# Improved Detection of Gait Abnormalities in Parkinson’s disease using IMU Sensors


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## Motivation

- ♦ Automated tracking of Parkinson’s disease (PD) motor symptoms during daily activities requires robust and clinically-relevant sensor metrics [1].
- ♦ Bradykinesia, a major motor symptom of PD, is activity-dependent and requires advanced tools for assessment that include gait.
- ♦ Bradykinesia can manifest during gait as a reduction in arm swing, leg velocity, range of movement, and heel-toe dynamics, which are difficult to capture with conventional sensors such as accelerometers.
- ♦ Recent advances in wearable inertial (IMU) sensors may provide an enhanced means of recording joint kinematic of bradykinesia gait disorders.

## Objective

To evaluate the ability of IMU sensor-based metrics to identify gait impairments associated with body bradykinesia in patients with Parkinson’s disease during unscripted activities of daily living.

## Approach

- ♦ Body bradykinesia assessment during gait was based on impairments listed in Item 31 of UPDRS.
- ♦ An automated classifier (neural network) was designed to isolate gait activity from other activities based on leg sensor data.
- ♦ Five gait metrics were analyzed using angular velocity (gyroscope) and compared during presence and absence of bradykinesia.

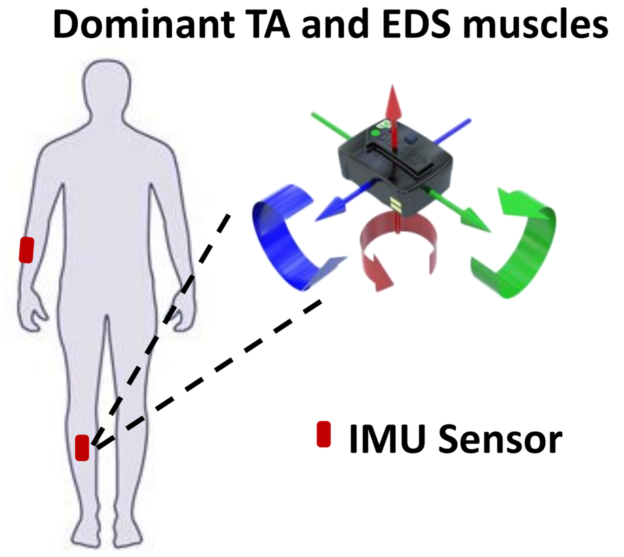
## Data Collection

### Subject Population

| PD Subjects Demographics | |
|---|---|
| Number | n = 6 |
| Age (y) | 57.5 ± 12.5 |
| Male/Female | 4/2 |
| Disease Duration(y) | 8.6 ± 5.4 |
| Total Data | 1000 min |
| Bradykinesia Prevalence* (%) | 58.7 |
| Hoehn-Yahr (ON) | II-III, |

* % of Total Data w/ bradykinesia

**Sensor Placement Location: Dominant TA and EDS muscles**




### Data Acquisition Protocol

- ♦ Data were acquired from 2 wireless IMU sensors (Trigno IM - Delsys Inc) from forearm and shank – see Figure
- ♦ Data were recorded continuously for 3 hours in a simulated home setting during unscripted activities.
- ♦ Video recordings were acquired and annotated by movement disorder experts to identify activity type and presence/absence of body bradykinesia (based on Item 31 of UPDRS)

