Quantitative Motor Assessment of Gait and Lower Extremity Bradykinesia Following the Discontinuation of Deep Brain Stimulation

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Introduction

Parkinson's disease (PD) results in a wide variety of impairments, many of which adversely affect gait. Decreased mobility negatively affects quality of life, and individuals with PD are at increased risk of falling. The current standard for evaluating motor impairment associated with PD is the Unified Parkinson's Disease Rating Scale (UPDRS), a qualitative assessment completed in the clinic. This study evaluated the ability of the Kinesia™ sensors to quantify motor symptom severities, both with deep brain stimulation on and off, during gait related activities and the potential for meaningful continuous home monitoring.

Methods

42 individuals with PD completed the protocol. 19 of these individuals completed the protocol both with deep brain stimulation (DBS) on, at the individual's typically used clinician determined settings, and off.

Five Kinesia™ motion sensor units, each containing a tri-axial accelerometer and tri-axial gyroscope, were placed on the back of each foot, each thigh, and the sternum.

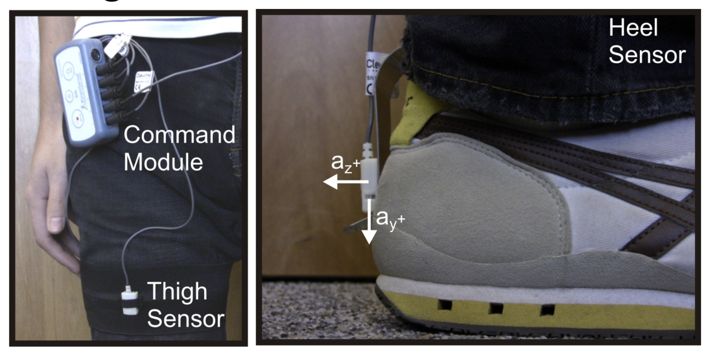

Figure 1. Kinesia™ sensors for measuring gait related impairment

The individuals performed the UPDRS gait related tasks. Video of the tasks was recorded and evaluated based on the UPDRS guidelines by three clinicians.

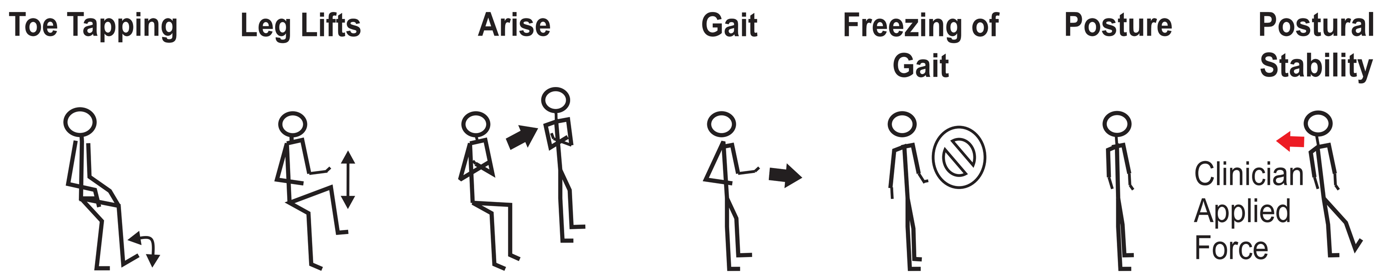

Figure 2. Evaluated UPDRS tasks.

Correlation between Kinesia™ sensor measured kinematics and clinician UPDRS scores were evaluated. Additionally changes in patient motor function from DBS were evaluated by comparing sensor-derived kinematics and average clinician scores using paired t-tests.

Continuous Evaluation

The potential for the sensors to provide a continuous assessment of an individual's activities was evaluated. Activities were classified based on data from the thigh sensor, which provided information about orientation and velocity.

