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SUPSI

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Evaluation of central and peripheral fatigue in quadriceps femoris using sEMG fractal dimension and muscle fiber conduction velocity

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BACKGROUND AND AIM

Over the past decade several new sEMG descriptors for central fatigue have been developed and tested in simulation studies or in healthy subjects. Mesin and colleagues (2009) proposed a novel vector composed of two indexes, (1) ECV (estimated conduction velocity) as indicator of peripheral fatigue and (2) FD (fractal dimension) as indicator of central fatigue. FD is a promising index, least affected by muscle fiber CV changes and mostly related to MU synchronization, although FD was never tested during a fatiguing task in healthy subjects, nor in patients.
The aim of the study is to analyze if the vector (CV, FD) can be used as a bi-dimensional marker for central and peripheral fatigue in healthy subjects.

		20% MVC		60% MVC	
		VL	VM	VL	VM
Conduction velocity (CV)	Initial (m/s)	6.30 ± 2.51	4.70 ± 0.91	7.07 ± 1.52	5.82 ± 1.82
	Slope (%/s)	-0.58 ± 1.81	0.03 ± 0.95	-1.09 ± 2.60	-1.44 ± 1.32
Fractal dimension (FD)	Initial (dim.)	1.55 ± 0.03	1.56 ± 0.03	1.57 ± 0.04	1.59 ± 0.04
	Slope (%/s)	-0.16 ± 0.35	-0.01 ± 0.37	-0.34 ± 0.51	-0.32 ± 0.50

Table 1 *Summary of results. Data are expressed as median value ± interquantile range.*

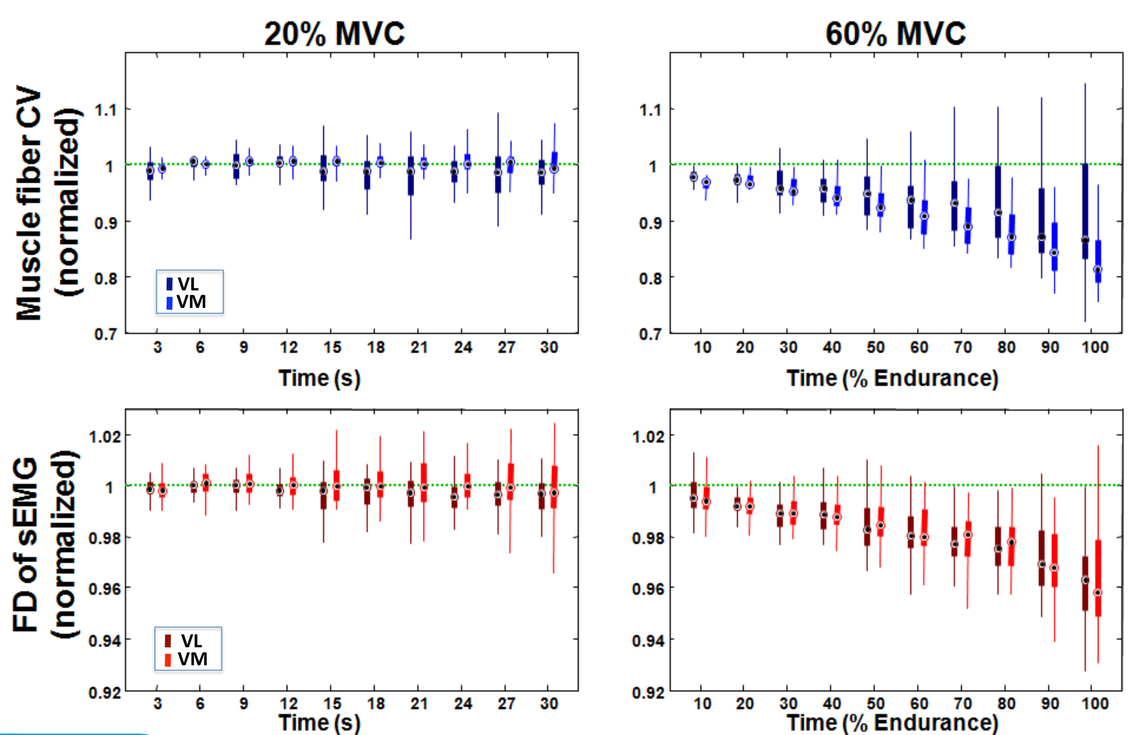

Figure 1 *Surface EMG changes in normalized fractal FD and MFCV in vastus lateralis (VL) and medialis (VM) muscles during different isometric contractions.*

MATERIALS AND METHODS

Twenty nine healthy women participated in the study after providing informed consent. None of the subjects had previous injuries of the lower limb and all participated regularly in different exercises and sports. Myoelectric signals were detected from the vastus lateralis (VL) and vastus medialis (VM) in single differential configuration using bi-dimensional arrays. FD and muscle fiber CV were measured by sEMG during a low level isometric contraction (20% MVC) for one minute, in order to allow an evaluation of peripheral fatigue of type I muscle fibers, followed by an endurance isometric contraction (60% MVC) until exhaustion, in order to evaluate peripheral fatigue of type II muscle fibers.

RESULTS

Table 1 summarizes the results for muscle fiber CV and FD at 20% and 60% MVC, in VM and VL muscles. Comparison between the two force levels revealed that initial values of CV and FD were significantly higher at 60% MVC, than at 20% MVC for both VL and VM muscles ($p<0.001$). In addition, initial estimates of CV were significantly higher for VL compared to VM muscle at both 20% and 60% MVC ($p<0.001$). Moreover the initial values of FD were significantly lower for VL compared to VM muscle at both 20% and 60% ($p<0.001$).

The average time course of muscle fiber CV and FD, during the 20% MVC and the 60% MVC isometric contractions is depicted in Figure 1.

DISCUSSION AND CONCLUSIONS

The statistically relevant decrease of FD during the 60% MVC endurance contraction is consistent with an increase of MU synchronization, one of the indicators of central fatigue. Whereas the decrease of muscle fiber CV during the same fatiguing contraction, as previously observed, is a clear sign of peripheral fatigue.
This study suggests that the bi-dimensional index (CV, FD) could be an effective indicator to differentially assess central and peripheral components of neuromuscular fatigability, with potential application in both clinical and sport sciences.

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