The effects of rest interval and resistance training on quadriceps femoris muscle. Part II: EMG and perceived exertion

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Aim. The purpose of this study was to examine the effects of rest interval on quadriceps femoris muscle activation and perceived exertion, during short-term resistance training.

Methods. Vastus medialis (VM) and vastus lateralis (VL) muscle electromyograms (EMG) were assessed in 15 males during a sustained 80% maximal voluntary contraction (MVC). During the pre-training evaluation, the absolute value of the 80% MVC (N·m) and contraction duration (s) was performed at 2, 4, and 6 weeks during the training period. Perceived exertion was measured via the Borg category-ratio scale every 5 s during the 80% MVC. Subjects were randomly assigned to 3 groups: group 1 received a 40 s rest interval in between exercise sets, group 2 received a rest period of 160 s, and the control group did not participate in training. Groups 1 and 2 performed isokinetic knee extensions at 180 degs:1 2 days per week for 6 weeks.

Results. The results demonstrated a significant decrease in VM EMG within the initial portion of the 80% MVC across the training period in the short rest interval group. The long rest interval and control groups showed no significant changes in VM EMG during 1st part of the contraction across the training period, whereas the control group exhibited a significant reduction in VL EMG across weeks 4 to 6. VL EMG increased during the 80% MVC in the control group across the training period. VM EMG increased during the sustained contractions in the long rest interval and control groups across the training period. The perceived exertion response was lower in the 1st part of the 80% MVC in the short and long rest interval groups, but not in the control group, across the training period. The results also showed a significant decrease in perceived exertion at the end of the sustained contraction in the short rest interval group, but not in the long rest interval group or the control group.

Conclusion. The findings from this study suggest that the application of relatively short rest intervals in between sets of resistance exercise induced a greater neuromuscular response of the VM muscle during short-term training.

Key words: Muscle, skeletal, physiology - Exercise - Electromyography - Fatigue.

Resistance exercise has come to be a regular component of many athletic training regimens, and its inclusion in recreational and physical fitness programs has increased. Many of the physiological adaptations subsequent to resistance training are well documented addressing hypertrophic, 1,2 morphological, 3,4 and performance 5,6 factors. Much less consensus exists in the scientific literature regarding electromyographic (EMG) and perceived exertion changes during this mode of training. Perceived exertion has been defined as the "subjective intensity of effort, strain, discomfort and/or fatigue that is experienced during physical exercise". Although this measurement is con-

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sidered a subjective estimation of effort, a close correspondence with force output and muscle activation, assessed via EMG, has been demonstrated.8-10 As the EMG signal is a reflection of the activation level of a muscle, the perceived exertion response is considered to be a function of centrally-generated motor commands andafferent feedback from mechanosensitive receptors arising from the contracting muscle.11 During constant torque, isometric quadriceps femoris (QF) muscle contractions, the perceived exertion response has been observed to exhibit a linear trend, as a function of contraction intensity level.10 A non-linear increase in perceived exertion during a sustained isometric contraction is likely the most accurate characterization of this relationship, which has also been found to exhibit a higher correlation with recorded EMG activity, than a linear trend.7

11 As a result of an increase in muscle force generating ability during resistance training, it may be speculated that a lower level of muscle activation will be necessary to achieve the same level of absolute torque output. In this regard, a concomitant decrease in the perceived exertion response should also occur.

A resistance-training variable that has been shown to exert a significant effect on the adaptation response is the recovery period in between sets of exercise.6,12 It is well known that the ability to voluntarily generate a maximal amount of force is compromised when the recovery period in between successive bouts of resistance exercise is inadequate.13 As the primary stimulus of physiological adaptation to resistance training is muscle activation, reductions in force generating ability, subsequent to muscle fatigue, may blunt the training response. This appeared to be the case following short-term (4 weeks) isokinetic training, when a relatively long inter-set rest interval was applied.8 Contrary evidence, however, suggests the opposite to be true: the elimination of rest intervals and, hence, the induction of muscle fatigue provides a stronger contribution to the resistance-training stimulus.12 Such equivocal findings further question the influence of afforded muscle recovery, through adequate inter-set rest intervals, on training-induced muscle changes. The purpose of this study was to examine the influence of inter-set rest interval length on muscle activation and perceived exertion changes during a short-term period of resistance training in healthy males.

