Motion Sensor Dyskinesia Assessment During Activities of Daily Living

GREAT LAKES NEUROTECHNOLOGIES

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Introduction

Dyskinesia throughout the levodopa dose cycle has been measured in patients with Parkinson's disease (PD) using a hand-worn motion sensor during the stationary tasks of arms resting and arms extended posture. Quantifying dyskinesia during unconstrained activities poses a unique challenge since these medication side effects are difficult to distinguish from voluntary movement. The goal of this study was to determine the feasibility of using motion sensors to quantify dyskinesia in PD patients during activities of daily living (ADLs).

Methods

- 15 PD subjects with varying dyskinesia severity were recruited
- Subjects were instrumented with motion sensor units containing tri-axial accelerometers and gyroscopes on each wrist and heel

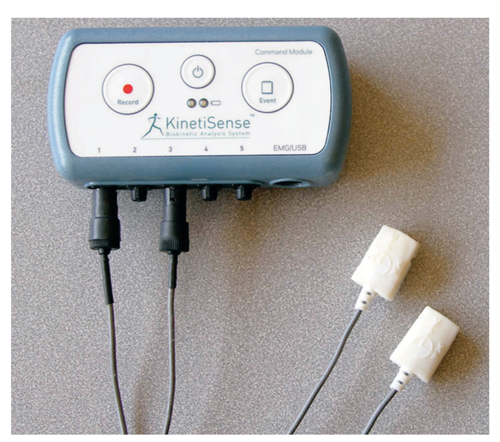


Figure 1. Motion sensors and wireless transmission module

Table 1. Subject Demographics

Age	58.7 ± 10.7 years
Gender	9 male, 6 female
Disease Duration	9.9 ± 4.5 years

- Five ADLs were completed at baseline (i.e., off medication), and one, two, and three hours after a dose of levodopa
- Videos of subjects performing tasks were scored by two clinical experts using a modified 0-4 Abnormal Involuntary Movement Scale (mAIMS)
- Scoring models were developed using clinician ratings and kinematic features extracted from sensor data

Cutting Food | **Drinking from Cup** | **Dressing** | **Grooming** | **Bagging Groceries**

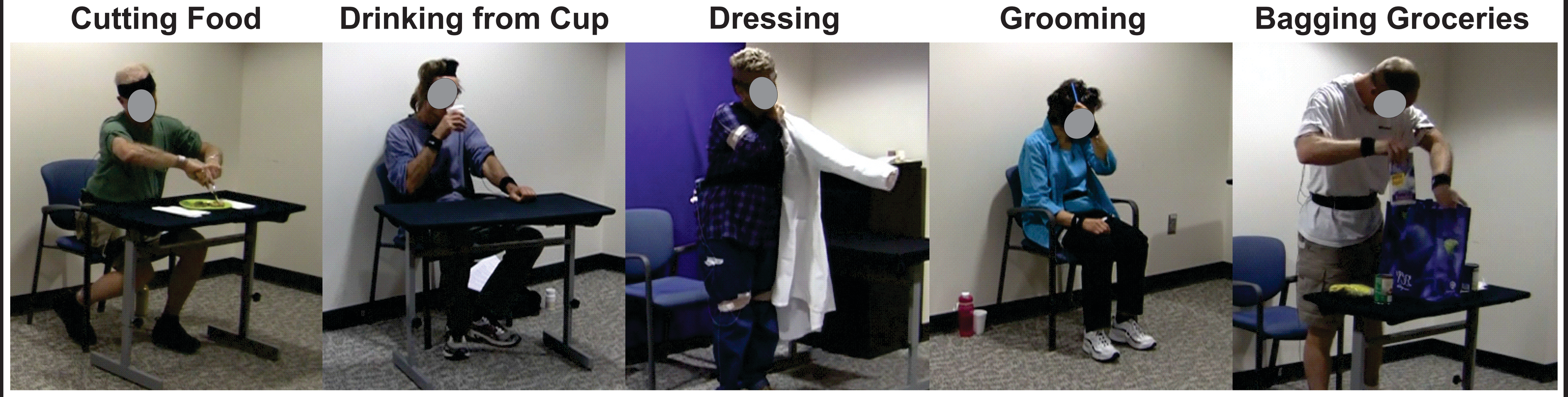


Figure 2. Activities of daily living were completed at several timepoints throughout the levodopa dose cycle

