Kinematic Akinesia Feature Extraction Using Kinesia™

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Introduction

Unlike parkinsonian tremor, which previous investigators have shown is well correlated with peaks in the power spectral density of hand velocity, akinesia can be much more difficult to quantify. According to the subset of the Unified Parkinson's Disease Rating Scale (UPDRS) that can elicit akinesia in the upper extremity (motor tasks 23-25), ratings should reflect speed, amplitude, hesitations, fatiguing, arrests in movement, and how these variables change over time. Objective quantification of akinesia features should aid in evaluating the efficacy of treatment protocols and improve overall patient management.

Methods

Kinesia™ is an FDA approved, compact wireless system that uses three orthogonal accelerometers and three orthogonal gyroscopes to monitor three-dimensional motion. Tremor and upper extremity bradykinesia subsets of the UPDRS motor exam were conducted on sixty patients with Kinesia on the hand. UPDRS scores for tremor and bradykinesia were assigned by two movement disorder specialists. For each task, the following kinematic features were calculated: root-mean-square (RMS) linear acceleration, velocity, and position; RMS angular velocity and excursion angle; peak power; and standard deviations of a one-second sliding window of peak frequency, amplitude, and RMS kinematics. Each kinematic feature was then regressed to the average clinician score.

Figure 1. Kinesia™ consists of a finger worn sensor unit that contains accelerometers and gyroscopes, and a wrist worn command module that wirelessly transmits data to a computer.

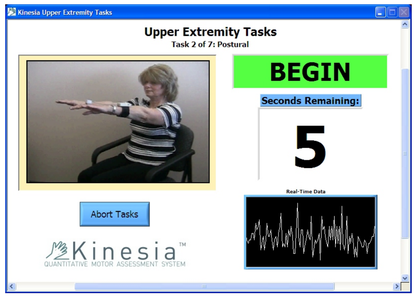

Figure 2. The Kinesia software uses clinical videos to automatically guide patients through motor tasks while motion data are being recorded.

Movement Tasks

Finger taps

Hand grasps

Rapid alternating movements

Results

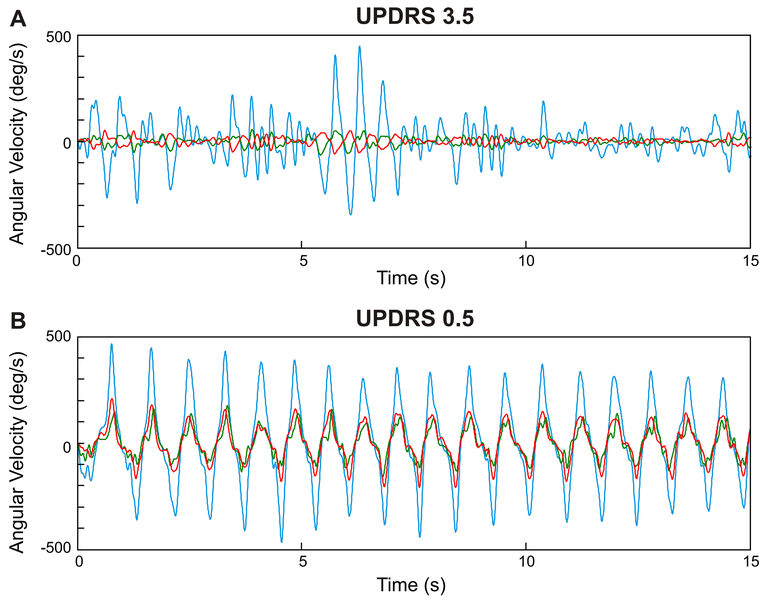

Figure 3. Three channels of angular velocity during the hand grasp task are shown for a patient with severe akinesia (top, UPDRS 3.5) and mild akinesia (bottom, UPDRS 0.5). In the bottom plot, the signals have a consistent amplitude and frequency and appear sinusoidal. Conversely, as shown in the top plot, the patient with severe akinesia has inconsistent amplitude and frequency and often hesitates.

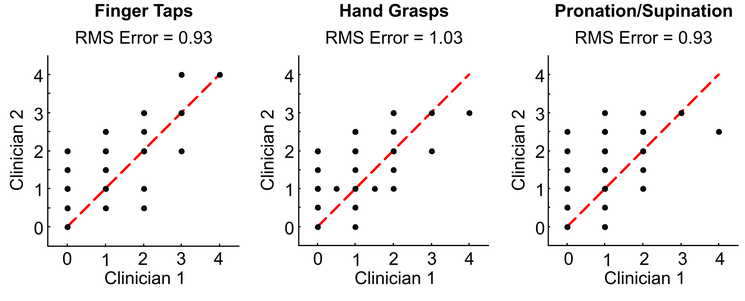

Figure 4. Two movement disorder specialists scored the three movement tasks per the UPDRS. The scores given by the two clinicians are plotted on the horizontal and vertical axes, respectively. The dotted red line corresponds to complete agreement. The root-mean-square (RMS) error between clinician scores is approximately 1 in the tasks designed to measure akinesia.

Quantitative Variables

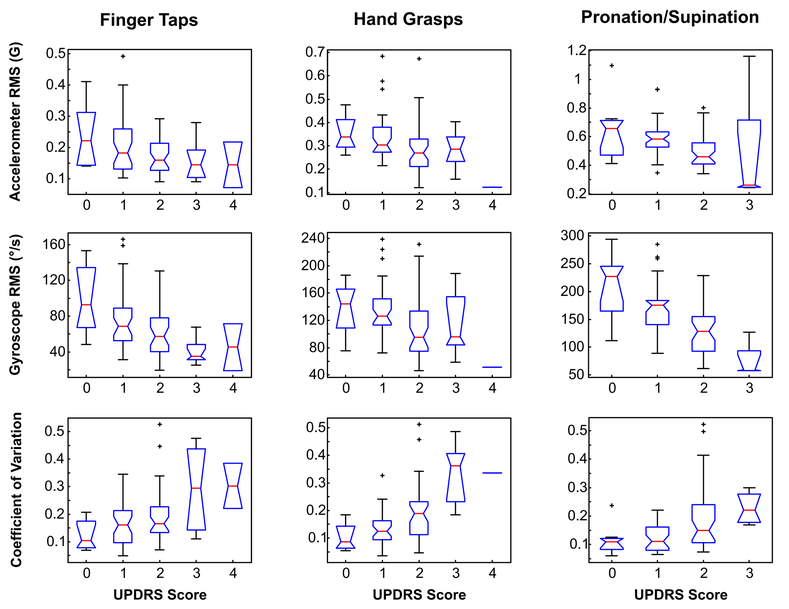

Figure 5. Quantitative variables were correlated with UPDRS scores for each of the three tasks. In general, the RMS values of the accelerometers (top row) and gyroscopes (middle row) decreased with increasing UPDRS scores. The coefficient of variation (bottom row), defined as the standard deviation of a one-second sliding windows of the RMS values of the peak gyroscope divided by the mean, increased with increasing UPDRS scores.

Conclusions

Kinesia™ is a compact, portable monitor that objectively quantifies kinematics of movement disorder motor symptoms. Specific quantitative kinematic features relating to amplitude and frequency can be extracted that correlate to clinician UPDRS scores for each akinesia task. Kinesia provides a useful tool for objective assessment of motor symptom response to existing and novel therapeutic interventions.

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