Sleep-Wake Estimation From Actigraphy Data in Parkinson's Disease: A Deep Learning Approach

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1) Introduction. Sleep is disrupted by neurological diseases and in the case of Parkinson's disease (PD), sleep disturbances are considered an early sign of PD and be present years before the onset of motor symptoms.

Common sleep problems observed in PD are insomnia, excessive daytime sleepiness, restless legs syndrome and REM sleep behavioural disorder.

We present a sleep investigation in healthy and PD participants whose actigraphy data were continuously collected for a period of 14 days and nights.

2) Data

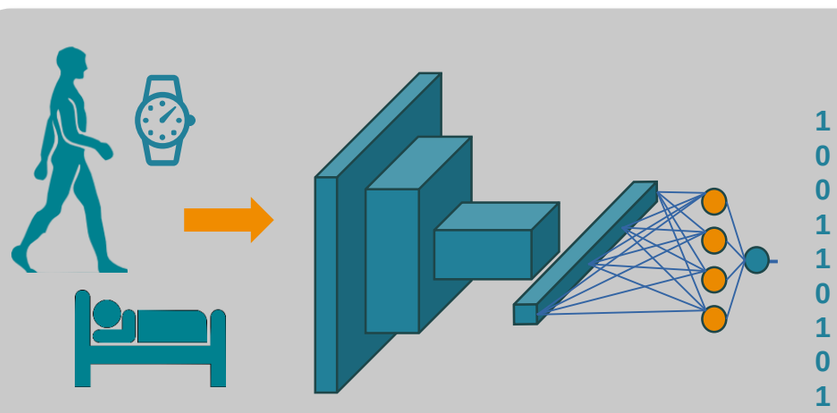
- 21 healthy control participants & six PD patients were recruited

Clinical and sleep assessments collected:
- REM Behaviour Sleep Disorder
- Restless legs syndrome questionnaire
- Pittsburgh Sleep Quality Index.
- Epworth Sleepiness Scale (daytime sleepiness)

- Polysomnography (PSG) & Actigraphy
- 1 night
- 100 Hz sampling frequency

- Sleep diaries & actigraphy recorded for 14 days and nights

3) Data Analysis & Model



Accelerometry time series were processed to reduce zero and high frequency components for both 1-night PSG and 14-day data collections.

In order prepare the training set, the 1-night PSG data were relabelled as a binary variable for sleep and awake periods, then accelerometry time series were divided in non-overlapping 30-second segments and associated with a PSG label. The segments were fed to a convolutional neural network (CNN) for training using Tensorflow-Keras framework to create a model for sleep.

The trained CNN model, deep learning sleep (DLS), was then applied to the 14-day accelerometry data for analysis of sleep in a free living scenario. Results for sleep time, sensitivity and specificity for sleep detection were compared with the participants' sleep diaries and against the Cole-Kripke (CK) algorithm.

4) Results. Our results showed that DLS was accurate measuring sleep time in both patient and control participants and also showed more accurate sleep time measurements than Cole-Kripke (Figure 1). When analysing prediction of sleep against the sleep diaries, the DLS obtained balanced sleep sensitivity and specificity results compared with the Cole-Kripke algorithm, which highly over-estimated sleep in patients as well as in healthy controls (Figure 2).

When analysing the sleep diaries it was observed that PD patients reported lower number of awakenings when compared with control participants, however both algorithms reported higher number of awakenings in PD patients than in controls.

