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# Time-frequency approaches for analyzing electromyographic bursting signals with high non-stationary components: towards assessing muscle function

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## INTRODUCTION & AIM

The contractile dynamics of peripheral muscles are governed by complex recruitment and relaxation strategies optimized by the central nervous system. These dynamics aim to maximize the efficiency of resulting work and are finely regulated by synergies, intermuscular coordination, and sensory feedback mechanisms. When individuals are affected by injuries, trauma, cognitive impairments, or neurodegenerative diseases, among others, such contractile dynamics are altered and often manifested in the musculature through changes in the frequency content of electromyographic (EMG) signals. During rapid contractions, these changes are challenging to study and detect because the time series comprising EMG exhibit highly non-stationary processes.

Aim. We have proposed an exploratory analysis of the time-frequency characteristics of EMG signals using three different approaches: spectrograms (SP), Hilbert transform (HT), and empirical mode decomposition.

## METHODS

*Experimental design and EMG recordings*

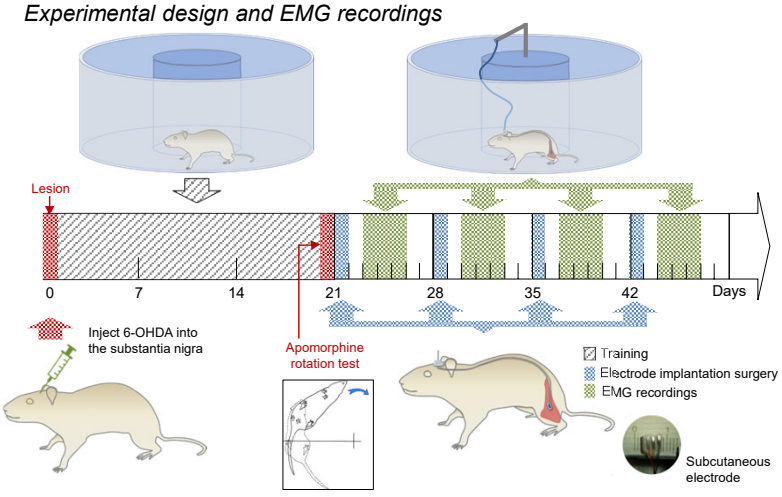


Fig. 1 Diagram of the experimental protocol used for collecting the data.

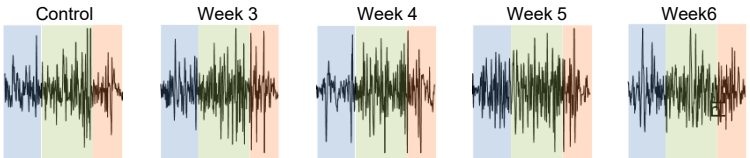


Fig. 2 EMG recordings evoked by BF contraction in control animals and at 3, 4, 5, and 6 weeks post-lesion. The lightly shaded areas represent the initial phase of contraction, the sustained contraction phase, and the final contraction phase (relaxation).

*Spectral analysis of EMG recordings*

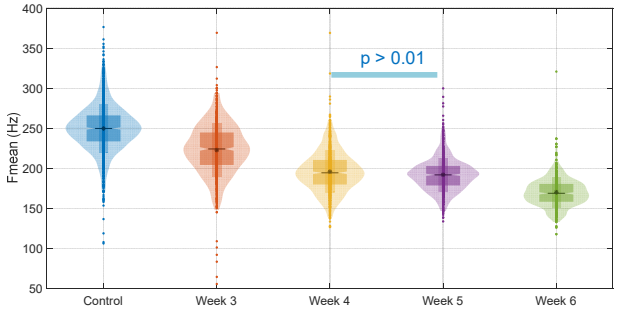


Fig. 3 Mean frequency obtained from the EMG recordings for each animal condition. A clear decreasing trend in mean frequency is observed as a function of post-lesion time in the animals.

