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CORRELATION BETWEEN MOTOR UNIT SYNCHRONIZATION ESTIMATED THROUGH INTRAMUSCULAR AND SURFACE EMG IN THE VASTUS MEDIALIS OBLIQUUS: A VALIDATION STUDY

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Background and Aim

Motor unit (MU) synchronization is the tendency of separate MUs to discharge near simultaneously (within 1-5 ms of each other) more often that would be expected by chance (Farmer et al., 1997). During isometric fatiguing contractions MU synchronization is generally assumed to increase. Interestingly, previous publications suggested that a decay of fractal dimension (FD) of the surface EMG (sEMG) signal during isometric fatiguing contractions, may be associated to an increase in MU synchronization, as expression of the central nervous system (CNS) adaptation to fatigue (e.g., Troiano et al., 2008).
However, other studies using intramuscular EMG (iEMG) have reported no change in MU synchronization during fatigue (e.g., Semmler and Norstrom, 1998).
Therefore, the aim of this study was to investigate the correlation between MU synchronization detected through iEMG and the FD of the sEMG signal in the vastus medialis obliquus muscle during isometric fatiguing contractions.

Figure 1

Surface and intramuscular EMG signals were detected from the vastus medialis obliquus, using bipolar and fine-wire electrodes, respectively.

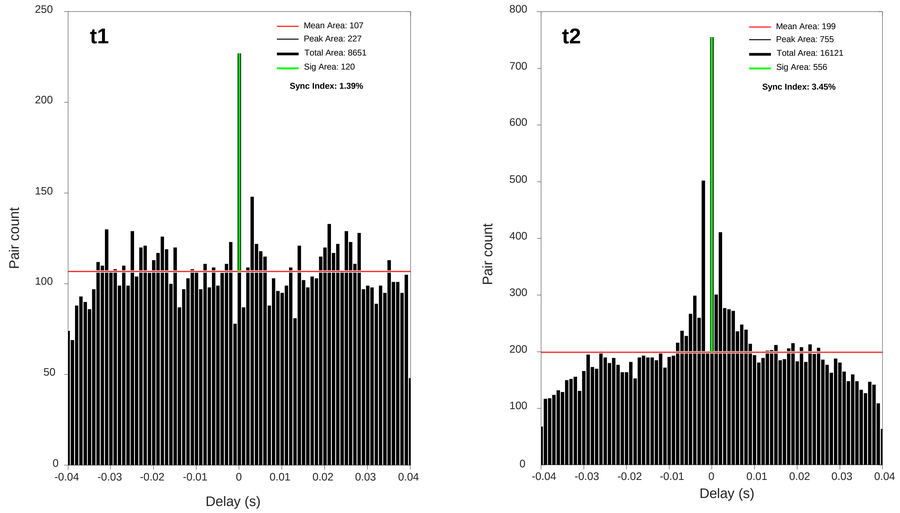
Materials and Methods

9 active healthy subjects (8 men and a woman) participated in the study after giving written informed consent. Participants seated on an isokinetic dynamometer and performed two maximal voluntary isometric knee extensions (MVC_pre), followed by a 5% MVC contraction for 300 s. Immediately after, a third MVC was performed (MVC_post).
Intramuscular and surface EMG signals were recorded concurrently using a couple of fine-wire electrodes and two couples of bipolar surface electrodes from the left vastus medialis obliquus (Figure 1).
The iEMG signal was fully decomposed using EMGLAB (McGill et al., 2005) and the synchronization of MU firings calculated using the *Synch Index* (De Luca et al. 1993) on cross-interval histograms (Figure 2).
The FD of the sEMG signal was calculated using the box-counting method (Gitter and Czerniecki, 1995). The degree of correlation between FD and the *Synch Index* was calculated using the Spearman's correlation coefficient (R_s).

Results

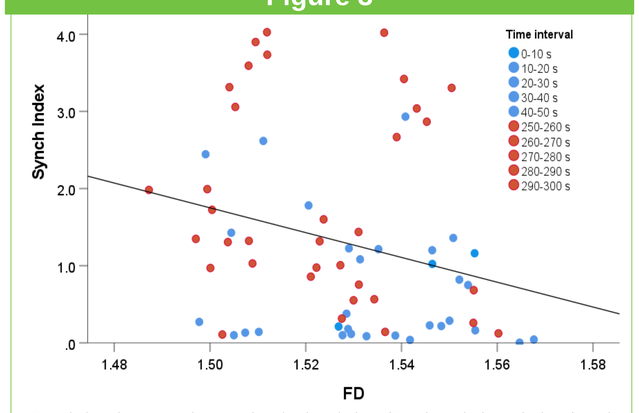
The average MVC_pre was 59.0 ± 15.0 kg, whereas the MVC_post was 40.0 ± 14.1 kg, with a decline in MVC of 32.2%. From the iEMG, across all the participants, 82±14 MU spike trains were identified during the first 50s (t1) of the isometric knee extension at 5% MVC; whereas between 250 and 300s (t2), the number increased to 108±5.
The *Synch Index* increased between t1 and t2 from 0.288 [IQR=1.081] to 1.348 [IQR=2.30] ($p<0.01$), whereas FD decreased from 1.535 [IQR=0.022] to 1.522 [IQR=0.032] ($p<0.001$). A statistically significant moderate correlation was found between the *Synch Index* and FD (R_s= -0.3; $p<0.05$) (Figure 3).

Figure 2



Cross-interval histograms during 5% MVC isometric knee extension of a participant at t1 and t2. Mean Area *is the total area under the mean value level;* Peak Area *is the total area under the histogram in the bins designated as a significant peak.* Total Area *is the total area under the histogram between ± the average interfering interval of the alternate MUAPT;* Sig Area *is the area of the peak exceeding the expected value. Synch Index = [Sig Area / (Total Area/2)] x 100. (De Luca et al., 1993).*

Figure 3



Correlation between the synchronization index (Synch Index) and the fractal dimension (FD). The two indices were calculated during the initial (blue dots) and final (red dots) 50 s of the 300 s 5% MVC isometric knee extension.

Conclusions

The results of our study suggest that during fatiguing isometric contractions, changes in the FD of the sEMG signal may be related to an increase in MU synchronization.

FD appears to be a valid alternative to the use of intramuscular EMG for the study of MU synchronization.

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