Figure 1

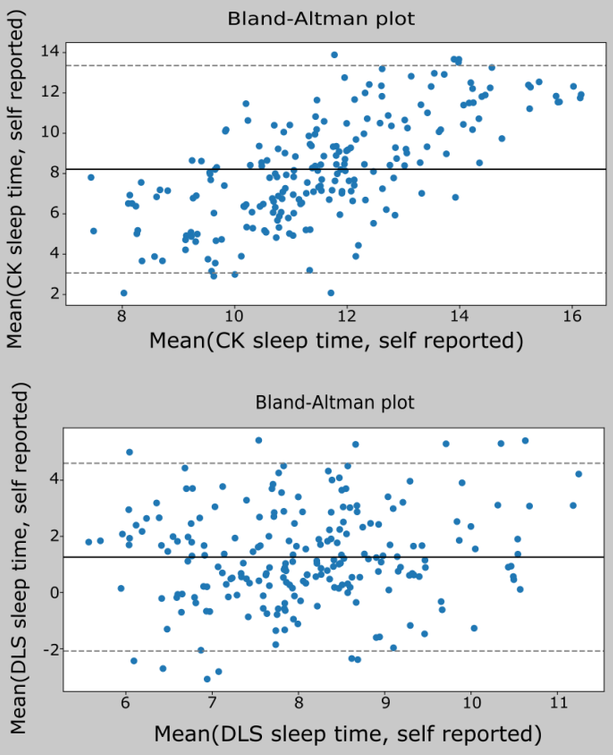
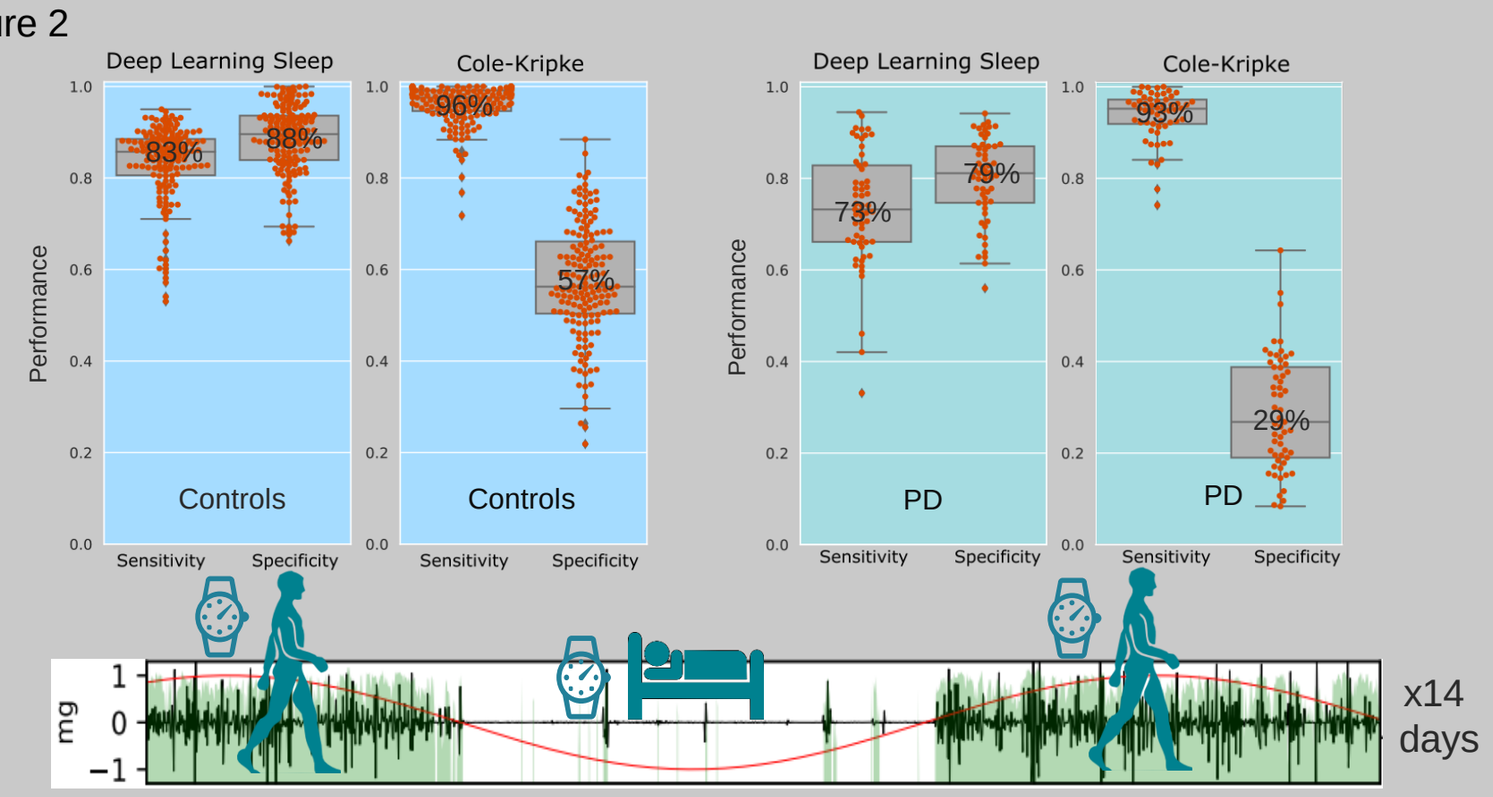


Figure 2



5) Conclusions. DLS is well suited for sleep-wake classification of actigraphy data from PD patients. Our results showed the potential of wearable technology for providing reliable sleep biomarkers in clinical trials for the ageing population and in Parkinson's disease.