Dyskinesia Severity Scoring

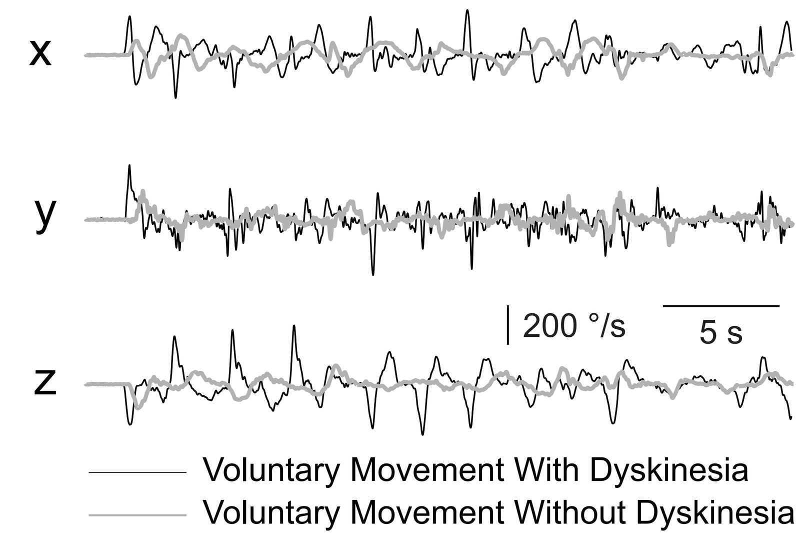


Figure 3. Signals recorded by the three-axis gyroscope in the motion sensor on the wrist of a single subject during the groceries task with dyskinesias present (black lines, hour 1; mAIMS score 3.5) and absent (grey lines, hour 3 ; average mAIMS score 0)

Percent of time the segment velocity was above 0.05
Average value of the segment velocity when it exceeded 0.05
Ratio between the mean segment velocity for frequencies below and above 3 Hz
Average of the RMS angular velocity
Standard deviation of the RMS angular velocity
Percent of time the RMS angular velocity was above 10
Average of the RMS angular velocity for frequencies below 3 Hz
Ratio of the peak power below and above 3 Hz for RMS angular velocity
Percent of time the RMS angular velocity exceeded the average value for a trial
Area in the power spectrum below 3 Hz for angular velocity
Ratio between the RMS angular velocity for frequencies above and below 3 Hz