Materials and methods

Subject characteristics

Subjects for this study included 15 healthy, college aged males (mean age=22.4±0.75 years, mean height=178.5±1.37 cm, and mean body mass=78.1±2.61 kg). All subjects did not undertake lower extremity resistance training for at least 6 months prior to the investigation. Individuals with a history of cardiovascular disease, diabetes, hypertension and orthopedic pathology or injury were excluded from participating in the study. Written informed consent was obtained in accordance with the Human Subjects Committee of the Biomedical Institutional Review Board of the University of Pittsburgh. The number of subjects in this study was determined using a power analysis for a fixed model multiple regression and correlation analysis as discussed in Cohen.14 For a pre-determined power of 0.80, α level of 0.05 and an effect size of 0.5 (η2), a non-centrality parameter (λ) of 7.8 was determined, which yielded an overall sample size of 15. An R2 value of 0.60 was used as a function of the sample size calculation as it was estimated that 60% of the variance of the dependant variables would be accounted for by the treatment effect in this study.

Test procedures

Following the pre-screening evaluation, subjects were assessed for activation of the vastus medialis (VM) and vastus lateralis (VL) muscles, and perceived exertion for 1 randomly selected lower limb. Muscle activation was measured during an isometric quadriceps contraction equivalent to 80% of each subject's pre-rest MVC. During the pre-training evaluation, the duration in which each subject maintained their 80% MVC was recorded. The absolute value of the 80% MVC (N-m) and duration (s) in which each subject maintained this level of torque was used to measure muscle activation at the pre-training evaluation, and at 2, 4, 6 weeks during training.

Submaximal voluntary contraction assessment

The maximal and submaximal isometric quadriceps contractions were performed on the Biodex System 2 Isokinetic Dynamometer (Biodex Medical Inc., Shirley, NY). Prior to testing, subjects completed a dynamic warm-up period that consisted of treadmill walking at 2.5 miles per hour for a period of 5 min followed
by muscle stretching. Following the warm-up period, subjects were placed in a comfortable upright and seated position on the Biodex Isokinetic Dynamometer Accessory chair. Subjects were secured using torso, pelvic and thigh straps in order to minimize extraneous body movements. Such extraneous body movements during isokinetic testing have been shown to result in lower peak torque generation.\textsuperscript{15, 16} The lateral femoral epicondyle was used as the bony landmark for matching the axis of rotation of the knee joint with the axis of rotation of the dynamometer resistance adapter. Once the subject was placed in a position that allowed for a comfortable and unrestricted motion for knee flexion and extension from a position of 90\(^\circ\) of flexion to terminal extension, the following measurements were taken: seat height, seat inclination, dynamometer head height and resistance pad level. These measures were recorded and stored in the Biodex Advantage Software program version 4.0 (Biodex Medical Inc., Shirley, NY) in order to standardize the testing position for each individual subject. Gravity correction was obtained by measuring the torque exerted on the dynamometer resistance adapter with the knee in a relaxed state at terminal extension. Subjects were asked to actively extend their knee to a comfortable position, at which point the dynamometer was locked for gravity correction. Values for the isometric variables measured were automatically adjusted for gravity by the Biodex Advantage Software Program v. 4.0. Calibration of the Biodex dynamometer was performed according to the specifications outlined by the manufacturer’s service manual.

Following the set up procedure, isometric knee extensor torque was measured with the knee at 60\(^\circ\) flexion. This specific knee angle has been demonstrated to generate maximal active quadriceps isometric tension.\textsuperscript{17, 18} During the measurement of isometric torque, each subject was required to fold their arms across their chest and was given verbal encouragement as well as visual feedback from the Biodex computer monitor in an attempt to achieve a maximal voluntary effort level.\textsuperscript{19-21} All the testing procedures, and verbal encouragement, were administered by the same investigator for all subjects. Following 2 brief sub-maximal, and 2 maximal isometric contractions, subjects were asked to perform a single maximal voluntary contraction (MVC) of the quadriceps for a period of 5 s. Following a 2 min period of recovery, an isometric quadriceps contraction corresponding to a torque level of 80\% of their MVC was performed by having each subject match a torque curve to a horizontal line on a computer monitor. Each subject was asked to maintain the isometric contraction until the 80\% MVC torque level could not be achieved for a 2 s duration, which was referred to as the failure point. This percentage of MVC has been selected because the recruitment of type II muscle fibers in normal, healthy subjects has been found to occur at this level of isometric tension.\textsuperscript{22} The time in which subjects could maintain the 80\% MVC during this pre-training evaluation was recorded. During the testing evaluations at 2, 4 and 6 weeks, each subject performed the isometric quadriceps contraction corresponding to the absolute torque level and duration of contraction attained during the pre-test in order to standardize comparisons between the different testing sessions. Previous measures of isometric peak torque have shown high test-retest reliability.\textsuperscript{23}

