# Autonomous Tracking of Body Bradykinesia during Unconstrained Activities in Parkinson's Disease

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## Motivation

♦ Sensor-based technology is needed for implementing personalized therapeutic approaches in Parkinson's disease (PD)[1].

♦ Current approaches measure bradykinesia using intermittent standardized UPDRS motor tasks, such as finger tapping (Item 23).

♦ Continuous sensor-based monitoring of whole-body bradykinesia during daily activity is important, yet remains to be achieved.

## Objective

♦ To develop a software platform of wearable sensors and real-time algorithms for automated detection of body bradykinesia during unscripted activities of daily living.

## Approach

♦ Defined presence and absence of body bradykinesia based on impairments listed in Item 31 of UPDRS.

♦ Selected sensors that can provide <u>both</u> muscle activity (EMG) and inertial movement (Gyro and Accelerometer) to characterize motor impairments of body bradykinesia.

♦ Because body bradykinesia manifests differently during gait, walking and non-walking segments were automatically classified prior to body-bradykinesia detection.

♦ Assessed body bradykinesia motor impairments by tracking changes in the magnitude of sensor-based metrics (e.g. reduced limb velocity, reduced limb amplitude and poverty of movement).

<u>Walking impairments</u>
- Reduced Arm Swing
- Reduced Step Length
- Hesitancy

<u>Non-walking impairments</u>
- Reduced Amplitude
- Reduced Velocity
- Hesitancy
- Poverty of Movement

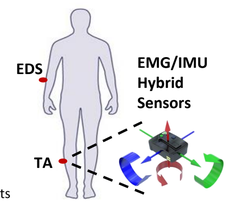
## Data Collection

### (1) Subject Population

| PD Subjects | Training Data* | Testing Data* |
|---|---|---|
| Number | n = 8 | n = 8 |
| Age (y) | 57.5 ± 12.5 | 63.2 ± 12.1 |
| Male/Female | 6/2 | 6/2 |
| PD Duration (y) | 8.6 ± 5.4 | 5.4 ± 1.7 |
| Total Data | 1000 min | 1000 min |
| Prevalence (%)** | 58.7 | 76.4 |
| Hoehn-Yahr (On) | II-III | II-III |

* Algorithms trained and tested using different data sets
** % of Total Data w/ bradykinesia

### (2) Sensor Placement



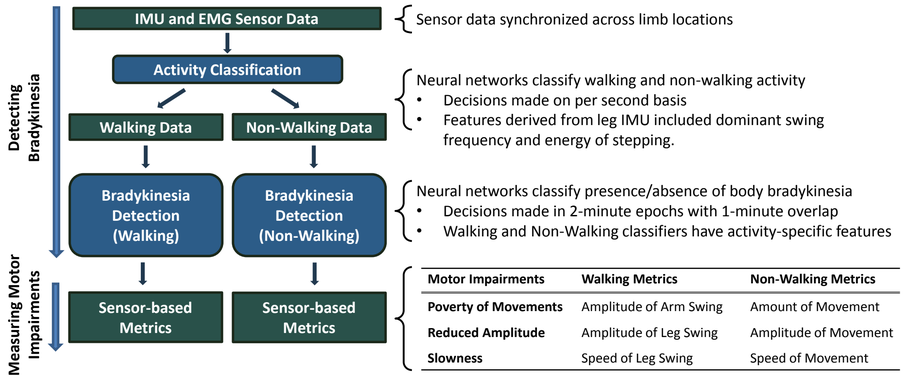

### (3) Data Acquisition Protocol

♦ Trigno™ wireless sensors (Delsys Inc) recorded sEMG and IMU measurements from upper- and lower-limb (see Fig.)

♦ Data were recorded continuously during 3 hours of unscripted activity in a simulated home setting.

♦ Video recordings were annotated by movement disorder experts to determine the presence/absence of body bradykinesia (based on Item 31 of UPDRS)

## Algorithm Design




| Motor Impairments | Walking Metrics | Non-Walking Metrics |
|---|---|---|
| Poverty of Movements | Amplitude of Arm Swing | Amount of Movement |
| Reduced Amplitude | Amplitude of Leg Swing | Amplitude of Movement |
| Slowness | Speed of Leg Swing | Speed of Movement |

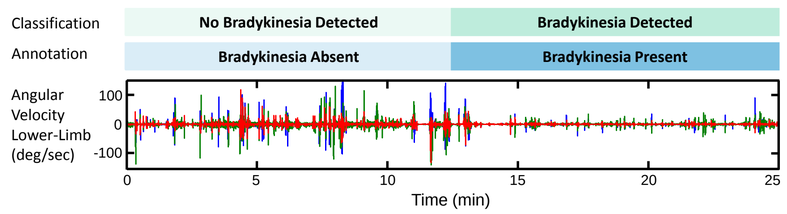
## Bradykinesia Classification Results

### Accuracy of Body Bradykinesia Detection

- The activity classifier separated walking and non-walking test data with 99.5% accuracy.
- Combined body bradykinesia classification accuracy under all activities was 96.5% .

