Automated Parkinson's disease gait and balance assessment for optimization of deep brain stimulation

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Introduction

Gait and balance disturbances, especially in advanced Parkinson's disease (PD) patients, can be very debilitating and may lead to increased fall risk. Deep brain stimulation (DBS) surgery is a treatment option when medication-induced side effects including motor fluctuations and dyskinesias impact patient quality of life. Significant challenges are associated with DBS programming for gait and balance including variable and delayed response across motor symptoms. Therefore, developing improved neuromodulation assessment tools for optimizing gait and balance response to DBS is still needed.

Methods

Goal: The objective of this study was to use motion sensors to capture kinematic data while PD subjects performed gait and balance tasks based on the Unified Parkinson's Disease Rating Scale (UPDRS), extract data features highly correlated to clinician UPDRS scores, and capture changes in symptom severity in response to DBS.

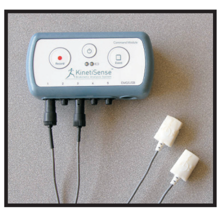
Subject Recruitment

Diagnosis 42 PD subjects

Gender 31 M/11 F

Age 67 ± 13 years

- 22 prescribed dopaminergic medication
- 20 also implanted with DBS
  - 18 bilateral STN
  - 1 unilateral STN
  - 1 unilateral VIM

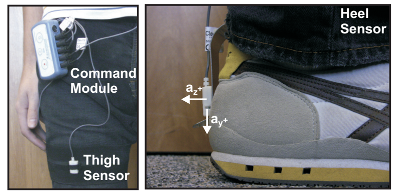


KinetiSense consists of five motion sensor units each containing accelerometers and gyroscopes, and a command module for synchronized wireless data transfer.

Data Collection

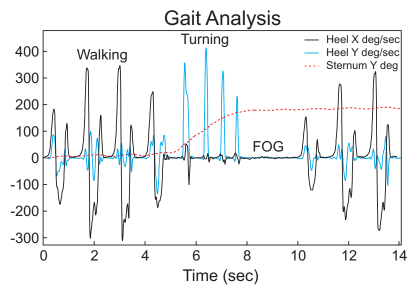
Subjects were instructed to perform six gait and balance motor tasks based on the UPDRS while wearing KinetiSense body-worn sensors: 1) Toe Tapping, 2) Leg Agility, 3) Arising from Chair, 4) Gait, 5) Freezing of Gait, and 6) Postural Stability. Non-DBS subjects performed each task once while DBS subjects performed each task with stimulation first turned on (DBS settings optimized by clinician during previous clinical visit) and repeated the tasks approximately 15 minutes after turning stimulation off. Task performance was videotaped for later online clinician scoring per UPDRS guidelines.

Motion Sensor Setup



Five motion sensors were placed on various parts of the body: heel (L/R), thigh (L/R), and sternum.

Feature Extraction



For Task 4 and 5, subjects were instructed to walk forward 30 feet, turn 180 degrees, and walk back. The data collected from the heel and sternum sensor were used to segment the gait task into walking and turning.

Kinematic Features

Task 4 (Gait):

1) Stride velocity

2) Cadence

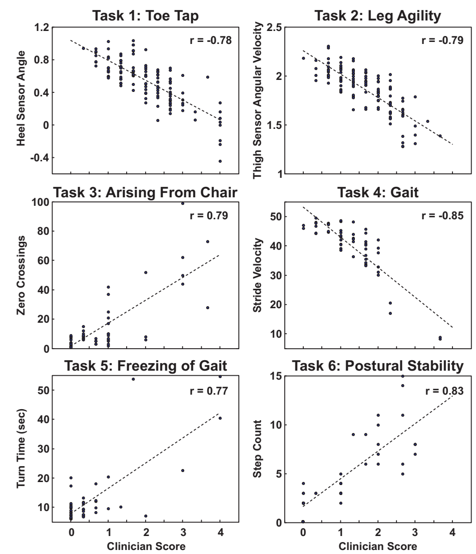
Task 5 (Freezing of Gait):

1) Turn time

2) Number of steps required during turn

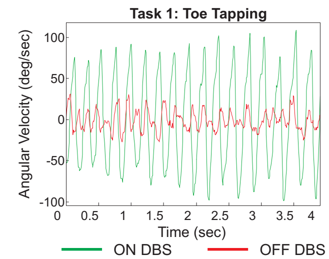
3) Time delay between completing the turn and initiating the walk again

Clinician Correlation

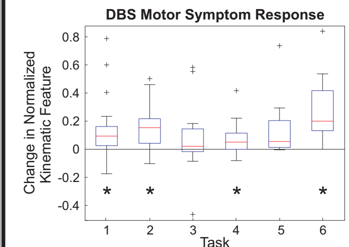


Kinematic features with the highest correlation to clinician ratings are plotted against UPDRS score. Dotted lines represent the linear regression fit.

DBS Response



Heel rotation velocity for Task 1 was captured ON- and OFF-DBS.



Box and whisker plots of change in normalized (0-1) kinematic features in response to DBS are shown for each motor task (positive values denote improvement). Task 1, 2, 4, and 6 significantly improved (p<0.05) as noted by the (*) below each box plot.

Conclusion

→Motion data was successfully captured from PD subjects performing gait and balance tasks based on the UPDRS.

→Kinematic features extracted from motion data were highly correlated to UPDRS clinician scores.

→Small but significant changes in gait and balance symptom severity were captured in response to DBS.

→This motion analysis technology can provide high sensitivity measures to better understand the effect of established and under investigation DBS targets on gait and balance impairment.

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