\textbf{Measurement of quadriceps muscle activation}

Muscle activation was measured from the VM and VL muscles during the pre-training isometric fatigue test. Bi-polar circular surface electrodes (Ag-AgCl) were placed on the appropriate muscles with an inter-electrode distance of approximately 1.5 cm. Prior to electrode placement, the area was shaved, cleaned with isopropyl alcohol and abraded in order to reduce myoelectrical impedance. Skin resistance was measured with an Ohm meter, and values below 2 k\text{\textcircled{2}}\text{\texttextquoteright}ms were accepted. Electrode placement for the VM was 20\% of the distance from the medial joint line from the knee to the anterior superior iliac spine.\textsuperscript{24} Electrode placement for the VL muscle was the midpoint between the head of the greater trochanter and the lateral femoral epicondyle.\textsuperscript{25} The reference electrode was placed over the medial shaft of the tibia approximately 6-8 cm below the inferior pole of the patella. The placement sites for the electrodes were the same throughout the study (i.e., the distances to each electrode site were re-measured prior to every test). EMG activity was collected and recorded via telemetry by an 8 channel FM transmitter and differential amplifier (Noraxon Telemetry, Noraxon Inc., Scottsdale, AZ). EMG signals were sampled at a rate of 1 000 Hz and broadcast to a FM receiver where they were bandpass filtered (16-500 Hz) and underwent analog to digital conversion by a 12 bit A-D board interfaced to a micro-
TABLE 1.—Six-week isokinetic training protocol.

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Processor. The raw EMG signals (µV·s) were stored on computer disk for subsequent analysis by the MyoSoft Software program (Noraxon Inc., Scottsdale, AZ). The raw signals were full-wave rectified and integrated (IEMG) every 10% of the 80% MVC. Each IEMG value was expressed as a one second average (µV) in order to equate levels of neuromuscular activation throughout the contraction between the subjects. Each 1 second average value for each muscle was then normalised to a 1 second average of IEMG activity during the pre-test MVC to yield a percent value. The IEMG signals calculated during the sub-maximal isometric test were measured prior to training and following 2, 4, and 6 weeks during the training period. EMG signals collected within the 1st and last second of the sub-maximal isometric test was not used for analysis because of knee movement that may have occurred at the initiation and completion of the test. Integrated EMG measurements have previously demonstrated high reliability coefficients for the VM and VL muscles ranging from r=0.92 to r=0.94, and r=0.77 to r=0.84, respectively.20-22

Measurement of perceived exertion

Perceived exertion was measured with a modified category-ratio scale (CR-10) as developed by Borg.22 The use of this scale has been previously found to correlate positively with increasing levels of lactate accumulation. Furthermore, it has been suggested that qualitative changes in motor unit recruitment may be perceived.30 In order to provide the subjects in the present study with a context through which sensation intensities can be evaluated, 1 high and 2 low anchors were applied under isometric conditions.31 While seated in the Biodye dynamometer chair, the subjects were asked to sit quietly and to “think about the feelings in their quadriceps and to assign a rating of 0 to those feelings”. All subjects performed 2 to 3 sub-maximal followed by 2 maximal familiarisation trials. Subjects were asked to contract their quadriceps as hard as they could and to maintain this contraction for 5 s. Prior to the contraction, subjects were asked to “think about the feelings in their quadriceps at the end of the contraction and to assign a rating of 0 to those feelings”. Following a brief period of volitional recovery (1 to 2 min) subjects were asked to contract isometrically at an intensity equivalent to 10% of their individual MVC for 5 s. Subjects were asked to match a horizontal line on the Biodye computer monitor that corresponded to this intensity. Prior to this contraction, subjects were asked to “think about the feelings in their quadriceps at the end of the contraction and to assign a rating of 0 to those feelings”. Following another brief period of volitional recovery (1 to 2 min), subjects were then asked to contract to an intensity equivalent to 80% of their individual MVC for as long as they could sustain it. When the subjects’ torque level fell below the target level for 2 consecutive seconds, the test was terminated. Subjects were asked to rate the feelings in their quadriceps every 5 s during the 80% MVC by visually observing the CR-10 scale. The rest periods in between the 3 contractions in this study were mainly determined by feedback from each subject. Therefore, when the subjects subjectively felt that they were recovered, the next contraction was initiated.