## RESULTS

*SPECTROGRAM*

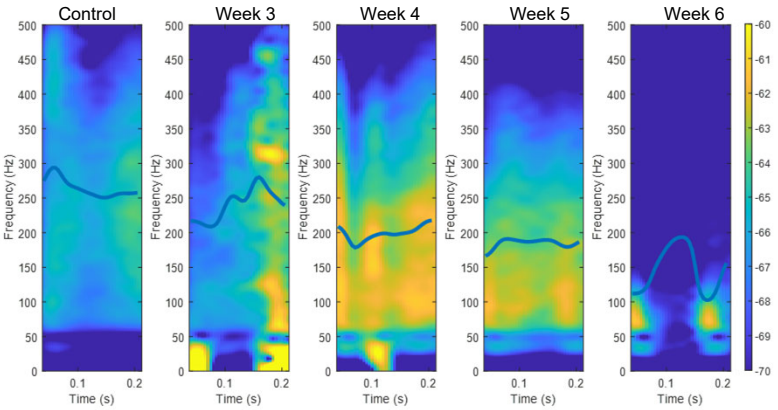


Fig. 4 Spectrograms obtained for each animal condition. The thick blue line represents the mean frequency as a function of time.

*HILBERT TRANSFORM*

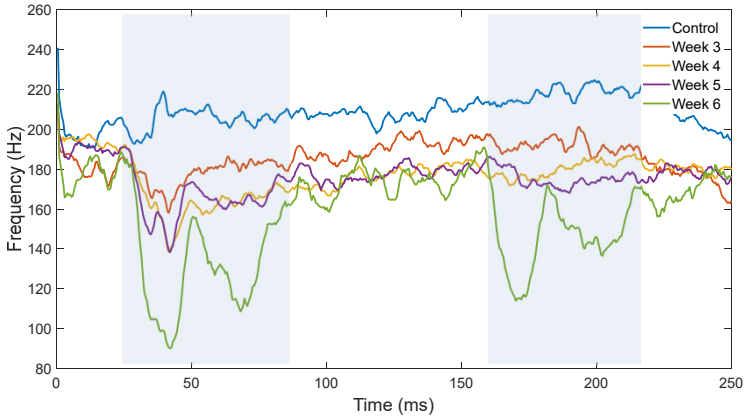


Fig. 5 Instantaneous frequencies obtained from the Hilbert transform applied to each of the EMG recordings for the different animal conditions.

*NA-MEMD and Hilbert Transform*

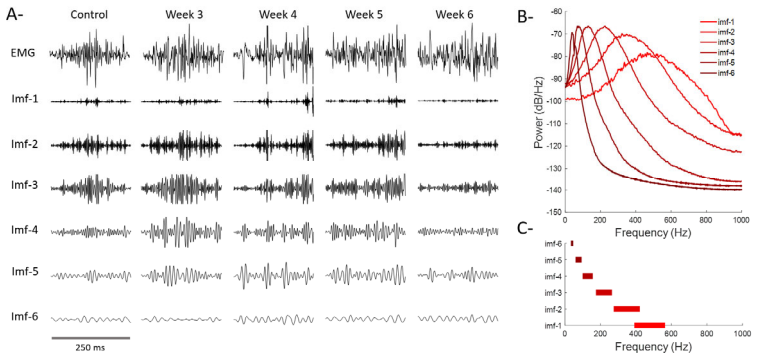


Fig. 6 Empirical decompositions applied to BF EMG signals for different post-lesion conditions. A) Decompositions of a BF EMG signal evoked during a gait step for each of the animal conditions. The first six intrinsic mode functions are displayed. The NA_MEMD algorithm was applied using the following parameters: the total number of projections of the signal (ndir = 64), and the stopping criterion employed in the sifting process was specified accordingly. The amplitude of the added noise was determined based on the standard deviation of all samples from the BF EMG signals, with three noise channels used. B) Average power spectra of each intrinsic mode function (IMF). C) Average bandwidths (BWs) for each IMF. The BWs were defined as the -3 dB drop from the maximum energy.

## CONCLUSION

This study allowed for extracting spectral information contained in non-stationary segments of the EMG, thus characterizing changes in contractile dynamics caused by the progressive functional alterations in the animal model of PD.