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ANALYSIS OF PARKINSONIAN SURFACE ELECTROMYOGRAPHY THROUGH ADVANCED SIGNAL PROCESSING AND NONLINEAR METHODS

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INTRODUCTION

Parkinson's disease (PD) is a neurodegenerative disease that affects approx. 4% of people over 80 years of age [4]. The result of depleted dopaminergic neurons in the substantia nigra, PD is characterised with symptoms such as muscle rigidity, bradykinetic gait, and severe tremor. To distinguish Parkinsonian electromyographic (EMG) signals from those of healthy controls, recent studies have employed non-linear methods which can capture the underlying activity of the neuromuscular system. Recurrence quantification analysis (RQA) has been shown to effectively characterise the degree of repeated synchronous structure in non-linear dynamical systems including parkinsonian EMG, through parameters such as determinism (%DET) and recurrence rate (%REC) [1]. Additional parameters such as intermuscular coherence and kurtosis have also been used to observe changes in EMG signals under various conditions [2,3]. To date, limited research has examined the potential to discern EMG of individuals with PD from healthy controls using RQA and intermuscular coherence. The work presented here aims to examine differences in Parkinsonian EMG from that of healthy controls using these measures.

METHODS

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 13 PD patients (age: mean 61.67 yrs. \pm 8.14 SD) and 13 healthy controls (age: mean 66.67 yrs. \pm 1.15 SD) during a loaded isometric knee joint extension at 15% of maximum voluntary contraction. Each subject performed 4 trials, 25 s in duration each, against a resistive load applied to the ankle.

Data Analysis

Through time-delayed phase space reconstruction of the EMG signals, recurrence plots were estimated to depict the behaviour of the EMG signals. Two recurrence quantification variables, recurrence rate (%REC) and determinism (%DET) were calculated from the recurrence plots to quantify the level of hidden non-linear structure in the EMG [1]. Intermuscular coherence was estimated and integrated above the significance threshold to characterise the correlation in

the frequency domain between neural activity in the agonist (rectus femoris) and antagonist (semitendinosus) muscles [3]. Statistical measures, skewness and kurtosis, were also evaluated to determine the degree of symmetry and peakedness about the mean of the distribution, respectively.

RESULTS

Preliminary results showed a significant increase in intermuscular coherence between agonist and antagonist muscles in the θ (4-8 Hz), α (8-12 Hz), β (15-30 Hz) and γ (30-60 Hz) frequency ranges for parkinsonian EMG (Fig. 1). Further to this, there was a significant increase in kurtosis ($p = 0.0457$) and %DET of EMG signals on the right leg of PD subjects when compared with the controls ($p = 0.0457$).

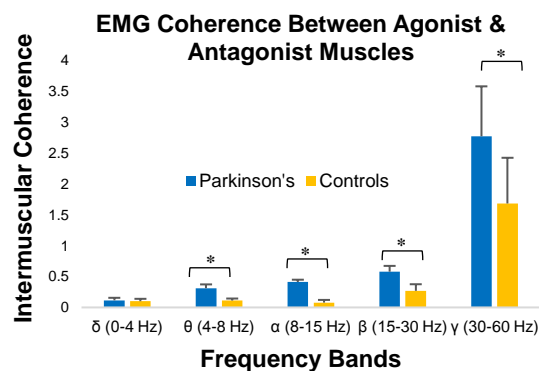


Figure 1 Coherence between EMG signals recorded from semitendinosus and rectus femoris muscles. The integral of the significant coherence in each band is shown (* $p < 0.05$).

DISCUSSION

Significant differences were observed in EMG determinism and intermuscular coherence between PD and control subjects. These results suggest increased synchrony of firing patterns of motoneurons during isometric contractions within the same muscle, and between agonist and antagonist pairs in PD. In future these results that could be used to enable early diagnosis of PD or potentially provide biomarkers to assess the efficacy of therapeutic interventions.

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