Isokinetic training protocol

Quadriceps training was performed on the Biodye System 2 Isokinetic Dynamometer at a pre-set angular velocity of 180 deg·s⁻¹ (concentric-only contractions). The training program (Table 1) was modified from a previous study such that the number of training sessions performed per week were reduced from 3 to 2, and the duration was extended from 4 to 6 weeks. This was done to prevent the possibility of an over-training response (resulting from too many sessions per week) while maintaining a similar amount of work throughout the protocol, as per Pincivero et al.6 Throughout the 6 week training period, all subjects performed a total of 1440 repetitions, including the repetitions performed during the 4 testing sessions. Five subjects were randomly assigned to 1 of 3 groups: Group 1 (training with a short inter-set rest interval), Group 2 (training with a long inter-set rest interval), and Group 3 (control - no training). Subjects in Group 1 received a rest period of 40 s in between exercise sets corresponding to a 2:1 rest:work ratio, and subjects in Group 2
received a rest period of 160 s corresponding to an 8:1 rest-to-work ratio. The 160 s rest interval was selected since it has been suggested that adequate recovery with respect to isokinetic strength testing occurs within this duration.\(^8\)\(^{13}\)\(^{32}\) Training sessions were separated by at least 72 h and were performed 2 days per week. Subjects assigned to the control group did not participate in the isokinetic training program and were asked to abstain from commencing any lower extremity resistance exercise program for the duration of the study.

Data analysis

**Quadriiceps femoris activation**

A 1-factor ANOVA with repeated measures was separately performed for each muscle and group across the training period (pre-test, week 2, week 4, and week 6), on the EMG recordings within the first 10% of the sustained contraction. A series of separate 2-factor ANOVAs with repeated measures was performed on the pre-test normalized EMG activity across the training period (pre-test, week 2, week 4, and week 6) and pre-training 80% MVC duration (10% to 100% of contraction duration, 10% increments), for each group and muscle. Repeated contrasts were subsequently performed as the multiple comparison procedure, if the overall F-test revealed statistically significant differences. All tests of significance were carried out at a pre-set \(\alpha\) of 0.05.

**Perceived exertion**

A 1-factor ANOVA with repeated measures was separately performed for each group across the training period (pre-test, week 2, week 4, and week 6), on the 1st and last recorded perceived exertion responses during the 80% MVC. Repeated contrasts were subsequently performed as the multiple comparison procedure, if the overall F-test revealed statistically significant differences. All tests of significance were carried out at a pre-set \(\alpha\) of 0.05.

**Results**

The isometric quadriceps peak torque (pre-test) and 80% MVC endurance time for subjects in the present study was 242.6±41.85 N·m and 42.9±10.23 s, respectively (mean±SD).

![Graph showing EMG data](image)

**Figure 1.**—Vastus medialis (VM) EMG normalized to pre-training MVC, of the first 10% of the sustained 80% MVC across the training period for subjects in the short rest interval (n=5), long rest interval (n=5), and control (n=5) groups. *Indicates statistically significant decrease across the training period.

**Quadriiceps femoris activation**

The results from this study demonstrated a significant decrease in VM EMG within the initial portion (i.e., 10%) of the sustained isometric contraction (F\(_{3,12}=3.40, p=0.05, \eta^2=0.46, 1-\beta=0.62\)) across the training period in the short rest interval group (Figure 1). The long rest interval group demonstrated no statistically significant changes in VM EMG during the first part of the contraction (F\(_{3,12}=2.10, p=0.15\)), nor did the control group (F\(_{3,12}=0.19, p=0.90\)) across the training period. The VL muscle demonstrated no statistically significant changes in EMG activity at the initiation of the contraction for the short rest interval group (F\(_{3,12}=2.16, p=0.15\)), nor the long rest interval group (F\(_{3,12}=1.32, p=0.31\)) during the 6 week period (Figure 2). However, the control group exhibited a statistically significant reduction in VL EMG across weeks 4 to 6 (F\(_{3,12}=3.59, p=0.05, \eta^2=0.47, 1-\beta=0.64\)).

