Non-Linear Analyses of Surface Electromyography in Parkinson's Disease

Matthew Flood, Madeleine Lowery
Insight Centre for Data Analytics, O'Brien Centre for Science, UCD, Belfield, Dublin 4
matthew.flood@ucdconnect.ie

Abstract

Non-linear measures, such as recurrence quantification analysis, have been applied to electromyographic (EMG) data to capture the underlying activity of the neuromuscular system. The application of such approaches to EMG data from individuals with Parkinson's disease (PD) is presented here. Preliminary results indicate differences in the level of determinism and coherence that distinguish Parkinsonian EMG from that of healthy age-matched controls.

1. Introduction

Parkinson's disease (PD) is a neurodegenerative disease that affects at least 1% of people over 65 years of age. PD inhibits a person from initiating movements through symptoms such as muscle rigidity, bradykinetic gait, and severe tremor.

Recent studies have employed non-linear methods to extract features of the surface electromyogram (EMG) in order to distinguish Parkinsonian signals from healthy controls. Recurrence quantification analyses (RQA) has shown its effectiveness in characterising the degree of repeated synchronous structure in non-linear dynamical systems such as EMG signals from individuals with PD [1]. Additional parameters such as intermuscular coherence, kurtosis, and skewness have also been used to examine how the content of the EMG changes [2].

The work presented here aims to establish the optimal measures that can discern Parkinsonian EMG from that of healthy controls. This will enable early diagnosis of PD to deliver proactive care for patients, and potentially provide biomarkers to assess the efficacy of different therapeutic interventions.

2. Methods

2.1. Data Acquisition

Surface EMG data were recorded in the Dept. of Exercise and Sports Sciences at the University of Copenhagen by Prof. Bente Jensen and Dr. Martin Rose. Data from 5 muscles of the upper leg were recorded in 3 healthy controls (age: mean 66.67 yrs. ± 1.15 SD) and 3 PD patients (age: mean 61.67 yrs. ± 8.14 SD) of maximum voluntary contraction during a loaded isometric knee joint extension at 15%. Each subject performed 4 trials, 25 s in duration each, against a resistive load applied to the ankle.

2.2. Data Analysis

Recurrence plots were estimated from the time-delayed phase space reconstruction of the EMG signals. From the recurrence plots, two recurrence quantification variables, recurrence rate (%REC) and determinism (%DET) were calculated to identify hidden non-linear rhythms in the EMG [1]. Intermuscular coherence between agonist (rectus femoris) and antagonist (semitendonosis) muscles were estimated, as well as measures of skewness and kurtosis. The latter two measures signify the degree of symmetry and peakedness about the mean of the distribution respectively.

3. Results

Preliminary results showed an increase in the gamma frequency range of the intermuscular coherence calculated between agonist and antagonist in the EMG signals PD and control subjects (Fig. 1). Further to this, there was increase in %DET of EMG signals from PD subjects over that of controls (Fig. 2). Skewness and kurtosis measures provided similar results between the two groups.

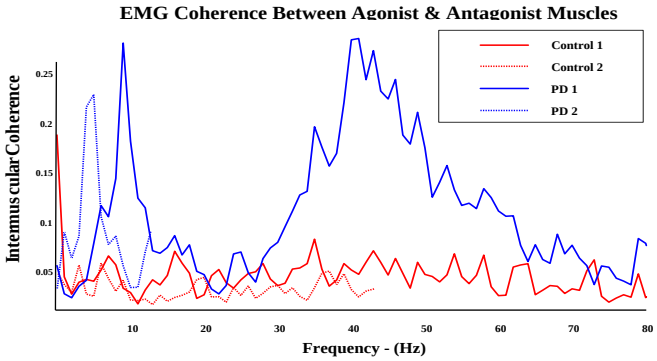

Figure 1: Intermuscular EMG coherence of PD (blue) and controls (red). Note the elevated peak in gamma range.

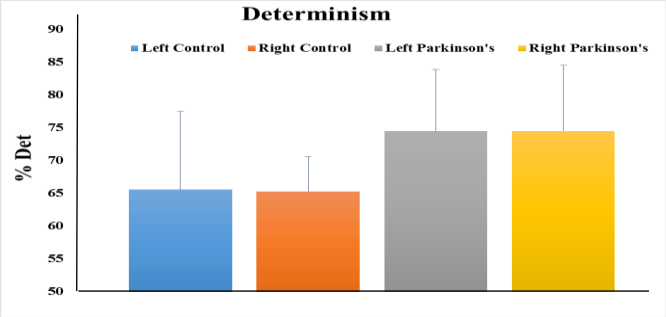

Figure 2: %DET between the left and right legs of PD patients (left) and controls (right).

4. Discussion

There were distinct differences in non-linear and coherence measures between the EMG of PD and control subjects. This result suggests an increase in synchrony of firing patterns of motoneurons during isometric contractions within the same muscle and between agonist and antagonist pairs, which is more pronounced in PD.

5. References

[1] C. J. Webber, *J Appl Physiol*, 78.3 (1995): 814-822.
[2] S. Rissanen, *Physiol Meas*, 28(12):1507-21, (Dec 2007)