EFFECTS OF DIVERTING ACTIVITIES ON ELECTROMYOGRAPHIC AMPLITUDE AND MEAN FREQUENCY

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Abstract:

The purpose of this study was to examine the effects of diverting activities on electromyographic amplitude and mean frequency. On three separate occasions, eleven men and eight women performed two bouts of fifty consecutive maximal concentric isokinetic muscle actions of the dominant leg extensors. Between these bouts, the subjects either solved math problems, performed contralateral dynamic constant external resistance leg extensions, or rested quietly. During each muscle action, electromyographic signals were detected from the vastus lateralis, rectus femoris, and vastus medialis. The results indicated that neither the mental nor the physical diverting activities consistently affected the mean electromyographic amplitude and mean frequency values relative to the control visit of quiet resting. If mental or physical diverting activities affected muscle activation in the vastus lateralis, rectus femoris or vastus medialis, electromyographic amplitude and mean frequency values were not sensitive enough to detect it.

Key words: *Sechenov phenomenon, peak torque, percent decline, distraction*

Introduction

For decades, researchers have studied muscle fatigue. Defined by Edwards (1981, p. 1) as “the failure to maintain the required or expected force”, fatigue limits the amount of work an individual is able to perform. In some sporting events, success is dependent on the athlete’s ability to perform repeated maximal or near maximal efforts interspersed with brief rest periods. Thus, in many applied settings, practitioners design training programs in an attempt to elicit muscular adaptations that may minimize the severity of fatigue that occurs during competition.

When scientists began studying muscle fatigue in humans, many of them observed a link between the degree of nervous system arousal and the ability of the muscle to prolong exhaustion. One of these scientists was the Russian physiologist Ivan Sechenov, who was particularly interested in the use of diverting activities to improve the ability to resist fatigue. For example, prior to his death in 1905, Sechenov (1935) found that during the act of sawing, more work could be performed by the right arm if, during brief rest periods, the left arm performed some type of submaximal activity. It was noted (Sechenov, 1935) that by using a diverting activity, the pain in the fatigued arm was minimized. Although these experiments were performed with very basic instrumentation, other studies (Alpert, 1969; Asmussen, 1936; Weber, 1914) reported similar findings (i.e. diverting activities enhanced recovery from exercise). In two of these investigations (Alpert, 1969; Weber, 1914), however, the benefits of diverting activities were believed to be due to circulatory factors, which was not consistent with the hypothesis originally put forth by Sechenov (1935). To further examine the mechanisms responsible for the “Sechenov phenomenon” (Asmussen, 1979, p. 417), Asmussen and Mazin (1978a,b) performed a series of experiments involving physical (contralateral muscle actions) and mental (solving math problems) diverting activities, as well as activities that were hypothesized to be non-fatiguing (pressing one’s fingers together and opening and closing one’s eyes). In one experiment, the authors (Asmussen & Mazin, 1978b) examined electromyographic (EMG) signals from the rectus femoris (RF) during patellar reflex testing while the subjects performed diverting activities with or without their eyes closed. It was reported that when the subjects performed fatiguing dynamic constant external resistance (DCER) muscle actions with their eyes open, brisker patellar reflexes were observed, leading the authors (Asmussen & Mazin, 1978b) to conclude that diverting activities improved performance via central nervous system (CNS) processes that were “independent of changes in local blood flow.” Recently, a study from our laboratory (Stock, Beck, & DeFreitas, 2011) demonstrated enhanced recovery with both mental and physical diverting activities. Specifically, it was found that when the subjects dealt with math problems between bouts of fatiguing isokinetic muscle actions, the initial peak torque values for the second fatiguing bout were the same as those for the first bout, thereby indicating 100% recovery. In addition, a decline in the average torque values was observed for the second fatiguing bout when the subjects rested quietly. When the subjects solved math problems or performed contralateral DCER muscle actions, however, no decline in the average torque values was observed.

As stated previously, EMG was used by Asmussen and Mazin (1978b) to examine the effects of diverting activities on recovery from exercise. Since that study was published, however, there have been several important developments in EMG research that have allowed investigators to further assess motor control strategies (Basmajian & De Luca, 1985; De Luca, 1997; De Luca, Adam, Wotiz, Gilmore, & Nawab, 2006; Farina, Merletti, & Enoka, 2004). Although there are several technical factors that influence the EMG signal (De Luca, 1997), the use of surface EMG provides an objective tool for the assessment of muscle fatigue. Specifically, researchers have often relied on amplitude (e.g. root-mean-square) and/or center frequency (e.g. mean or median) values. Mean frequency (MNF) values have been widely used to characterize muscle fatigue during submaximal constant-force isometric muscle actions (De Luca, 1984; Häkkinen & Komi, 1983). While there are advantages to examining the EMG signal while the length of the muscle remains constant, these types of tasks are not common in daily activities. In sports medicine and rehabilitation settings, for example, issues such as gait analysis and the activation timing of muscles during cycling are difficult to assess with isometric muscle actions. Some studies have examined EMG amplitude and MNF during repeated maximal isokinetic muscle actions (Beck, et al., 2004; Komi & Tesch, 1979; Perry-Rana, et al., 2002). Komi and Tesch (1979) compared these responses during 100 concentric isokinetic muscle actions between subjects with predominantly fast-twitch fibers for the vastus lateralis (VL) versus those with primarily slow-twitch fibers. The authors (Komi & Tesch, 1979) reported that the analysis of MNF values was sensitive enough to detect differences in the fatigability between fiber types. Similarly, Gerdle, Larsson, and Karlsson (2000) demonstrated that when examined on an individual subject basis, the decline in EMG MNF during repeated maximal isokinetic muscle actions was highly correlated with changes in peak torque. EMG amplitude has been used in many intervention-based studies to examine issues such as the neural adaptations that occur with strength training (deVries, 1968; Moritani & deVries, 1979) and neuromuscular fatigue (deVries, Moritani, Nagata, & Magnussen, 1982; Housh, et al., 1996). Therefore, it is possible that the beneficial effects of mental or physical diverting activities on recovery could be further explained by changes in EMG amplitude and MNF.