The results demonstrated no significant main effects or interactions for VL EMG in both the short and long rest interval groups. The control group exhibited a significant contraction duration main effect (F\(_{3,36}=2.96, p=0.01, \eta^2=0.43, 1-\beta=0.92\)), as EMG activity of the VL muscle increased during the 80% MVC (Figure 3). Muscle activation of the VM did not demonstrate any significant main effects or inter-
Figure 2.—Vastus lateralis (VL) EMG normalized to pre-training MVC, of the first 10% of the sustained 80% MVC across the training period for subjects in the short rest interval (n=5), long rest interval (n=5), and control (n=5) groups. * indicates statistically significant decrease across weeks 4 to 6 in the control group.

Figure 3.—Vastus lateralis (VL) EMG normalized to pre-training MVC, during the sustained 80% MVC across the training period in the control group.

Figure 4.—Vastus medialis (VM) EMG normalized to pre-training MVC, during the sustained 80% MVC across the training period in the long rest interval group.

Figure 5.—Vastus medialis (VM) EMG normalized to pre-training MVC, during the sustained 80% MVC across the training period in the control group.

actions for the short rest interval group. A significant contraction duration main effect was observed for the VM muscle for the long rest interval group ($F_{9,36}=4.59, p<0.001, \eta^2=0.53, 1-\beta=0.99$), and the control group ($F_{9,36}=2.68, p=0.02, \eta^2=0.40, 1-\beta=0.89$) as VM EMG increased during the 80% MVC (Figures 4, 5, respectively).

**Perceived exertion**

The results for perceived exertion at the beginning and end of the 80% MVC prior to training, and every
2 weeks during the training period are presented in Figure 6. The results demonstrated a significant reduction in perceived exertion at the initiation of the sub-maximal isometric contraction in the short rest interval group ($F_{1,12}=9.21$, $p=0.002$, $\eta^2=0.70$, $1-\beta=0.97$), the long rest interval group ($F_{1,12}=4.10$, $p=0.032$, $\eta^2=0.51$, $1-\beta=0.70$), but not in the control group ($F_{1,12}=2.71$, $p=0.09$, $\eta^2=0.40$, $1-\beta=0.51$). The results also showed a significant decrease in perceived exertion at the end of the sustained contraction in the short rest interval group ($F_{1,12}=4.30$, $p=0.028$, $\eta^2=0.52$, $1-\beta=0.73$), but not in the long rest interval group ($F_{1,12}=1.88$, $p=0.187$), nor the control group ($F_{1,12}=1.30$, $p=0.32$).

Discussion

The major findings of the present investigation demonstrated that the short rest interval group experienced a significant decrease in VM EMG at the initiation of the sustained contraction, across the training period. A significant decrease in VL EMG at the initiation of the contraction was observed only in the control group across weeks 4 to 6. The amplitude of the EMG signal was shown to increase significantly during the sustained contraction for the VL muscle in the control group, and the VM muscle in the long rest interval and control groups; however, the EMG increase was not found to differ during the training period. The perceived exertion response exhibited a significant decrease at the beginning of the sustained contraction across the training period in both short and long rest interval groups. The short rest interval group also displayed a significant decrease in perceived exertion at the end of the sustained contraction across the training period, whereas no significant changes were noted for the long rest interval and control groups.