Activities of Daily Living Classifications

- Standing and Moving
- Standing
- Sitting and Moving
- Sitting

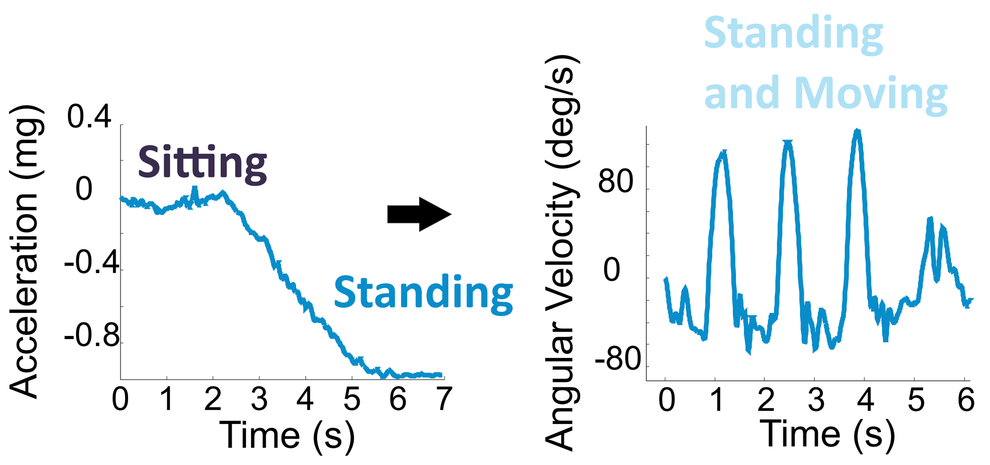

Figure 3. Example kinematic patterns used for classification.

Deep Brain Stimulation

Discrete Evaluation

Toe tapping, leg lifts, and gait showed a significant change in kinematic measures and UPDRS scores between DBS on and DBS off ($p<0.05$).

Foot Sensor Data During Gait

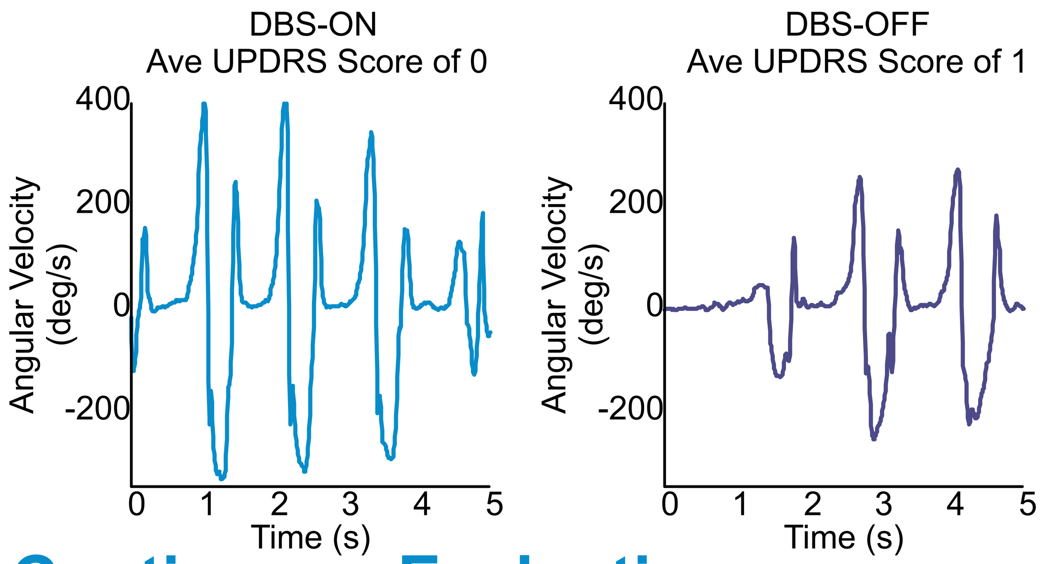

Figure 4. Subject demonstrated reduced velocity amplitude with DBS off during gait.

