Computerized identification of motor complications in Parkinson’s disease

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Objectives: To investigate whether spirography-based objective measures are able to effectively characterize the severity of unwanted symptom states (Off and dyskinesia) and discriminate them from motor state of healthy elderly subjects.

Background: Sixty-five patients with advanced Parkinson’s disease (PD) and 10 healthy elderly (HE) subjects performed repeated assessments of spirography, using a touch screen telemetry device in their home environments. On inclusion, the patients were either treated with levodopa-carbidopa intestinal gel or were candidates for switching to this treatment. On each test occasion, the subjects were asked to trace a pre-drawn Archimedes spiral shown on the screen, using an ergonomic pen stylus. The test was repeated three times and was performed using dominant hand. A clinician (DN) used a web interface which animated the spiral drawings, allowing him to observe different kinematic features, like accelerations and spatial changes, during the drawing process and to rate different motor impairments [2]. Initially, the motor impairments of drawing speed, irregularity, and hesitation were rated on a 0 (normal) to 4 (extremely severe) scales followed by marking the momentary motor state of the patient into 2 categories that is Off and Dyskinesia. A sample of spirals drawn by HE subjects was randomly selected and used in subsequent analysis.

Methods: The raw spiral data, consisting of stylus position and timestamp, were processed using time series analysis techniques like discrete wavelet transform, approximate entropy and dynamometric features, like accelerations and spatial changes, during the estimation of the quantitative measures into 4 principal components. A stratified 10-fold cross-validation (also known as rotation estimation) was applied to assess the generalization ability of the logistic regression classifier to future independent data sets. To investigate mean differences of the 4 PCs across the three categories, a one-way ANOVA test followed by Tukey multiple comparisons was used.

Results: The agreements between computed and clinician ratings were very good with a weighted area under the receiver operating characteristic curve (AUC) coefficient of 0.91 (Table 2). The mean PC scores were different across the three motor state categories, only at different levels (Figure 1). The first 2 PCs were good at discriminating between the motor states whereas the PC3 was good at discriminating between HE subjects and PD patients. The mean scores of PC4 showed a trend across the three states but without significant differences. The Spearman’s rank correlations between the first 2 PCs and clinically assessed motor impairments were as follows: drawing speed (PC1: 0.34; PC2: 0.83), irregularity (PC1: 0.17; PC2: 0.17), and hesitation (PC1: 0.27; PC2: 0.77).

Conclusions: These findings suggest that spirography-based objective measures are valid measures of spatial- and time-dependent deficits and can be used to distinguish drug-related motor dysfunctions between off and dyskinesia in PD. These measures can be potentially useful during clinical evaluation of individualized drug-related complications such as over- and under-medications that maximizing the amount of time the patients spend in the On state.