Quadriceps femoris activation

It has been suggested that during the time course of resistance-training, increases in strength are attributed to neuromuscular adaptations within the first 4-6 weeks, followed thereafter, by hypertrophic changes. Such neuromuscular adaptations may have likely been present for the VM muscle in the short rest interval group, as a significant decrease in the EMG signal occurred across the training period within the first 10% of the sustained pre-training 80% MVC. As the EMG signal is known to fluctuate considerably during a sustained contraction, the 1st 10% of the 80% MVC allows the examination of muscle activation changes during training without the confounding influence of muscle fatigue. More recent evidence, however, demonstrates that morphological 4 and hypertrophic 33 changes occur much earlier in the training period. A reduction in the EMG during a sustained contraction at a pre-determined contraction intensity and time duration may be indicative of a decreased central command from the motor cortex to the peripheral muscle group. The consequence of such a decrease is that less muscle is necessary to generate a sub-maximal force.34 As the contractions performed during the training sessions were maximal voluntary efforts, the response observed for the VM muscle may be plausible given that recruitment of this portion of the quadriceps femoris complex has been suggested to be contraction intensity dependent.35-37 It is further speculated that the greater induction of muscle fatigue during the training sessions in the short rest interval group may have provided an effective stimulus for adaptation of this particular muscle. This contention was proposed by Rooney et al.17 who found that the elimination of rest periods in between individual repetitions of a single set of elbow flexor resistance exercise resulted in significant strength gains, as compared to the allowance of rest in between repetitions. Contrary to these findings, Pincivero et al.6 found that a relatively long rest interval in between sets of isokinetic knee exten-
Response and flexion exercise led to significantly greater strength improvements for the hamstrings muscles, than a short rest interval length, following 4 weeks of training. However, gains in knee extensor work and power, which demonstrated a training effect, was not significantly different between rest interval groups. The findings of the present investigation partially concur with Cannon and Cafarelli. Following 5 weeks of resistance training of the adductor pollicis muscle, no significant changes in the EMG/force ratio during an 80% MVC isometric contraction to failure were detected. It was therefore concluded that no increases in central neural drive to the muscle occurred as a result of training as the same degree of activation was necessary to maintain this predetermined level of force. Such appeared to be the case in the present study with the VL muscle in the short rest interval group, as well as both muscles in the longer interval group. It was subsequently demonstrated that 8 weeks of maximal isometric quadriceps training reduced the EMG/force ratio of predetermined sustained contractions although the maximal isometric IEMG was unchanged. Garfinkel and Cafarelli thus surmised that less activation of the quadriceps muscles occurred in order to produce a given force. Training mode specificity in this instance, as well as the longer training period, may have contributed to the significant findings. As mentioned previously, the underlying rationale for the hypothesized reduction in IEMG following training may reside in morphological changes within the muscle. A greater percentage and hypertrophy of type IIa muscle fibers following strength training would, theoretically, increase the capacity of the muscle to apply force. As such, a reduction in the number of activated motor units may occur in order to contract at the same absolute intensity. In fact, the absolute resistance load equivalent to 80% MVC determined prior to training in the present investigation may reflect a reduced percentage of the relative MVC after training. This assumption, however, was not specifically investigated in the present study.

Perceived exertion

The perceived exertion response during a sustained muscle contraction is shaped by a number of factors. Physiologically, it has been hypothesized that a copy of the centrally-generated motor command during a voluntary muscle contraction generates corollary discharges that are “fed forward” to the somatosensory cortex contributing to this perceptual sensation. It has been suggested that the contribution of this mechanism is relatively greater during brief, rather than sustained, muscle contractions. However, the predominant mechanisms underlying the perceived exertion response may be feedback processes arising from the contracting muscles. As both mechanisms are assumed to be proportional to the magnitude of a voluntary muscle contraction, the perceived exertion response should be reflective of the contraction. This notion was observed by Pincivero et al. in 30 healthy individuals, in which a close correspondence between the magnitude of brief, isometric quadriceps femoris muscle contractions (10% to 90% MVC) and perceived exertion estimation was observed. Following a period of resistance training when muscle force generating ability increases, the relative effort to exert a pre-training level of absolute force should, theoretically, decrease. Such was the case for both training groups as the perceived exertion response at the initiation of the pre-training 80% MVC significantly declined across the training period. However, the terminal (i.e., end contraction) perceived exertion estimate was only observed to decrease in the short rest interval group, as a function of training. It must be noted that the duration of the sustained 80% MVC at week 2, 4, and 6 was the absolute time in which the contraction was sustained during the pre-training sessions, and not to the point of failure. It has been observed that the relatively short periods of rest induced a greater degree of muscle fatigue, through reductions in torque output.may have increased feelings of muscular discomfort. The accumulated effect of this pattern across the training period may have affected the tolerance level of the subjects in this group, thereby lowering their subjective estimate of physical exertion. It is also plausible that changes in neural drive to the contracting muscle mediated this adaptation in perceived exertion, as VM EMG decreased during the initial portion of the 80% MVC in the short rest interval group.

Conclusions

In addition to enhancing force output, engagement in a resistance training program can reduce the detrimental effects of contraction-induced muscle fatigue. Participation in a short-term resistance training program in the present investigation resulted in a reduction in perceived exertion at the initiation of a sub-maximal, pre-training torque level contraction. However, the application of a relatively short rest interval was shown to decrease perceptual feelings of exertion at the
end of the sustained muscle contraction. This effect may have been mediated by neuromuscular adapta-
tions, particularly in the VM muscle, which displayed a significant reduction in activation at the initiation of the contraction across the training period. It appears that the induction of muscle fatigue during a short-term period of training with maximal effort contractions may provide a greater stimulus for neuromuscular adaptations.

References