ANALYSIS OF EXERCISE-INDUCED MUSCLE SORENESS AND ELECTROMYOGRAPHIC CHANGES

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INTRODUCTION

It is well recognized that unaccustomed exercise, particularly eccentric exercise, results in muscle damage and muscle soreness (Armstrong, 1990). In the days after unaccustomed eccentric contractions, extensive disruption of the ultrastructure of skeletal muscle occurs, as well as the release of myocellular proteins, for example creatine kinase(CK) and myoglobin etc, into the blood and the delayed onset of muscle soreness (Ebbeling, 1989). Delayed Onset Muscle Soreness (DOMS) is a sensation experienced after unaccustomed exercise. It is usually first felt between 8 and **24** hours after the termination of exercise, peaks in intensity between **24** and **72** hours, and then decreases dramatically. DOMS is particularly prevalent after exercise involving unaccustomed eccentric, lengthening muscle actions and is associated with connective or contractile tissue. Several investigator have recently implicated indexes of acute inflammation as a mechanism for Z-line disruption(Fielding, 1993) and DOMS(Smith, 1991) especially after eccentric exercise. DOMS is a complex of symptoms, namely pain on movement and a sensation of swelling and stiffness of the muscles performing negative work(Giamberardino, 1996).

After fatiguing muscle with exercise, there is a decrease in tnaximal force production, which has been observed as early as 1h after exercise. The surface electromyographic (EMG) activity is modified during muscle fatigue(Bigland-Ritcgie, 1981). The EMG power spectrum is shifted toward the lower frequencies as exemplified by the fall in mean power frequency (MPF) during static contractions as well as during dynamic exercise. The EMG spectrum from eccentric, concentric muscle contractions under human were studied as a factor of mechanical damage of muscle fiber and functional change of metabolic tissue. The primary purpose of the study was to examine the relationship beteween DOMS in after exercise and EMG change in during exercise. A secondary purpose was to examine their relationship to local muscle fatigue and perceived scale of DOMS. We hypothesized that if exercise-induced muscle soreness is associated with muscle fatigue then the localized DOMS to muscle contractions would be accompanied by attenuated response in index of muscle fatigue.

METHODS

Five male subjects [age 21(SD2) years, height 172(SD6) cm and body mass 72(SD6) Kg] participated in this investigation after giving verbal and written informed consent in accordance with institutional guidelines. Subjects had not performed resistive exercises for at least 2 weeks before the experimental trials. Subjects were instructed to maintain their normal diet and to abstain from physical activity, alcohol, caffeine, and from taking analegestic medicines 48 h before and during the experimental trials. The practice served as a warm-up for each test session. Subjects performed going up and down movements in time to a metronome (35 up / min) . The right leg was going up (concentric), the left leg was going down (eccentric), during a 150 - 210 min period. The subjects were instructed to perform successively as many stepping as possible. The exercise was stopped when the subjects could no longer step going up and down. On average, the subjects reached exhausion after 188 min of repeated work. Subject wore ankle weights(1Kg). Subjects were asked to perceive exertion of the lower limb (Gastrocnemius and Soleus).

. The surface EMG was recorded bipolary by silver chloride electrodes with an interelectrodedistanceof 20 mm from Gastrocnemius and Soleus,at four sites, all of eight sites on the two legs. The electrodes were placed longitudinally on the muscle belly on each marked sites. Care was taken that the interelectrode resistance was below 2 kOhms. The EMG signals were stored simultaneously with the skin temperature on a digital recorder. The EMG signals were digitized with a sampling frequency of 1.5 kHz, full-wave rectified, and then integrated and averaged. Muscle soreness was assessed before and after exercises, by having an investigator passively push at lower leg muscles on cutaneous. And subjects described scales as the perceived soreness intensity in all of the forty-eight sites on two legs after 0, 2, 4, 8, 12, 24, 48, 72 hours, respectively. A simple number range was chosen, 0-10 category - 10 as very very sore scale. Sites were marked with a permanent marker to ensure that the same sites were palpated during subsequent measurements (Figure 1).

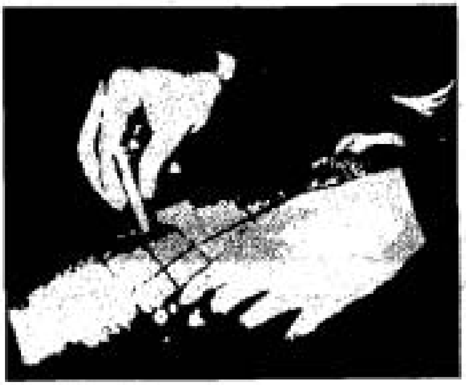

Figure 1. Illustrated schematic experimental procedure. DOMS was evaluated for the 24 sites on each lower leg.

After analog-to-digital conversion on EMGs, a data reduction was applied to mean power frequency and integrated EMG. A mean spectrum was then computed by calculating the root mean square values of 16 spectra obtained from consecutive time windows of 500 ms duration. The resulting spectrum was defined by 256 points in amplitude and phase in the 1 to 1025 Hz bandwidth. Meanwhile, the amplitude values were transmitted to a microcomputer by means of a GPIB (IEEE 488) interface system. The total EMG power(PEMG) and the MPF was computed from the mean spectrum. Muscle soreness was analyzed by a nonparametric Wilcoxon matched-pairs signed-rank test. Average and analysis of EMG for each repetition, averaged over the 16 repetitions, were analyzed with the use of a repeated-measures analysis of variance. Statistical significance was set at $P < 0.05$.