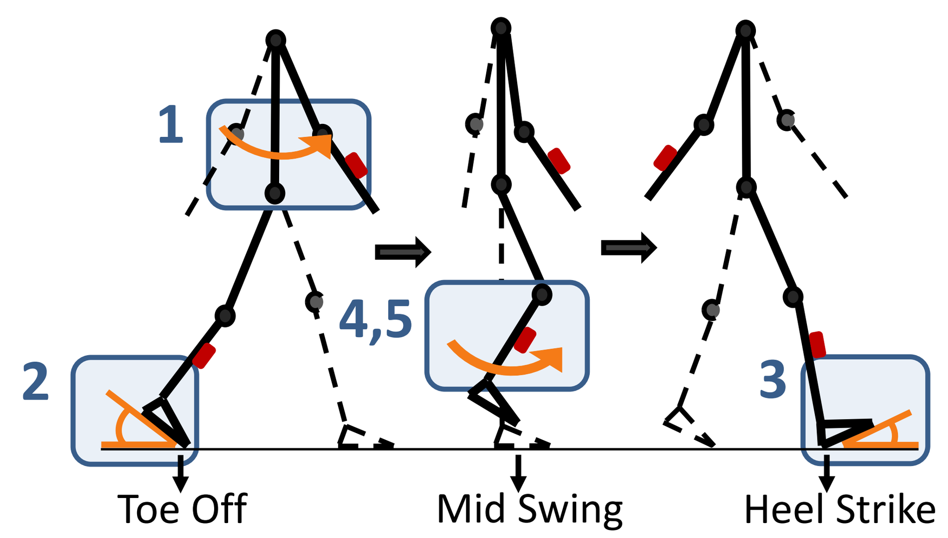
## Methods

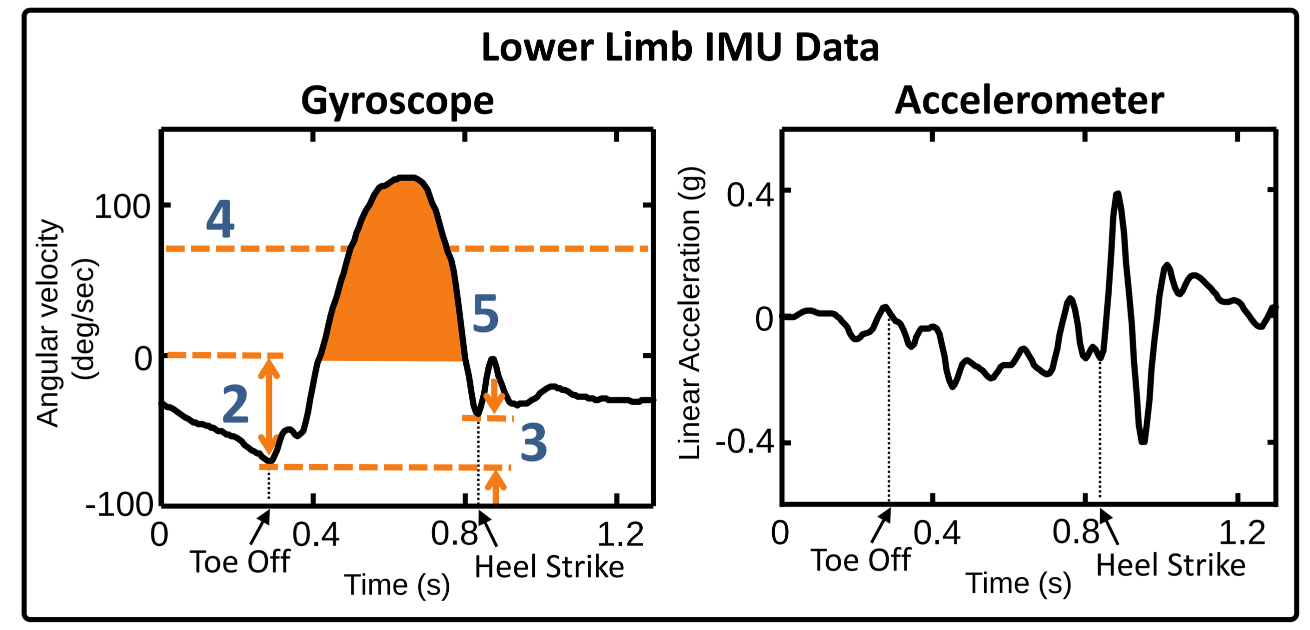
- ♦ Gait impairment metrics were calculated on the basis of angular velocity magnitude and range of movement from gyroscope data. [Refer to Analysis section]
- ♦ Statistical comparisons (Mann-Whitney-Wilcoxon test) were computed to test the discriminability of gait impairment metrics for Bradykinesia and Non-Bradykinesia portions of the gait data. [Refer to Results section]

