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RELATIONSHIP BETWEEN FRACTAL DIMENSION AND FIRING RATE SLOPES IN QUADRICEPS MUSCLE DURING FATIGUING CONTRACTIONS

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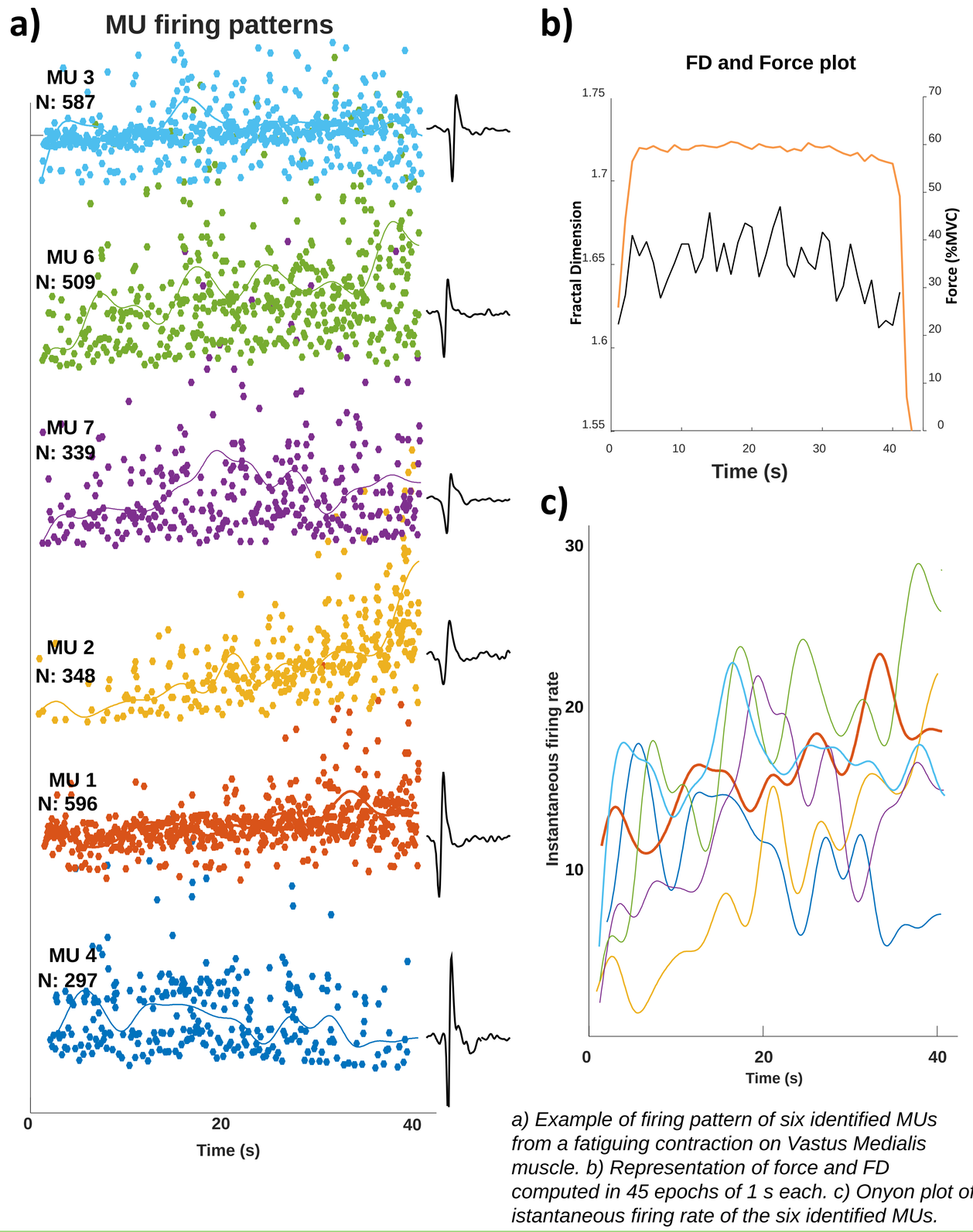
Background and Aim

Myoelectric fatigue has been studied extensively using different parameters extracted from EMG signals (e.g. muscle fiber conduction velocity, mean power frequency, high order statistics) [1-3]. Recently fractal dimension (FD) of EMG signals was proposed as an index of central fatigue, as it is related to the synchronization of the firing patterns of the active motor units (MUs) [4]. The aim of the present study was to investigate if the slope of FD during fatiguing contractions was correlated with the increase of firing rate (FR) of the active MUs.