RESULTS

In the present study, going up and down exercise have it that Gastrocnemius and Soleus was main load. Recorded EMG was shown to decrease in the high - frequency bands. Figure 2 illustrates changes in EMG power spectrum of both muscle contractions. A continuous increase in PEMG was observed during all sites on lower leg. This increasing myoelectrical activity was associated with a decrease in MPF. The average decline in MPF, was significantly higher in pre-exercise than last condition of exercise. Then, in perceived category scale, DOMS observed greater after eccentric contraction than after concentric contraction. At 12, 24 hours after exercise, eccentric was at the most intensive of DOMS.

After the exercise stimulus, the intensities of soreness was significantly higher at a few subsequent test times(8, 12, 24, and 48 h) than was the pre-exercise stimulus scores($P < 0.05$)(Figure 3).

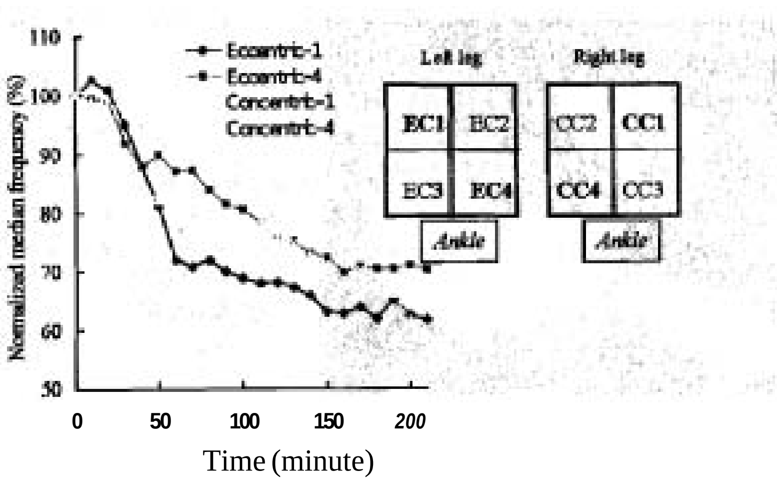

Figure 2. Normalized median frequency versus exercise time at gastrocnemius (1) and soleus (4) both left and right legs.

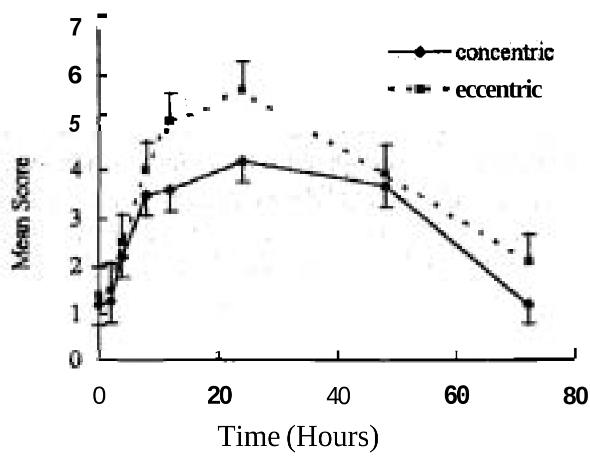

Figure 3. Mean values of overall DOMS in concentric (right leg) and eccentric (left leg), postexercise test at 0,2,8,12,24,48, and 72.

DISCUSSION

The major finding in the present study was the following: eccentric muscle activity causes the most soreness and fatigue to the muscle. DOMS is reported to be prominent in the life of most individuals, particularly sportsmen, because a great number of physical activities/sports involve eccentric contractions. The perception of the intensities of soreness increased after the exercise stimulus and peaked 24 h after the exercise stimulus. In this study, four additional time periods of data were collected between the pre-exercise test and the usual reporting time of 24 h. The responses at 4, 8, and 12 h after the eccentric exercise confirmed that intensity of soreness progressively increased for up to 24h. Other investigators have reported that soreness responses returned to baseline levels by 5(Newham, 1986), 7(MacIntyre, 1995) or 10(Clarkson, 1992) days, but because the protocol ended at 72 h in this study, neither intensity of soreness nor pain has returned to the pre-exercise levels. Alternatively, it could be that the affective dimension is not a prominent experience in muscle soreness compared with other pain syndromes(MacIntyre, 1995).

During the data collection, subjects were asked to subjectively report the location of their muscle soreness by indication on body diagram where they felt the soreness. At 2 h post exercise, all subjects reported their soreness level at site almost of 15th both lower legs in moderate. By 24-48 h post exercise, all of the subjects reported soreness proximally a little strong at site of 11th upper 13-16th. Although this is anecdotal information Newham and colleagues(1983) reported tenderness beginning medially, laterally, and distally and then becoming more diffuse throughout the quadriceps muscles by 24-48 h after the exercise. In addition, lateral gastrocnemius contains more fast twitch (FT) fibres than soleus, and there has been evidence to suggest that in humans FT fibres are more susceptible to muscle damage than their slow twitch counterparts(Friden, 1983). PEMG was found to increase linearly with exercise duration in both conditions. This rise in myoelectrical activity might be due to an increase in firing rate of motor units, the recruitment of additional motor units, or an increase in the synchronization of motor unit discharge. The shift in EMG power spectrum toward lower frequencies can also account for the increased PEMG, because when the low-frequency components of EMG signal are increased.

CONCLUSIONS

DOMS should be considered one of the primary symptoms of most neuromuscular disorders. The EMG effects may be attributed to neural mechanisms, motor units synchronization, improved coordination, and muscle activity. Therefore it may be thought that different training background of our subjects could explain part of the EMG differences observed in each soreness sensitivity.

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