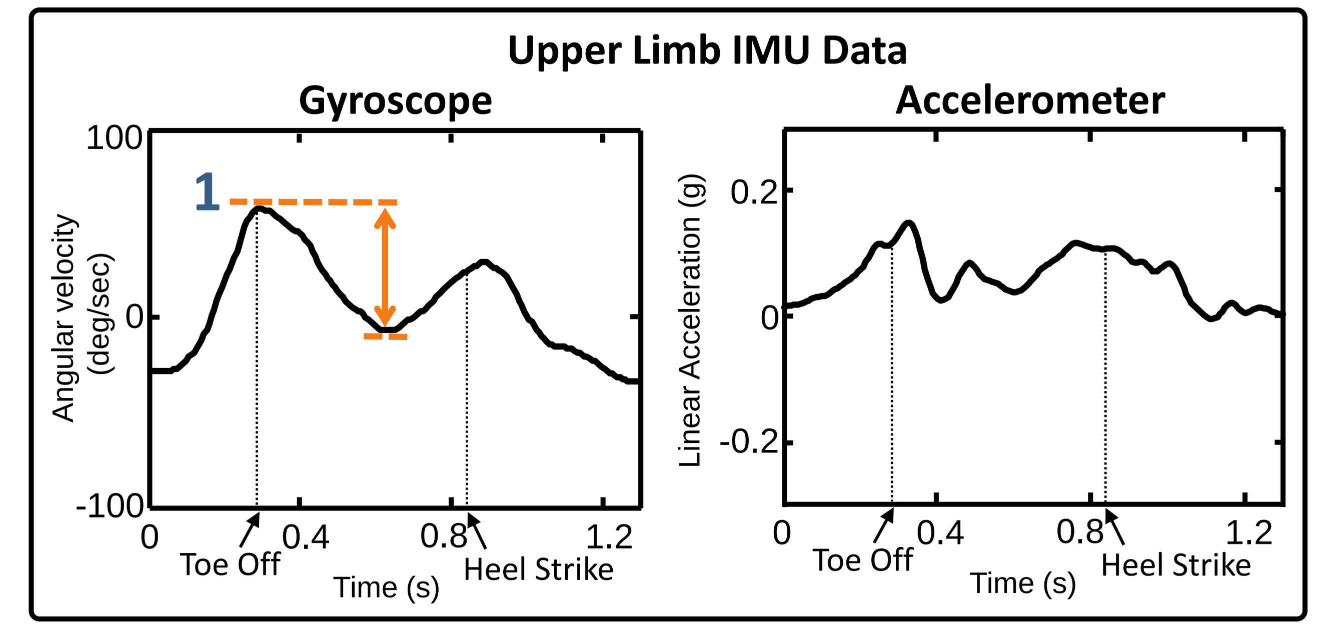
## Analysis

- ♦ The numbers [1-5] in the figure refer to the five sensor-based gait metrics that were derived to quantify gait impairments associated with bradykinesia.
- ♦ Raw gyroscope data from upper and lower limb are compared with raw Accelerometer data for the same IMU recording.
- ♦ These comparisons illustrate the greater precision in identifying data features from the angular velocity plots compared to accelerometer plots.