Although studies have examined the mechanisms responsible for the Sechenov phenomenon (Alpert, 1969; Asmussen, 1936; Asmussen & Mazin, 1978a,b; Weber, 1914), previous authors were likely unable to provide detailed analyses of EMG signals due to limitations in technology and/or signal processing. Therefore, the purpose of the present study was to examine the effects of mental and physical diverting activities on EMG amplitude and MNF values.

Methods

Subjects

Eleven men (mean±SD age = 22±2 years; height = 179.8±5.0 cm; body weight = 79.0±10.9 kg) and eight women (mean ± SD age = 22±2 years; height = 161.1±5.2 cm; body weight = 64.9±12.3 kg) volunteered to participate in this investigation. Each subject completed a pre-exercise health and exercise status questionnaire, which indicated no current or recent neuromuscular or musculoskeletal problems. The study was approved by the University Institutional Review Board for Human Subjects, and all subjects signed an informed consent prior to testing.

Unilateral leg extension one-repetition maximum (1-RM) testing and familiarization session

Prior to data collection, the subjects participated in a maximal strength testing and familiarization session to minimize the influence of a learning effect on each of the study's dependent variables. Upon arrival, the subjects were tested for concentric DCER 1RM leg extension strength of the non-dominant (based on kicking preference) leg extensors according to the previously described methods (Kraemer, Ratamess, Fry, & French, 2006). Before assessing the 1RM, the subjects were seated in the leg extension machine (CYBEX Strength Systems Leg Extension, Cybex International, Inc., Medway, MA) with the back firmly against the back pad and the feet behind and in contact with the roller pad. The back pad and roller pad were then adjusted to align the knee joint with the machine's axis of rotation. The subjects first performed eight to ten repetitions with approximately 50% of their estimated 1RM, followed by another set of three to five repetitions with roughly 85% of their estimated 1RM. The weight was then increased to a load that was close to the 1RM, and the subject performed one repetition. A repetition was considered successful if the subject was able to fully extend his/her non-dominant leg in a slow (i.e. two to three seconds), controlled manner. Attempts were discarded if the investigator observed a change in posture throughout the range of motion. Once the 1RM was determined, 50% of the 1RM was calculated and subsequently used for the physical diverting activity trial.

Five minutes after the 1RM test, the subjects were seated and strapped to the isokinetic dynamometer (LIDO Multi-Joint II, Loredan Biomedical, West Sacramento, CA) in accordance with the manufacturer's instructions for lower-body testing (Loredan Biomedical, Inc., 1992). The knee joint was visually aligned with the input axis of the dynamometer. Familiarization with the isokinetic dynamometer began with a warm-up of ten submaximal concentric muscle actions of the dominant leg extensors in which the subjects were instructed to provide an effort corresponding to 50% of their maximum. Each muscle action was performed at a velocity of $180°\cdot s^{-1}$ through a 90° range of motion. After the warm-up, the subjects were instructed on the procedures for the fatigue test. Specifically, the subjects were told to perform fifty consecutive maximal concentric muscle actions of their leg extensors with passive leg flexion after each muscle action. The investigator gave strong verbal encouragement in an attempt to ensure that the subjects were providing a maximal effort for each muscle action. No isokinetic torque or EMG data were collected during the familiarization session.

Testing sessions

At least 48 hours after the 1RM testing and familiarization session, the subjects returned to the laboratory to perform one of three separate trials (i.e. the physical diverting activity trial, the mental diverting activity trial, or the control trial). These trials were randomly performed and separated by at least 48 hours of rest. However, for each of the three trials, the subjects performed two bouts of fifty consecutive maximal concentric isokinetic muscle actions of the dominant leg extensors at a velocity of $180°\cdot s^{-1}$. Between the bouts, a three-minute time period was used to assess the effects of the mental diverting activity (math problems), physical diverting activity (contralateral exercise), and quiet rest (control) on recovery. Thus, the peak torque data from the first and second bouts of fifty consecutive maximal concentric isokinetic muscle actions served as the pre-test (Pre) and post-test (Post) data, respectively. Other than the intervention during the three-minute rest period (i.e. math problems, contralateral exercise, control), identical testing procedures were used for all three trials.

