

Table 1: Descriptive measures from pre- to post-fatigue for maximum voluntary contraction (MVC), motor unit activation (MUA), and doublet twitch amplitude. Values are mean (standard deviation) for both genders and muscle groups. Time is measured in minutes, and corresponds to the duration after the tenth fatiguing contraction was performed that the measure was taken.

Variable	Time	Elbow Flexors		Knee Extensors	
		Female	Male	Female	Male
MVC (N)	Pre*	197.4(31.5)	364.6(64.9)	438.9(70.1)	677.4(102.4)
	0*	158.6(38.4)	262.2(60.8)	379.3(60.9)	487.9(86.2)
	15*	154.6(59.2)	311.9(80.3)	392.9(85.7)	517.7(90.2)
	30*	174.3(36.9)	317.7(81.3)	406.9(79.7)	543.4(81.5)
	45*	185.6(36.9)	324.6(55.8)	406.4(92.3)	553.7(70.8)
MUA (%)	Pre	93.6(3.3)	94.9(3.9)	86.2(10.8)	91.3(6.6)
	0	85.1(11.8)	86.6(7.8)	89.8(4.7)	84.3(6.7)
	15	84.2(10.5)	91.4(5.9)	89.6(6.5)	86.1(10.6)
	30	90.4(5.9)	91.5(7.7)	89.8(6.1)	85.8(9.8)
	45	91.3(3.4)	91.5(4.5)	88.4(8.6)	87.8(8.7)
Twitch (N)	Pre*	25.3(9.8)	70.4(22.0)	207.3(32.9)	310.0(73.4)
	0	21.3(18.6)	34.3(21.8)	140.9(27.9)	132.4(37.3)
	15	13.8(11.4)	41.2(21.9)	135.9(24.8)	158.8(70.6)
	30*	17.0(10.9)	40.1(21.3)	150.6(26.6)	202.5(36.8)
	45*	18.0(8.9)	38.1(20.5)	154.9(24.8)	205.2(30.7)

* Indicates significant difference ($P < 0.05$) between genders when muscles are grouped.

electrodes of 20 Hz and 500 Hz respectively. In order to determine the mean root mean square ($MRMS_{30}$) and mean median frequency (MMF_{30}) of each fatiguing contraction, the 30-second signal was broken into overlapping epochs of 0.25 seconds (Figure 2b) [5]. A mean root mean square ($MRMS_1$) was then determined for each one-second increment by calculating the average of the seven root mean square values in each of the appropriate epochs. Finally, the $MRMS_{30}$ was calculated by taking the average of the 30 $MRMS_1$ values. Similarly, after the time signal was transformed into the frequency domain through a fast Fourier transform (512 point Hamming window), the MMF_{30} of each fatiguing contraction was calculated using the same process. All signal processing and calculations were performed using custom software created in LabView 6.0 (National Instruments, Austin, TX).

Statistical analysis

The dependent measures analyzed for both tasks were maximum voluntary contraction (MVC), percent MVC, motor unit activation (MUA), and electrically evoked twitches from pre-fatigue to post-fatigue (Figure 2a). The electrically evoked twitches were also analyzed throughout the 10 fatiguing contractions. Furthermore, the ability to maintain 50% of MVC during the fatiguing contractions (SLP) was assessed by calculating the slope of the force signal after the rising and falling edges were removed (Figure 2a), and the lines of best fit from a linear regression for the $MRMS_{30}$ and MMF_{30} over the 10 fatiguing contractions ($MRMS_{slope}$ and MMF_{slope} respectively) were

analyzed. The MVC, percent MVC, MUA, twitches, and SLP variables were analyzed using mixed four-factor repeated measures ANOVA (gender \times side \times muscle \times time) designs (it should be noted that only the time \times muscle and sex \times muscle interactions were of interest with respect to percent MVC). Due to the small sample sizes and their effect on Mauchly's test of sphericity, the Greenhouse-Geisser epsilon was calculated and utilized to adjust the degrees of freedom in order to avoid the assumptions made about the variance-covariance matrices of the dependent variables (SPSS for Windows v11.5, ©SPSS Inc. 1989–2002). Therefore, significance of the repeated-measures tests were derived using the adjusted degrees of freedom. Any within- or between-subjects main effects were assessed using pairwise comparisons with Bonferroni corrections for multiple comparisons, and time interactions with sex, side, and muscle were assessed using independent samples T-tests. The $MRMS_{slope}$ and MMF_{slope} were analyzed using a one-sample T-test for group differences. Significance was accepted at $P < 0.05$.

Results

Descriptive data (mean and standard deviation) for the pre/post measures of MVC, MUA, and evoked twitches are presented in Table 1, whereas results for the evoked twitches and SLP derived for the fatiguing contractions are presented in Table 2.

Pre/Post measures

There were no significant sex differences for the arms or legs with respect to $MRMS_{slope}$, MMF_{slope} , and no gender