion across the sub-maximal contraction intensities, and no gender main effect ($F_{1,46} = 0.28$, $p = 0.60$) or contraction intensity by gender interaction ($F_{8,368} = 0.86$, $p = 0.55$) (Figure 1).

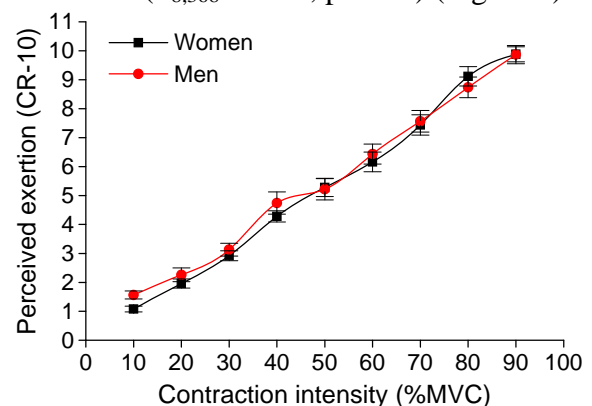


Figure 1: Ratings of perceived exertion following the sub-maximal isometric contractions, illustrating the close correspondence between the subjective rating and relative target level.

The normalized IEMG data demonstrated a significant increase with sub-maximal contraction intensity ($F_{8,368} = 1,238.3$, $p < 0.001$), while VL activity was significantly greater than RF and VM IEMG ($F_{8,368} = 407.7$, $p < 0.001$) (Figure 2). The relatively greater levels of normalized IEMG activity of the VL, over the VM and RF muscles, is consistent with previous studies (1-3) suggesting the possibility of a greater activation weighting in favor of stronger individual muscles within synergistic groups.

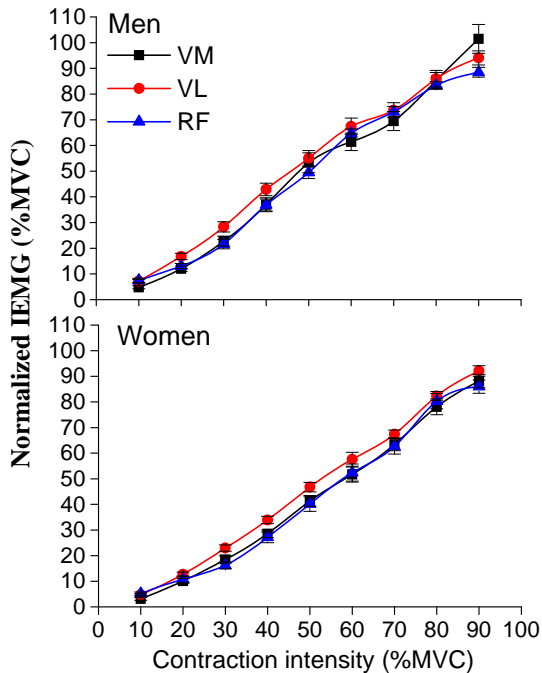


Figure 2: Normalized IEMG of the VM, VL, and RF muscles in men and women during sub-maximal (10-90% MVC) isometric knee extension contractions.

Following the removal of the concurrent visual feedback regarding torque level matching, a linear decline in knee extensor torque was observed at most sub-maximal contraction intensities, while subjects maintained the same level of perceived exertion. The results demonstrated a significant contraction intensity main effect ($F_{8,368} = 76.1$, $p < 0.001$), and no significant gender main effect ($F_{1,46} = 3.10$, $p = 0.09$) or interactions ($F_{8,368} = 0.90$, $p = 0.52$). Illustrated in Figure 3, it was observed that the reduction in knee extensor torque following visual feedback removal was dependent on the initial sub-maximal contraction intensity target. Specifically, the reduction in normalized knee

extensor torque significantly increased at greater sub-maximal contraction intensities.

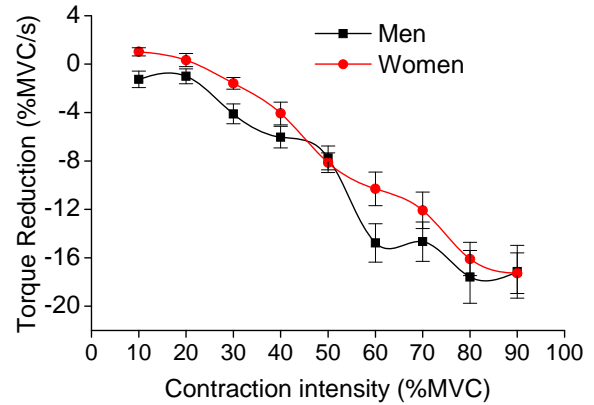


Figure 3: Reduction in normalized knee extensor torque during sub-maximal contractions following visual feedback removal.

The modulation of muscle-produced torque in order to maintain a constant level of exertion is a concomitant mechanism accompanying a reduction in force generating ability, due to fatigue processes. A similar pattern of a muscle force decrease was observed over a prolonged contraction period (100 s) at a single initial sub-maximal target (4), partially confirming the results of the present study.

CONCLUSIONS

The major findings of the present study demonstrated that during sustained isometric knee extensor contractions, healthy young adults maintain a constant rating of perceived exertion through modifications in torque generation. Although the constant perceived exertion contractions were relatively brief (i.e., 10 s), it is suggested that physiological mechanisms related to muscle fatigue contributed to the torque reduction at greater sub-maximal contraction intensities.

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