For the mental diverting activity trial, the subjects were given a clipboard with a worksheet of math problems (Aplusmath.com, Education 4 Free, LLC) to complete during the three minute time period between the fatigue bouts. Immediately after the first fatigue test, the subjects were instructed to correctly solve as many problems as possible in three minutes. The subjects were not removed from the dynamometer during this time period, but were instructed to focus their attention solely on solving the math problems. The worksheet involved addition, subtraction, multiplication, and division. In addition, the subjects were not allowed to use hand calculators, but were asked to show their work for each problem. The problems were designed to be difficult, but not to the point that the subjects could not complete them. Once the three-minute time period had ended, the clipboard and pen were handed to the investigator, and the second bout of fifty consecutive maximal concentric isokinetic muscle actions of the dominant leg extensors were performed.

For the physical diverting activity trial, contralateral DCER leg extension exercise was performed during the three minute time period between the fatiguing bouts. Immediately after completing the first fatiguing bout, the subjects were removed from the dynamometer and walked to the DCER leg extension machine, which was only ten feet away. The subjects then performed five sets of ten repetitions with 50% of their pre-determined 1RM using only the non-dominant leg extensors. A thirty-second rest period was used between the five sets. When the subjects had completed the five sets of DCER leg extensions, they were once again seated and strapped to the isokinetic dynamometer. Using the dominant leg extensors, the subjects performed the second fatiguing bout in the same manner as the first.

For the control trial, the subjects rested quietly during the three minute time period between the fatiguing bouts. The subjects were not removed from the dynamometer, and were asked not to speak, to keep their eyes open, and to remain as still as possible, as finger tapping and closing one's eyes have been shown to influence recovery from fatigue (Asmussen & Mazin, 1978b). After three minutes of quiet rest, the subjects performed the second fatiguing bout.

Torque measurements

The torque signal from the isokinetic dynamometer was sampled continuously throughout the fatiguing bouts by a 12-bit analog-to-digital converter (NI 9201 Voltage Input Module, National Instruments, Austin, TX) at a rate of 3,000 samples/second. The isokinetic peak torque value for each contraction was determined based on the highest value in the torque curve. The initial peak torque for each fatiguing bout was defined as the average from the three contractions with the highest peak torque values, and the final peak torque was determined as the average from the three contractions with the lowest peak torque values.

EMG measurements

For each trial, surface EMG signals were detected during the concentric isokinetic muscle actions from the VL, RF, and vastus medialis (VM) of the dominant thigh with three separate bipolar electrode arrangements. For each muscle, the recording electrodes (circular, 1 cm diameter, Ag/AgCl, Ambu, Ballerup, Denmark) were placed in accordance with the SENIAM project (Hermens, et al., 1999). The interelectrode distance was 30 mm, and the reference electrode was placed over the patella. The skin over the belly of each muscle was carefully prepared prior to testing by shaving and cleansing with alcohol rubbing. After detection, the EMG signals were pre-amplified (gain = 1,000) and analog filtered (band-pass filter with cut-off frequencies of 10 Hz and 1500 Hz). The EMG signals were then digitized at a sampling rate of 3,000 samples/second with a 16-bit analog-to-digital converter (Biovision, Wehrheim, Germany) and stored in a personal computer (Dell Optiplex 745, Round Rock, TX) for subsequent analyses. Following each trial, the surface of the skin was marked with a permanent marker, and the electrodes were placed in the same positions over each muscle for all three trials.

Signal processing

All signal processing was performed using custom programs with LabVIEW programming software (version 8.2, National Instruments, Austin, TX). For each fatiguing bout, the EMG signals from each muscle during the fifty concentric isokinetic muscle actions were selected for analysis. Specifically, the EMG signals were selected visually and encompassed the entire range of motion. The selected signals were band-pass filtered (zero-lag, fourth-order Butterworth) at 10-500 Hz, and the amplitude (root-mean-square; RMS) and MNF values were calculated. For the MNF analyses, each selected signal was processed with a Hamming window and the discrete Fourier transform was used to generate the power spectrum. For each trial, these data were then normalized to the RMS and MNF values corresponding to the first concentric isokinetic muscle action of the Pre data (i.e. Contralateral Pre initial value, Control Pre initial value, Math Problems Pre initial value). Thus, all EMG amplitude and MNF values were expressed as a percentage of their initial values. For each subject, muscle, and fatiguing bout (Pre and Post), the normalized EMG amplitude and MNF data points corresponding to the initial peak torque (three contractions with the highest peak torque values) and final peak torque values (three contractions with the lowest peak torque values) were averaged and utilized for subsequent statistical analyses.