**Gait Cycle and Corresponding Sensor Metrics**

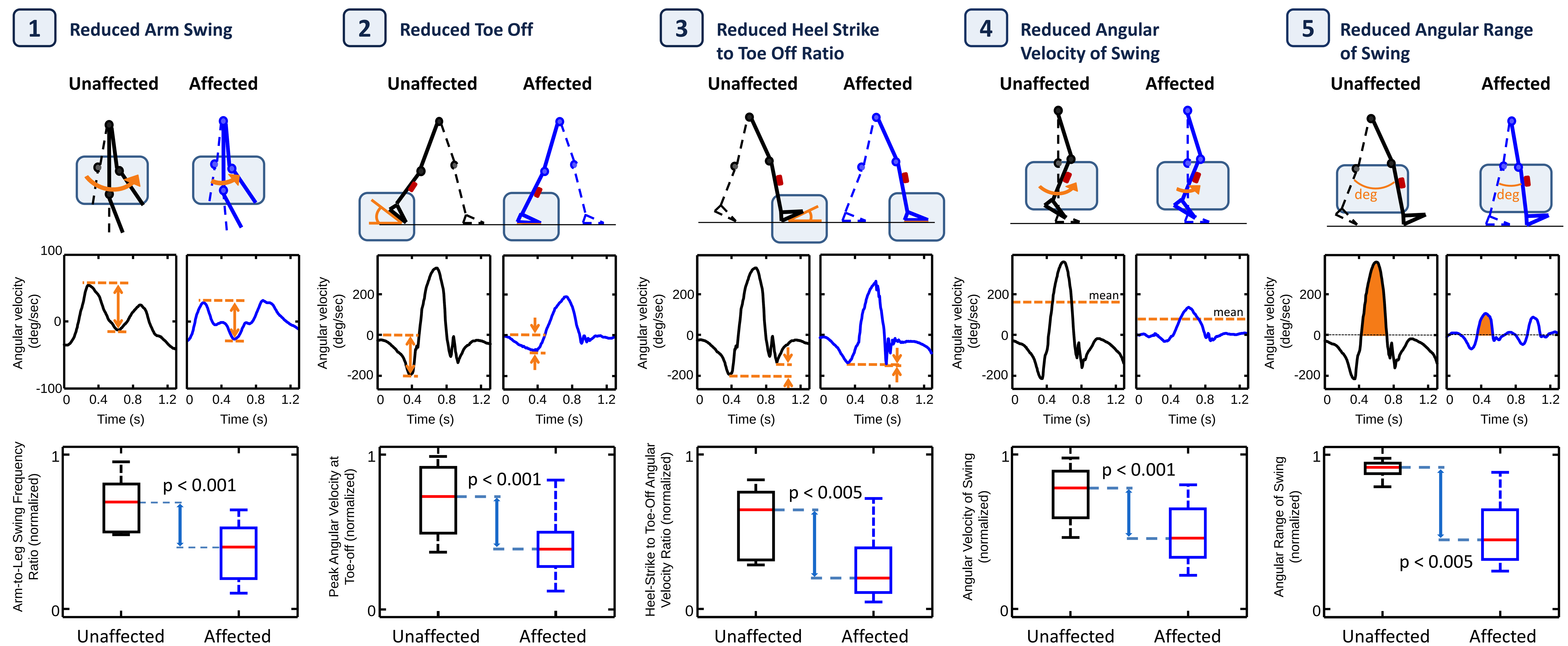



## Results

- ♦ The numbers [1-5] identify the bradykinesia gait impairments described in the Analysis. Corresponding raw angular velocity for instances with and without bradykinesia are analyzed.
- ♦ The results demonstrate that IMU sensors provide objective gait metrics with significant discriminability for bradykinesia.




## Conclusion

- ♦ The work demonstrates the viability to develop robust and clinically-relevant metrics for improved detection of gait abnormalities in PD.
- ♦ A subsequent study [see Adjacent Poster: Roy et al. “Autonomous Tracking of Body Bradykinesia…”] utilized these impairment metrics as features to train a neural network classifier to detect body bradykinesia and achieved <5% error during unscripted activities in a population of n=16 PD subjects.


## Acknowledgments

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## References


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