Continuous Evaluation

Gait

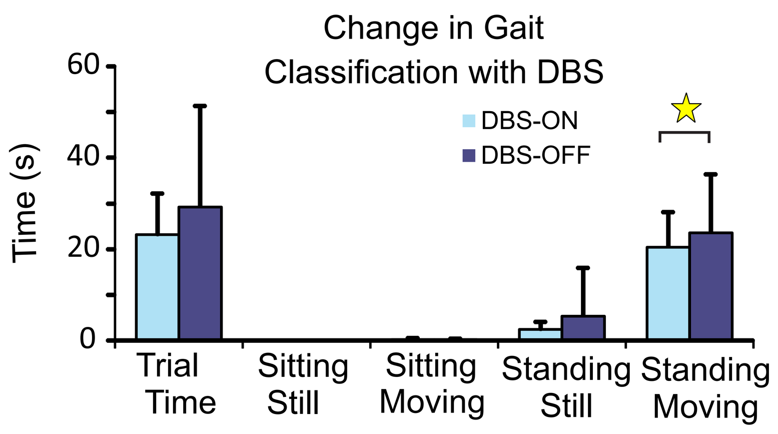

Figure 5. The gait task showed a significant increase in time standing and moving, which includes walking, with DBS off ($p=0.045$). Change in gait UPDRS score was also significant ($p<0.05$).

Arise

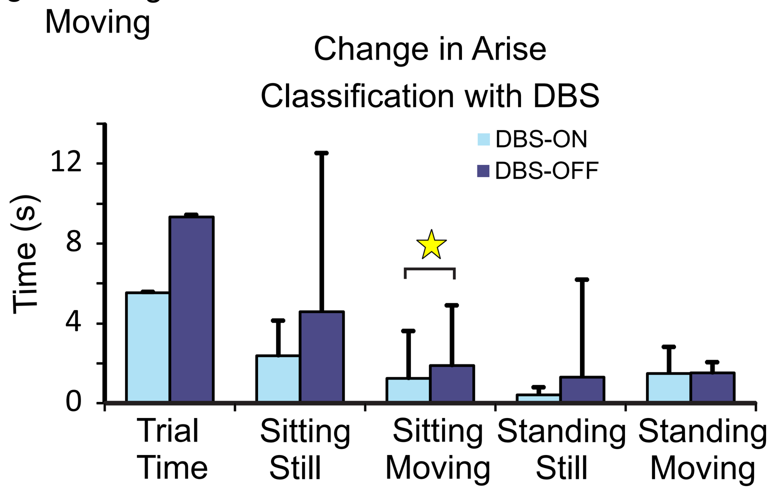

Figure 6. The arise task showed significant increase ($p<0.05$) in time spent seated and moving with DBS off. Change in UPDRS arise score was not significant ($p=0.058$).

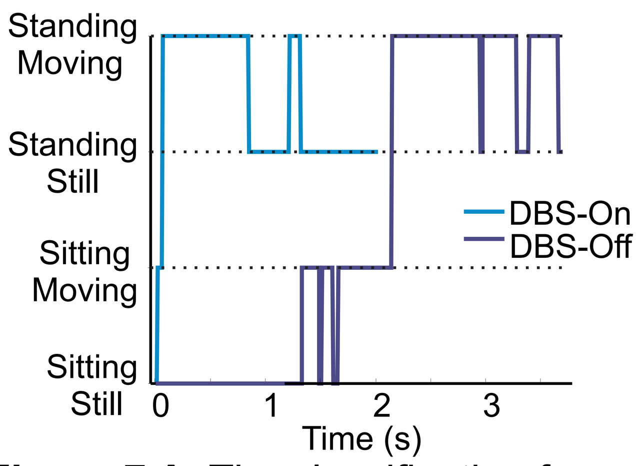

Figure 7 A. The classification for one subject during arise with DBS on and off.

Figure 7 B. An example of the rocking position seen during sitting and moving.