Statistical analyses

Twelve separate two-way [time (Pre and Post) × intervention (math problems, contralateral exercise, and control)] repeated measures analyses of variance (ANOVAs) were used to examine the normalized EMG amplitude and MNF values that corresponded to the initial and final peak torque values for each of the three muscles. In addition, linear regression analyses were performed for the normalized EMG MNF versus repetition relationship for each muscle and trial. Figure 1 shows example EMG MNF data from one subject for the vastus lateralis. Three separate two-way [time (Pre and

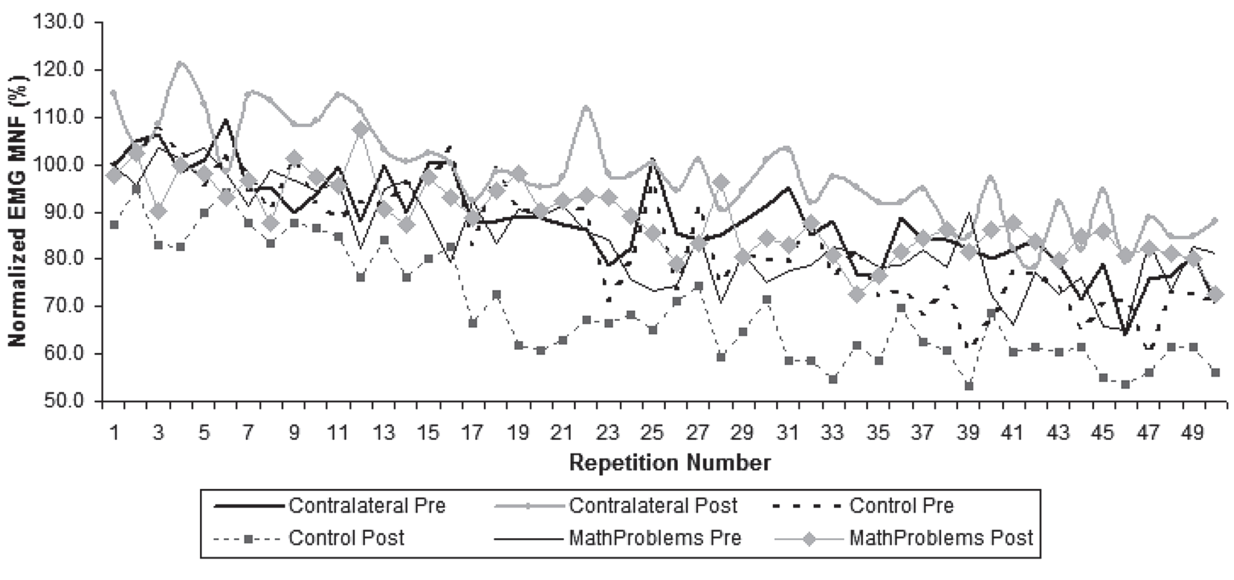

Figure 1. An example of the normalized electromyographic (EMG) mean frequency (MNF) values across the 50 repetitions for one subject for the vastus lateralis. For each trial (contralateral exercise, control, math problems), the values were normalized to the initial contraction for Pre. For this subject, the mean ± standard deviation linear slope coefficient for the decline in EMG MNF across the six tests was -0.599±0.120 %/repetition.

Post) × intervention (math problems, contralateral exercise, and control)] repeated measures ANOVAs were then used to examine the linear slope coefficients for the decline in normalized EMG MNF for the VL, RF, and VM. When appropriate, follow-up analyses included one-way repeated measures ANOVAs, paired samples *t*-tests, and Bonferroni *post-hoc* comparisons. An alpha level of .05 was used to determine statistical significance for all analyses.

Results

Initial EMG amplitude

The results from the two-way repeated measures ANOVAs for the initial EMG amplitude for the VL and VM indicated that there were no significant time × intervention interactions, and no main effects for time or intervention (Figure 2). For the initial EMG amplitude for the RF, however, the two-way repeated measures ANOVA demonstrated no significant time × intervention interaction, no main effect for intervention, but a main effect for time. The marginal mean pairwise comparisons indicated that when collapsed across intervention, the average EMG amplitude value for Pre was significantly greater than that for Post.

Initial EMG MNF

The results from the two-way repeated measures ANOVAs for the initial EMG MNF for the VL, RF, and VM indicated that there were no significant time × intervention interactions, and no main effects for time or intervention (Figure 2).