Table 2. Kinematic Feature Descriptions

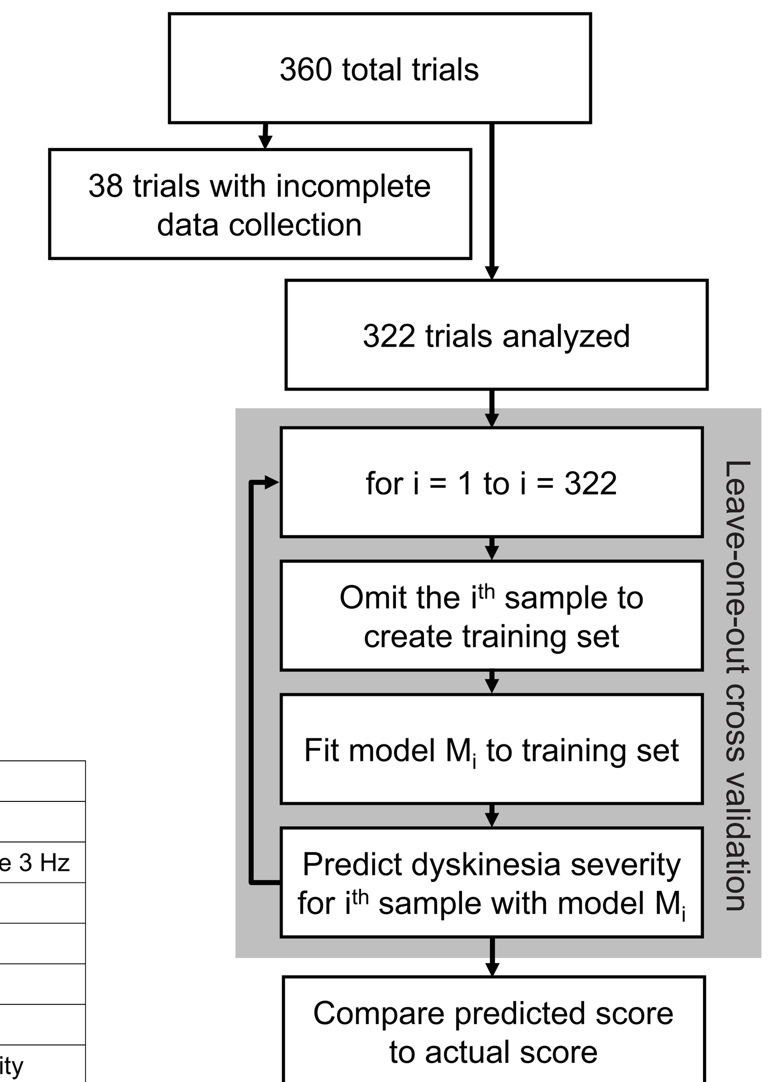


Figure 4. Data analysis flow diagram

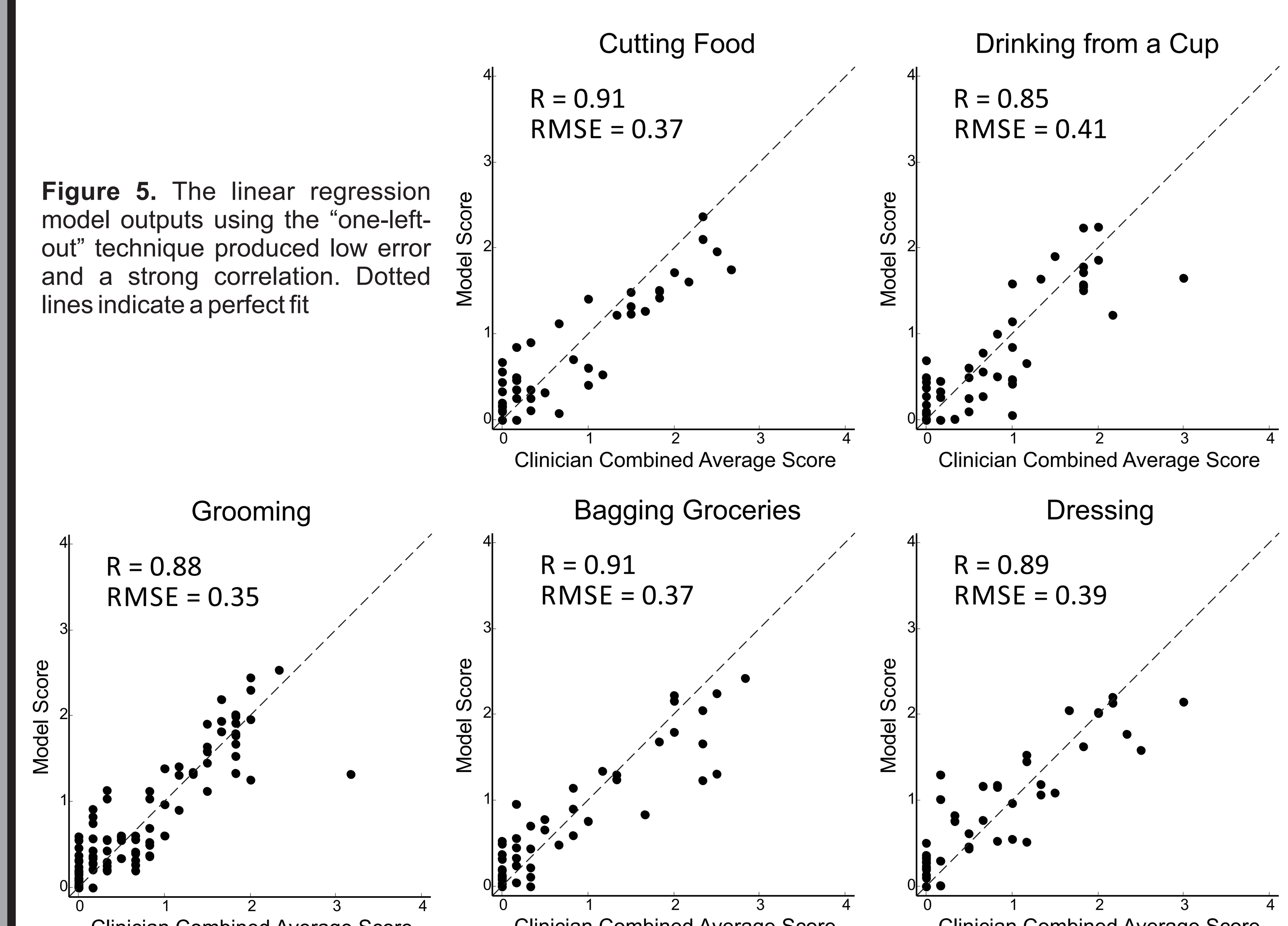


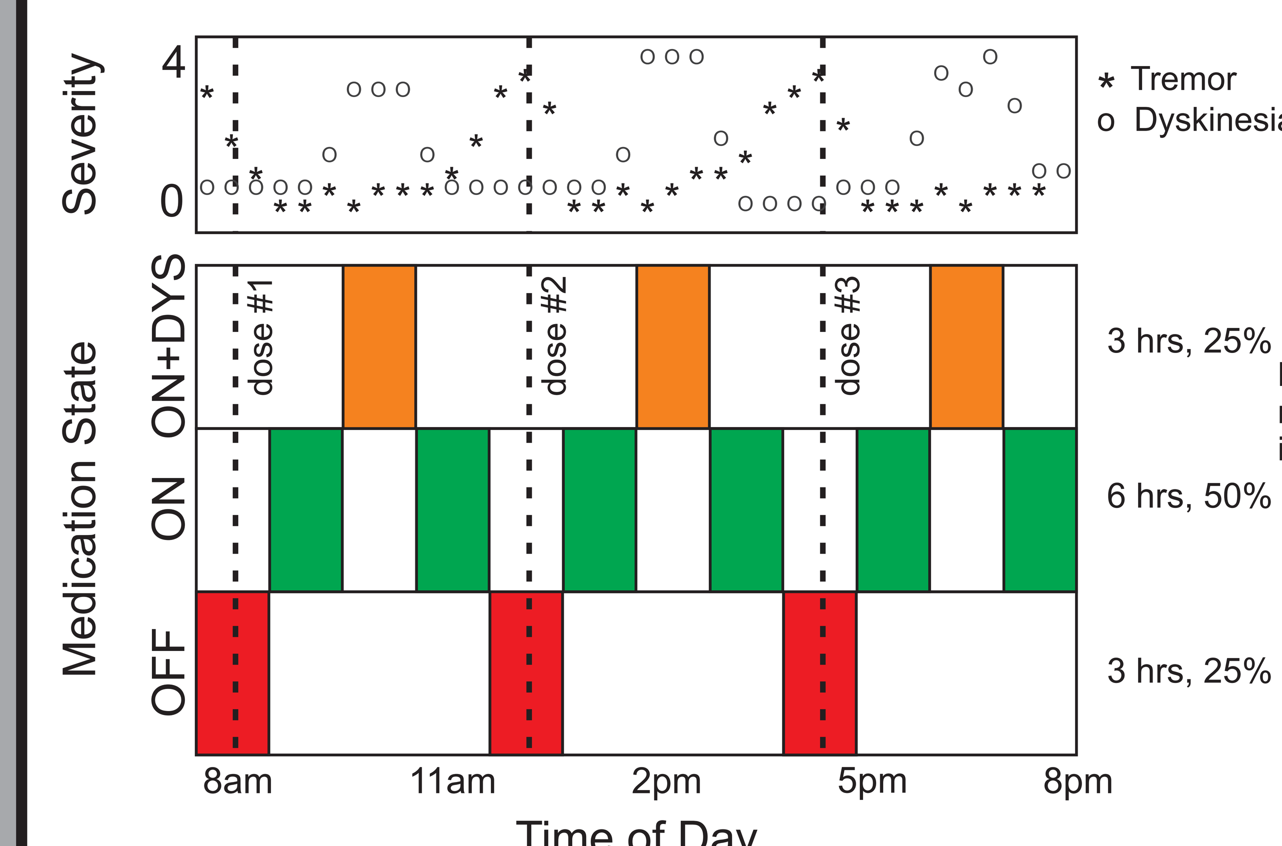
Figure 5. The linear regression model outputs using the "one-left-out" technique produced low error and a strong correlation. Dotted lines indicate a perfect fit

Conclusions

- Dyskinesia scores predicted by a linear regression model using kinematic features achieved high correlation (R = 0.86) and low error (RMSE = 0.39)
- A system with two motion sensors units may provide an accurate measure of overall dyskinesia that can be used to monitor patients as they complete complex movements associated with typical activities
- Such a system could provide valuable insight on symptom fluctuation in the context of daily life

Ongoing Work

- A more continuous data collection protocol will be used to fully capture the medication dose response and further validate scoring algorithms
- Sensor ergonomics and attachment methods will be improved to simplify donning and minimize patient burden
- Automated analysis and web-based reporting interface for clinical care and research studies



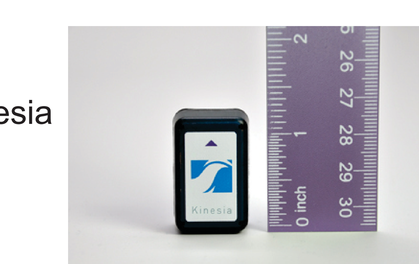


Figure 6 (above). Wireless motion sensor unit with inductive charging

Figure 7 (left). Motor symptom report concept displays tremor and dyskinesia scores, as well as medication state

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