Change in Impairment

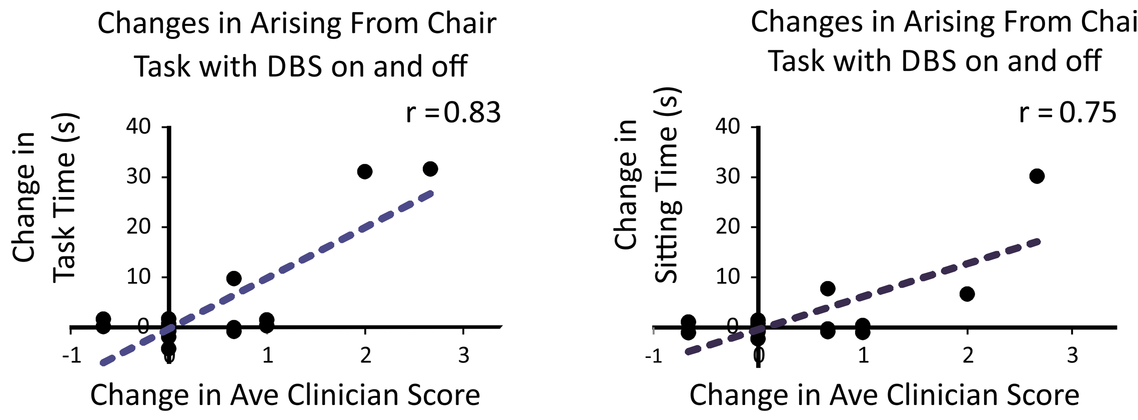

Figure 8. The correlations between the classification and clinical measure changes from DBS. Change is DBS off minus DBS on, and positive change is increased impairment.

Related Publications

1. Mera, T. O., Filipkowski, D. E., Riley, D. E., Whitney, C. M., Walter, B. L., Gunzler, S. a, & Giuffrida, J. P. Quantitative analysis of gait and balance response to deep brain stimulation in Parkinson's disease. Gait & posture,2113, 38(1), 109–14.
2. Heldman, D., Filipkowski, D. E., Riley, D. E., Whitney, C. M., Walter, B. L., Gunzler, S. a, Giuffrida, J.P. & Mera, T . Automated motion sensor quantification of gait and lower extremity bradykinesia. Conf Proc IEEE Eng Med Biol Soc. 2012;2012:1956-9.

Discrete Evaluation

Discrete evaluation provides a well defined instantaneous measure of impairment in predefined tasks.

Correlation to UPDRS Scores

Kinematic measures had correlations greater than 0.7 with the UPDRS scores for all of the tasks except posture.

Thigh Movement During Leg Lift Task

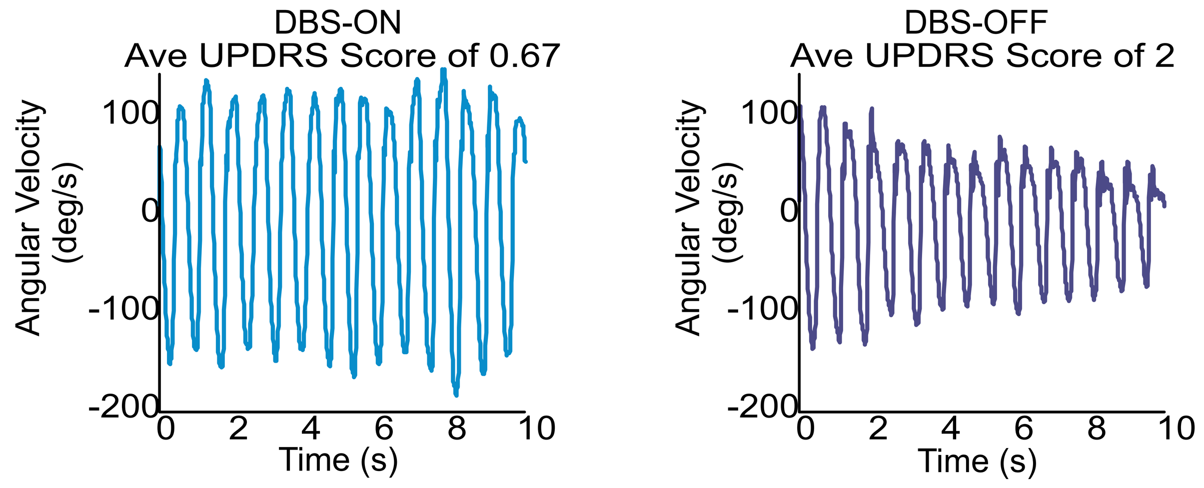

Figure 9. The magnitude of the angular velocity correlated with UPDRS leg lift score. The kinematics on the right show reduced speed overall and over time, which corresponded to increased impairment on the average clinician UPDRS score.