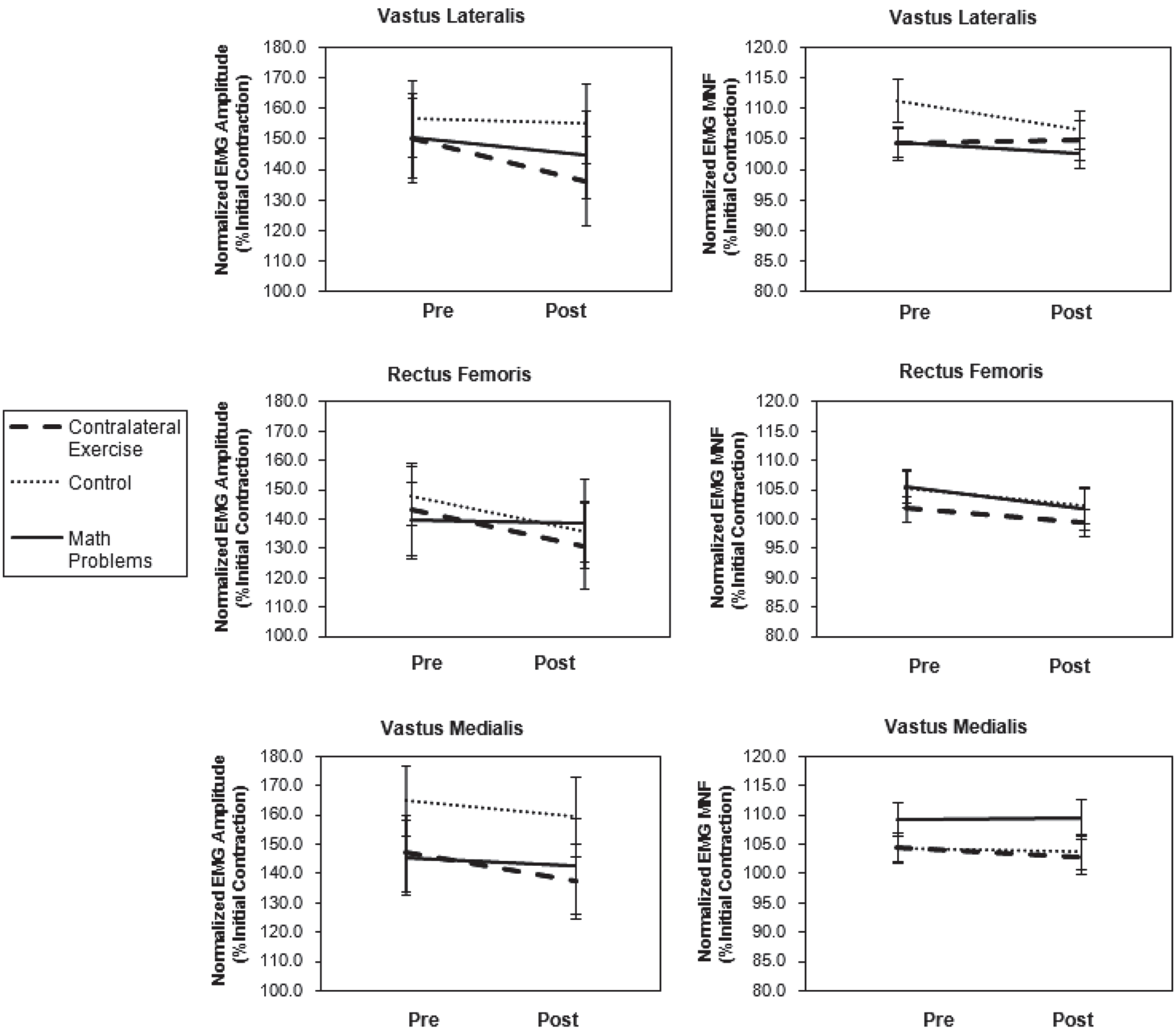

Figure 2. Mean ± standard error of the mean normalized electromyographic (EMG) amplitude and mean frequency (MNF) values corresponding to the initial peak torque values (three contractions with the highest peak torque values) for the vastus lateralis, rectus femoris, and vastus medialis. The EMG amplitude and MNF values were expressed as a percentage of the initial values for the first fatiguing bout (Pre). The three charts on the left correspond to the EMG amplitude data. The three charts on the right correspond to the EMG MNF data.

Final EMG amplitude

The two-way repeated measures ANOVAs for the final EMG amplitude for the VL and VM indicated that there were no significant time × intervention interactions, and no main effects for time or intervention (Figure 3). For the final EMG amplitude for the RF, however, the two-way repeated measures ANOVA demonstrated no significant time × intervention interaction, no main effect for intervention, but a main effect for time. The marginal mean pairwise comparisons indicated that when collapsed across intervention, the average EMG amplitude value for Pre was significantly greater than that for Post.

Final EMG MNF

The results from the two-way repeated measures ANOVAs for the final EMG MNF for the VL and VM indicated that there were no significant time × intervention interactions, and no main effects for intervention (Figure 3). There were, however, main effects for time. The marginal mean pairwise comparisons indicated that when collapsed across intervention, the average EMG MNF value for Pre was significantly lower than that for Post for both the VL and VM. For the final EMG MNF for the RF, however, the two-way repeated measures ANOVA demonstrated a significant time × intervention interaction. Follow-up paired samples *t*-tests showed that the average EMG MNF values increased from Pre to Post for the contralateral exercise and math problems trials, but not for the control trial. For Pre, the results from the one-way repeated measures ANOVA showed a greater average EMG MNF value for the math problems trial than that for the contralateral exercise trial, but no difference when compared to that from the control trial. For Post, the one-way repeated measures ANOVA was not significant.

