This is the accepted version of a paper presented at 20th International Congress of Parkinson’s Disease and Movement Disorders, June 19-23 2016, Berlin.

Citation for the original published paper:

Construction of a levodopa-response index from wearable sensors for quantifying Parkinson’s disease motor functions: Preliminary results.
In:

N.B. When citing this work, cite the original published paper.

Permanent link to this version:
http://urn.kb.se/resolve?urn=urn:nbn:se:du-22628
Construction of levodopa-response index from wearable sensors for quantifying Parkinson's disease motor functions

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Objective

The goal of this study was to investigate the feasibility of wrist worn motion sensors to objectively measure motor functions in Parkinson’s disease (PD). More specifically, the aim was to construct a sensor-based levodopa-response index (SBLRI) and evaluate its clinimetric properties (convergent validity and internal consistency).

Results

The SBLRI was strongly correlated to mean TRS with a Pearson correlation coefficient of 0.79 (CI: 0.74-0.83, p<0.001). The 95% confidence interval for the mean squared error of SBLRI on patients’ data was ± 1.62 with a mean value of 0.57 whereas on healthy controls data was ± 1 with a mean value of 0.27. The sensor-based spatiotemporal parameters had good internal consistency with a Cronbach’s Alpha coefficient of 0.87 and significantly differed between patients and healthy controls. Figure 2 shows four graphs of SBLRI and mean TRS for four patients.

Methods

Data collection

Nineteen advanced PD patients and 22 healthy controls were recruited in a single center, open label, single dose clinical trial in Sweden. The subjects performed standardized motor tasks while wearing one sensor on each wrist and one on each ankle. Each sensor unit consisted of three-dimensional accelerometer and gyroscope. The patients were video recorded and the videos were blindly rated by three independent movement disorder specialists. The clinical scores were given using the Treatment Response Scale (TRS) on a scale from -3 = ‘Very Off’ to 0 = ‘On’ to +3 = ‘Very dyskinetic’. The clinical assessments were based on the overall motor function of the patients. A mean TRS was defined as the mean of the three specialists’ assessments per time point. The measurements were repeated over several time points following a single levodopa/carbidopa morning dose (50% over normal to induce dyskinesias).

Data processing and analysis

Sensor measurements during rapid alternating movements of hands (Figure 1) were processed with time series analysis methods to calculate spatiotemporal parameters designed to measure bradykinesia and dyskinesia. For each hand, 96 spatiotemporal parameters were calculated and their average scores were then used in a principal component analysis to reduce the dimensionality by retaining 6 principal components. These components were then used as predictors to support vector machines and to be mapped to the mean TRS ratings of the three specialists and to calculate the SBLRI. For this analysis, a 10-fold stratified cross-validation was performed.

Conclusions

The results demonstrated that the SBLRI had good clinimetric properties for measuring motor functions (Off and dyskinesia) in PD patients. The method could also distinguish hand rotation movements exhibited by patients from those exhibited by healthy controls. The SBLRI provides effect-time profiles, which could be useful during therapy individualization of advanced PD patients.

Figure 1. Subject wearing a wrist motion sensor while performing rapid alternating movements of hands. The subjects performed the tests first with the right hand and then with the left hand and each test lasted for 20 seconds.

Figure 2. Four representative cases of patients with superimposed mean TRS and SBLRI scores over time. TRS – Treatment Response Scale, SBLRI – sensor-based levodopa response index.