Continuous Evaluation

Continuous evaluation provides a general measure of impairment during everyday life.

Validation used data from the thigh during the gait and arise tasks. The gait and arise tasks showed expected average classification (see pie charts) and showed the potential to provide clinically meaningful information about impairment.

Gait Task

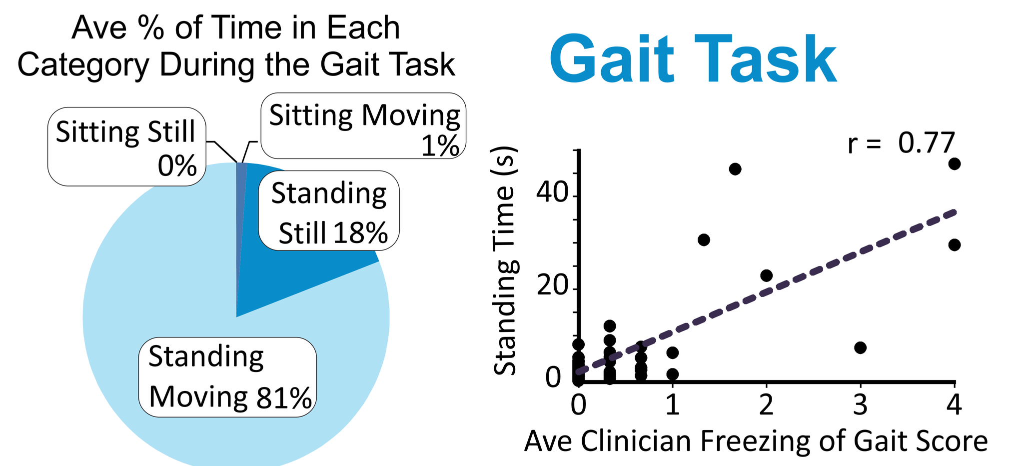

Figure 10. Standing time had a correlation greater than 0.7 with the freezing of gait and gait UPDRS scores.

Arise Task

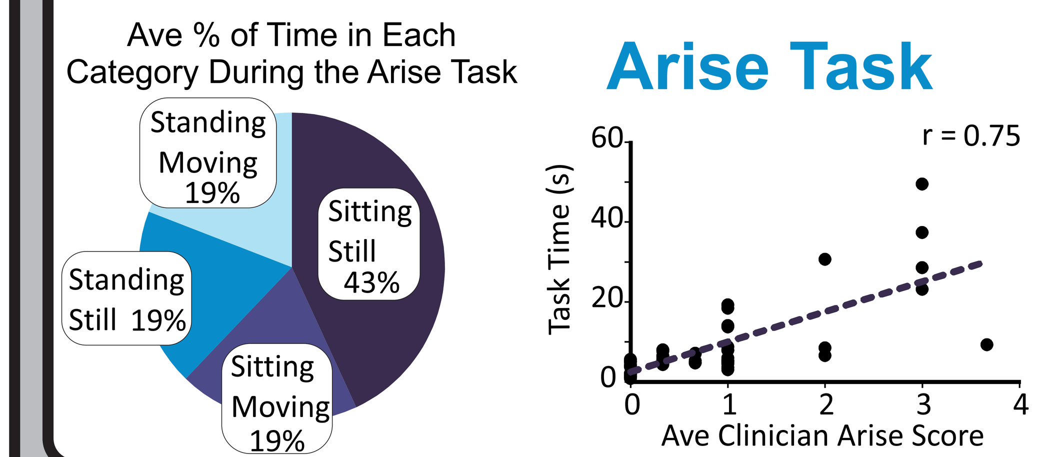

Figure 11. Arise task time had a correlation greater than 0.7 with the arise UPDRS score.

Conclusions

Mobility is essential for independence, and the evaluation of gait can provide a global measure of impairment. The Kinesia™ sensors were able to quantify clinically relevant information both for discrete and continuous evaluation methods. Home monitoring with this system could improve quality of life by targeting more gait related outcomes during the evaluation of new treatments, management of medications, and deep brain stimulation programming.

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