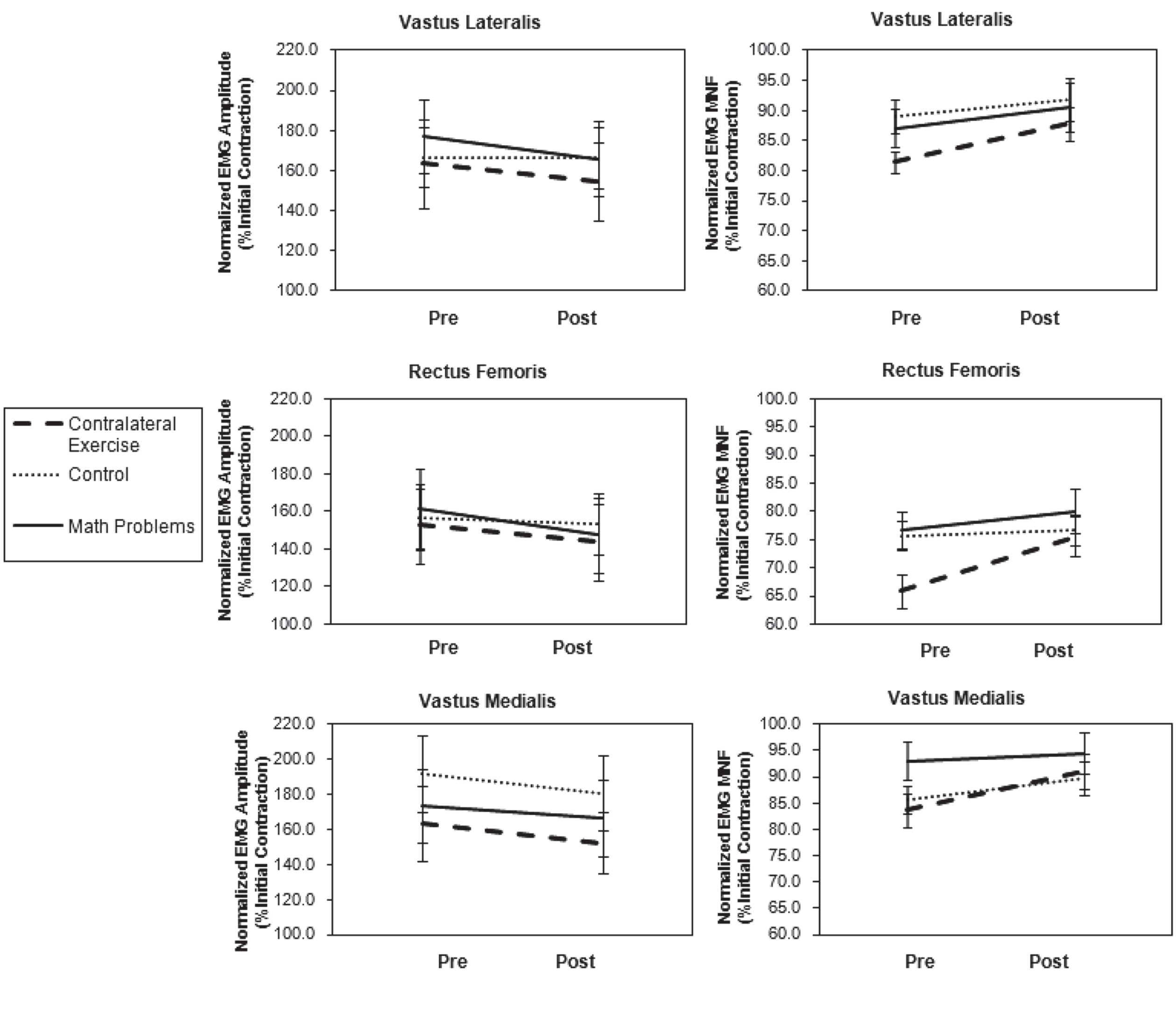

Figure 3. Mean ± standard error of the mean normalized electromyographic (EMG) amplitude and mean frequency (MNF) values corresponding to the final peak torque values (three contractions with the lowest peak torque values) for the vastus lateralis, rectus femoris, and vastus medialis. The EMG amplitude and MNF values were expressed as a percentage of the initial values for the first fatiguing bout (Pre). The three charts on the left correspond to the EMG amplitude data. The three charts on the right correspond to the EMG MNF data.

Linear slope coefficient for the decline in EMG MNF for the VL

The results from the two-way repeated measures ANOVA indicated that there was no significant time × intervention interaction (Figure 4). There were, however, main effects for time and intervention. For time, the marginal mean pairwise comparisons showed that the values for Pre were significantly less than those for Post. For intervention, the marginal means for the math problems trial were significantly greater than those for the contralateral exercise trial.

Linear slope coefficient for the decline in EMG MNF for the RF

The results from the two-way repeated measures ANOVA indicated that there was no significant time × intervention interaction (Figure 4). There were, however, main effects for time and intervention. For time, the marginal mean pairwise comparisons showed that the values for Pre were significantly less than those for Post. For intervention, the marginal means for the math problems trial were significantly greater than those for the contralateral exercise trial.