Materials and Methods

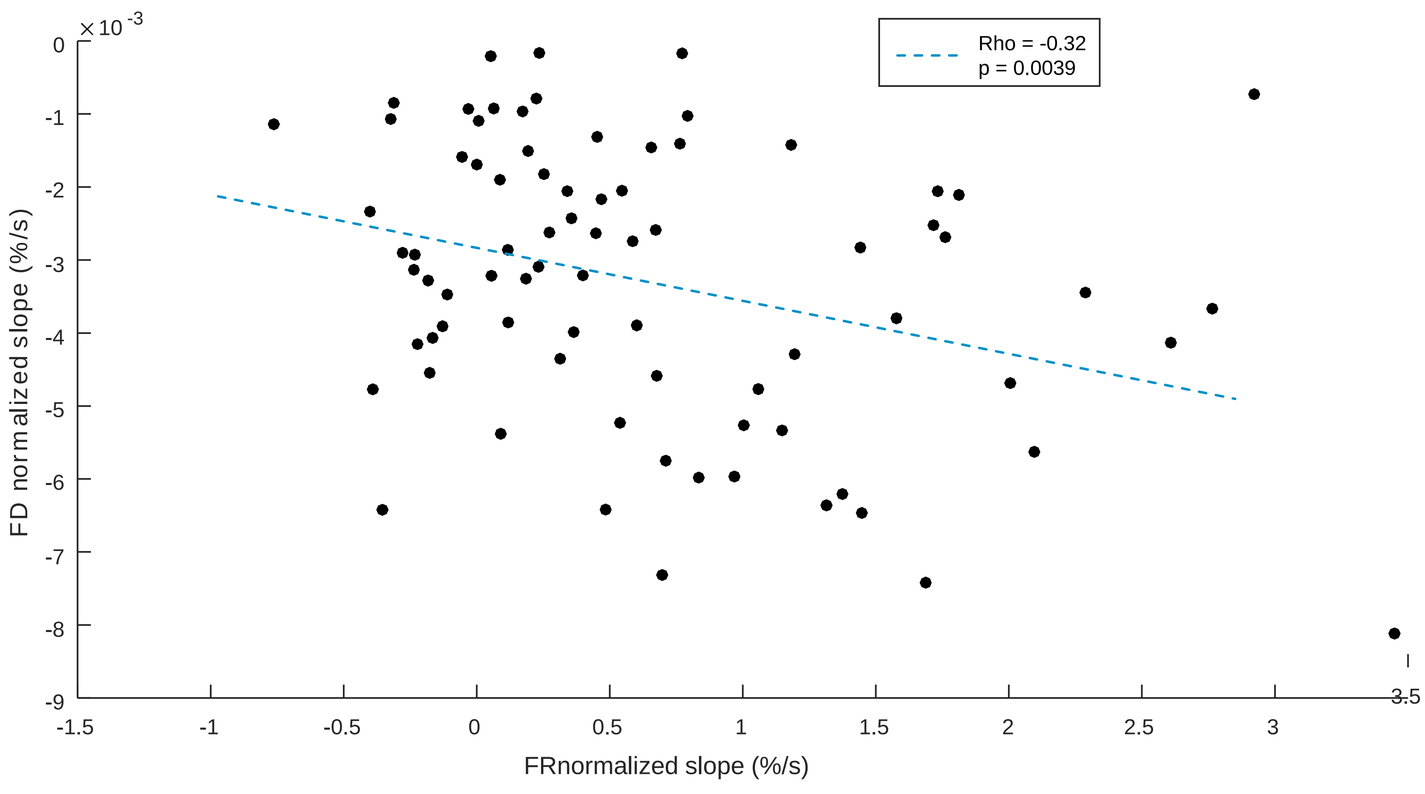
A dataset of EMG signals collected in previous experiments was used for this study. The database included EMG data from 70 subjects. Subjects were sitting on an ergometer were asked to perform isometric leg extension with the knee flexed at 120 degrees. EMG signals were detected in monopolar configuration from Vastus Medialis and Vastus Lateralis muscles of left and right leg using bidimensional arrays of 32 electrodes with 8mm IED (Spes Medica, Italy). Signals were decomposed using the decomposition tool implemented in the OTBiolab software (OTBioelettronica, Torino, Italy) (Figure 1a). The parameters set for the algorithm were the same for each signal and were selected on preliminary tests on a subportion of the dataset. The instantaneous firing rate of the identified motor units was extracted and linear regression was applied to identify initial value and slope (Figure 1c). FD was computed for each channel and time epoch of 1s (Figure 1b). The average value among all channels was computed and linear regression was applied to obtain initial value and slope. Pearson correlation coefficient was applied to evaluate the correlation between slope of FD and FR.

Figure 1



a) Example of firing pattern of six identified MUs from a fatiguing contraction on Vastus Medialis muscle. b) Representation of force and FD computed in 45 epochs of 1 s each. c) Onyon plot of istantaneous firing rate of the six identified MUs.

Figure 2



Relationship between FD normalized slope and FR normalized slope. Each dot represents a subject. Regression line is depicted in dashed blue. A significant inverse correlation was observed. Rho and p are indicated.

Results

The decomposition algorithm identified in average 3.5 motor units in 122 signals, with an average number of 562 firings for each identified MU. The firing patterns were visually inspected in order to remove duplicates or incorrect results. The total number of analysed signals was 84. A significant correlation was observed between slope of FD and slope of FR of the active motor units (see figure 2).

Conclusion

FD of EMG signals is sensitive to changes of firing rate during fatiguing contractions, thus it could be used as a tool to evaluate central nervous system changes, as it does not require large bidimensional arrays or decomposition algorithms.

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