| Bradykinesia Classification | Sensitivity (%) | Specificity(%) | Accuracy(%) |
|---|---|---|---|
| Non-Walking | 99.4 | 90.9 | 97.4 |
| Walking | 92.6 | 100 | 93.8 |
| | | Overall | 96.5 |

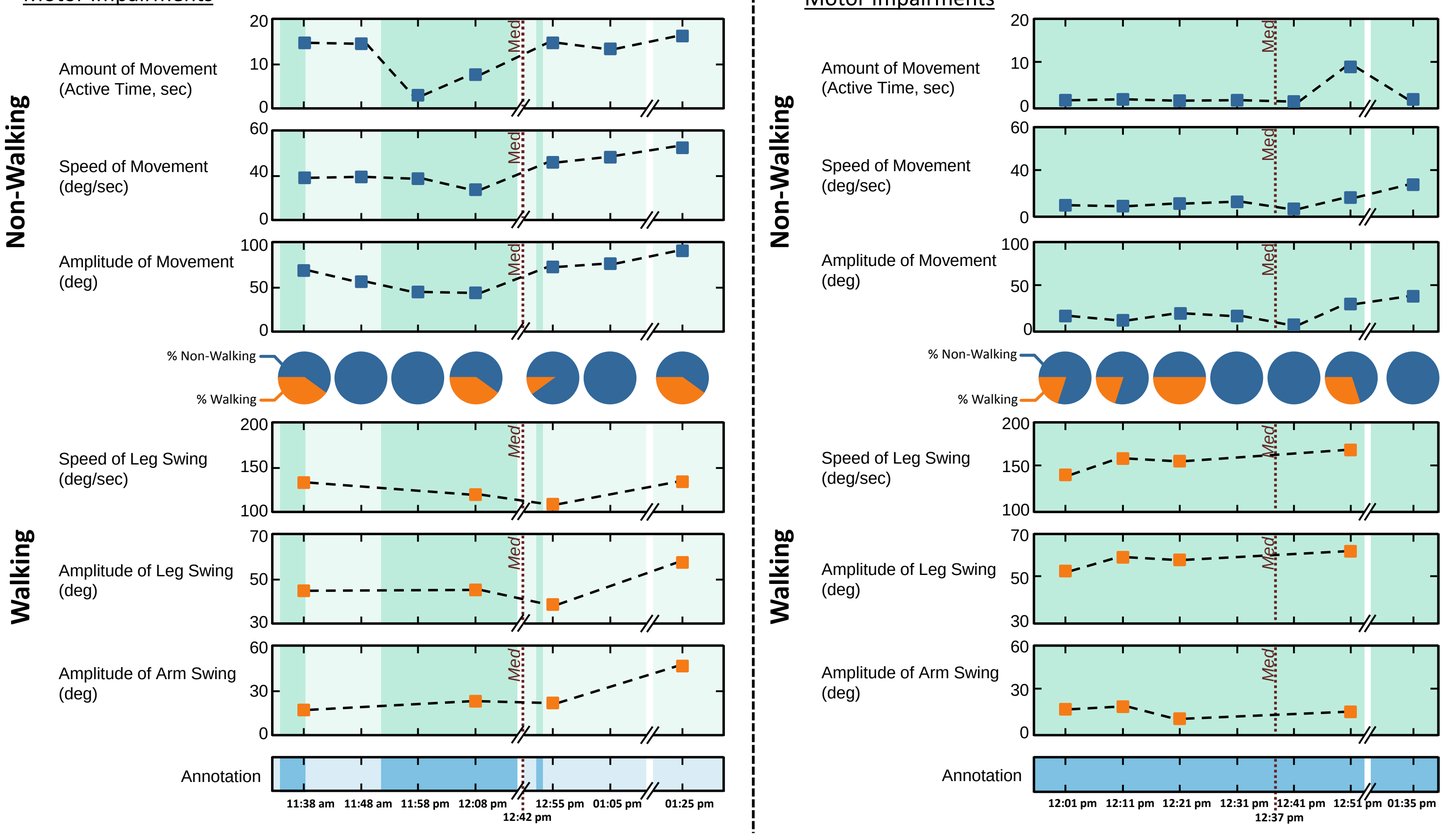
### Example of Body Bradykinesia Detection




## Results for Tracking the Effects of Dopamine Replacement on Body Bradykinesia

**<u>Case 1:</u>** *This patient responds to medication intake with a change in body bradykinesia assessment that coincides with improvements in motor impairments.*

**<u>Case 2:</u>** *This patient responds to medication intake with no changes in body bradykinesia assessment but he has improvements in motor impairments during non-walking which can inform the clinician of changes in body bradykinesia severity.*




## Conclusion

First achievement of a wearable system that is used during normal daily activities to provide:

- Body Bradykinesia classification with <5% error
- Objective metrics to quantify motor impairments associated with body bradykinesia

This proof-of-concept tool provides assessments and metrics that are responsive to PD medication.

## Acknowledgments

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## References

[1]Movement Disorders , Vol 31, No 9 2016.