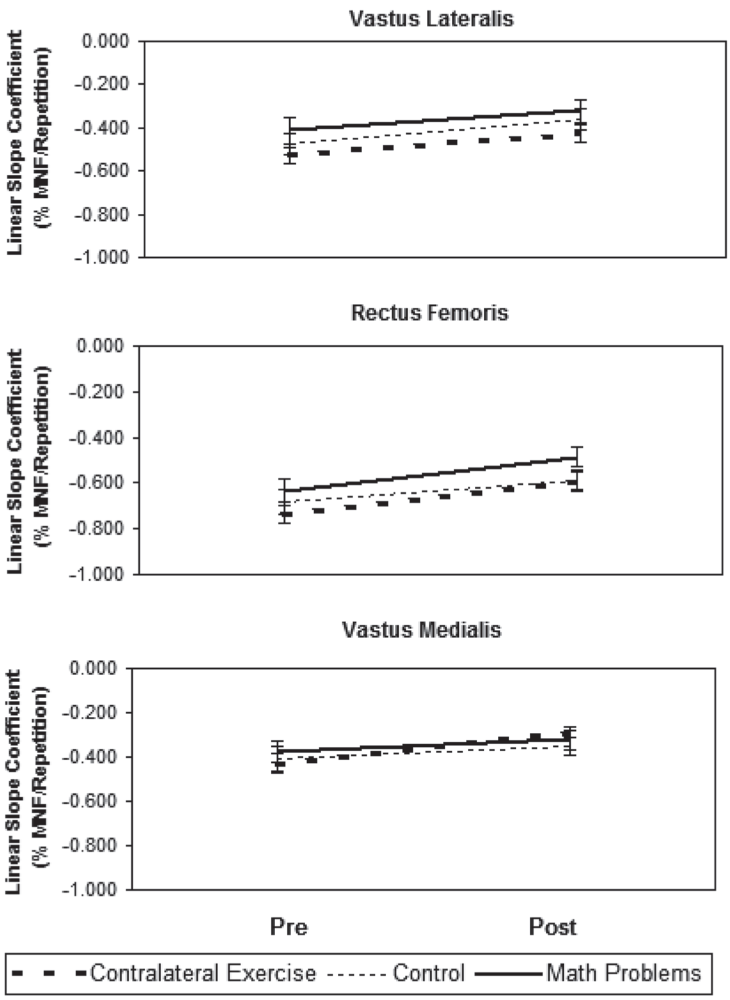

Figure 4. Mean±standard error of the mean values for the linear slope coefficient for the decline in electromyographic (EMG) mean frequency (MNF) across 50 repetitions for the vastus lateralis, rectus femoris, and vastus medialis before (Pre) and after (Post) each intervention period (contralateral exercise, control, or math problems).

Linear slope coefficient for the decline in EMG MNF for the VM

The results from the two-way repeated measures ANOVA indicated that there was no significant time × intervention interaction, no main effect for intervention, but there was a main effect for time (Figure 4). When collapsed across intervention, the marginal means for Pre were significantly less than those for Post.

Discussion and conclusions

A recent study from our laboratory (Stock, et al., 2011) demonstrated that when subjects performed either mental or physical diverting activities following a fatiguing bout of maximal concentric isokinetic muscle actions, recovery was better than that from quiet resting. As a result, we (Stock et al., 2011) concluded that the use of diverting activities could potentially be used to enhance recovery during training sessions. As displayed in Figures 2, 3, and 4, however, the mechanism(s) responsible for this improved recovery could not be explained by differences in EMG amplitude or MNF values. Specifically, of the fifteen repeated measures ANOVAs performed in this study, only one resulted in a significant time × intervention interaction. Thus, we must conclude that if the Sechenov phenomenon affects central drive to the muscle, EMG amplitude or MNF values may not be sensitive enough to detect it.

As stated previously, Sechenov (1935) noted that during the act of sawing, more work could be performed by one's right arm if, during intermittent rest periods, the left arm was exercised. Following a study by Asmussen (1936), the consensus among many scientists was that the use of diverting activities could be used to reduce muscle fatigue during exercise, and these methods were commonly utilized by Danish gymnasts during their training (Alpert, 1969). However, while some authors attributed the benefits of physical diverting activities to changes in the CNS (Asmussen, 1936; Sechenov, 1935), others (Alpert, 1969; Weber, 1914) believed that the positive effects could be explained by changes in blood flow to the non-fatigued muscle(s). As a result, Asmussen and Mazin (1978a,b) performed several experiments to further study the mechanisms responsible for the Sechenov phenomenon. In one experiment, the authors (Asmussen & Mazin, 1978b) examined EMG signals from the RF during patellar reflex testing while the subjects performed fatiguing muscle actions with or without diverting activities. It was reported that when the subjects performed fatiguing muscle actions with a diverting activity, much faster patellar reflexes were observed, which the authors (Asmussen & Mazin, 1978b) believed was due to the enhanced cerebral cortex function. What was noteworthy, however, was that these results were demonstrated with physical diverting activities (contralateral muscle actions), as well as activities that were not physically demanding (opening and closing one's eyes). As a result, the authors (Asmussen & Mazin, 1978b) concluded that the improved performance commonly shown with the Sechenov phenomenon was independent of circulatory factors, and that the effects could be explained by changes in CNS activity, particularly in the reticular formation. While it is possible that the maximal concentric muscle actions used in this study induced both central and peripheral fatigue, the EMG amplitude and MNF values did not reflect the improved recovery from the diverting activities.

Although it has been hypothesized that assessment of EMG amplitude patterns during repeated maximal concentric isokinetic muscle actions could provide information on muscle fiber type (Komi & Tesch, 1979), inconsistencies have been reported in the literature. Whereas studies by Perry-Rana et al. (2002) and Beck et al. (2004) demonstrated increases in EMG amplitude as the contraction series progressed, others have reported no change (Kellis, 1999), or decreases (Komi & Tesch, 1979). Although we did not report results for individual subjects in the present study, there were no consistent patterns for EMG amplitude during the fatiguing bouts (i.e. some demonstrated increases, some showed decreases, and there was no change for others). This does not necessarily mean, however, that the information in the surface EMG signal is unreliable or invalid. Rather, it simply means that more advanced techniques may be needed to extract this information. In this regard, von Tscharner (2000) has developed a wavelet analysis specifically for EMG signals. From the standpoint of examining fatigue during dynamic muscle actions, a major advantage of this analysis is that it generates an intensity pattern that shows changes in intensity across both time and frequency during a contraction. The EMG intensity patterns have been used in previous studies to examine muscle activation patterns for the tibialis anterior during running with and without shoes (von Tscharner, Göpfert, & Nigg, 2003), as well as to determine differences in the muscle activation patterns of male versus female runners (von Tscharner & Göepfert, 2003). In addition, Huber, Göpfert, Kugler, and von Tscharner (2010) recently examined EMG spectral differences for sprint-trained versus endurance-trained athletes. The authors reported that compared to the endurance-trained athletes, the EMG wavelet spectra for the sprint-trained athletes showed higher proportions of the lower frequency components, and the differences were sufficient enough to detect whether an athlete had been previously trained for sprinting or endurance sports (Huber, et al., 2010). It was also noted that the differences between the spectra from the two groups of athletes would not have been identified with EMG MNF analyses alone, as the uniqueness of the spectra was manifested in their shapes. Thus, although these methods are complex, analysis of EMG wavelet spectra and/or intensity patterns combined with pattern classification techniques may provide information on the effects of diverting activities that could not be obtained with EMG amplitude and MNF data.

In summary, the results of the present study demonstrated that when subjects performed fatiguing bouts of isokinetic muscle actions, the enhanced recovery with mental and physical diverting activities that we reported previously (Stock, et al., 2011) could not be explained by changes in EMG amplitude or MNF. These results are in contrast to those of Asmussen and Mazin (1978b), who noted qualitative differences in the EMG signal for the RF when subjects performed fatiguing muscle actions with their eyes closed versus open. It is possible that performing contralateral DCER muscle actions or solving math problems may not have affected central drive to the muscles. It is also possible that standard EMG amplitude and MNF analyses are not sensitive enough to detect the changes in muscle activation. Therefore, advanced EMG signal processing techniques should be utilized in future studies to further examine the mechanisms responsible for the Sechenov phenomenon. In addition, examining the effects of diverting activities on recovery using different types of fatiguing protocols (e.g. isometric muscle actions, treadmill running, and cycle ergometry) should be considered.

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UČINCI ODVRAĆAJUĆIH AKTIVNOSTI NA ELEKTROMIOGRAFSKU AMPLITUDU I PROSJEČNU FREKVENCIJU

Cilj je ovog istraživanja ispitati učinke odvraćajućih aktivnosti na amplitudu i prosječnu frekvenciju elektromiografskog signala. U tri odvojene situacije, jedanaest muškaraca i osam žena izvodilo je dvije serije od pedeset uzastopnih, maksimalnih, koncentričnih izokinetičkih mišićnih akcija ekstenzorima dominantne noge. Između serija, subjekti su ili rješavali matematičke probleme, izvodili kontralateralna dinamička opružanja s konstantnim vanjskim opterećenjem ili su se odmarali. Tijekom svake mišićne akcije bilježili su se elektromiografski signali u mišićima *vastus lateralis, rectus femoris* i *vastus medialis.* Rezultati su pokazali da ni psihičke ni fizičke odvraćajuće aktivnosti nisu konzistentno utjecale na prosječnu elektromiografsku amplitudu i frekvenciju. Ukoliko su mentalne ili fizičke odvraćajuće aktivnosti ipak nekako utjecale na mišićnu aktivaciju mišića *vastus lateralis, rectus femoris* ili *vastus medialis*, elektromiografske vrijednosti prosječne amplitude i frekvencije nisu bile dovoljno osjetljive da to otkriju.

Ključne riječi: *Sechenov fenomen, vršni okretni moment, postotak opadanja, odvlačenje pažnje*