

Unsupervised Assessment of Motor Fluctuations in Parkinson's Disease: A Cross-Sectional Study with Wearable Sensors and Diaries

Affiliations: ¹ Department of Neurology, University of Brescia, Brescia, Italy; ² Laboratory of digital Neurology and biosensors, University of Brescia, Italy; ³ Department of Continuity of Care and Frailty, Neurology Unit, ASST Spedali Civili di Brescia, Brescia, Italy; ⁴ Department of Neurology, Christian-Albrechts-University of Kiel, Kiel, Germany

1 Materials:

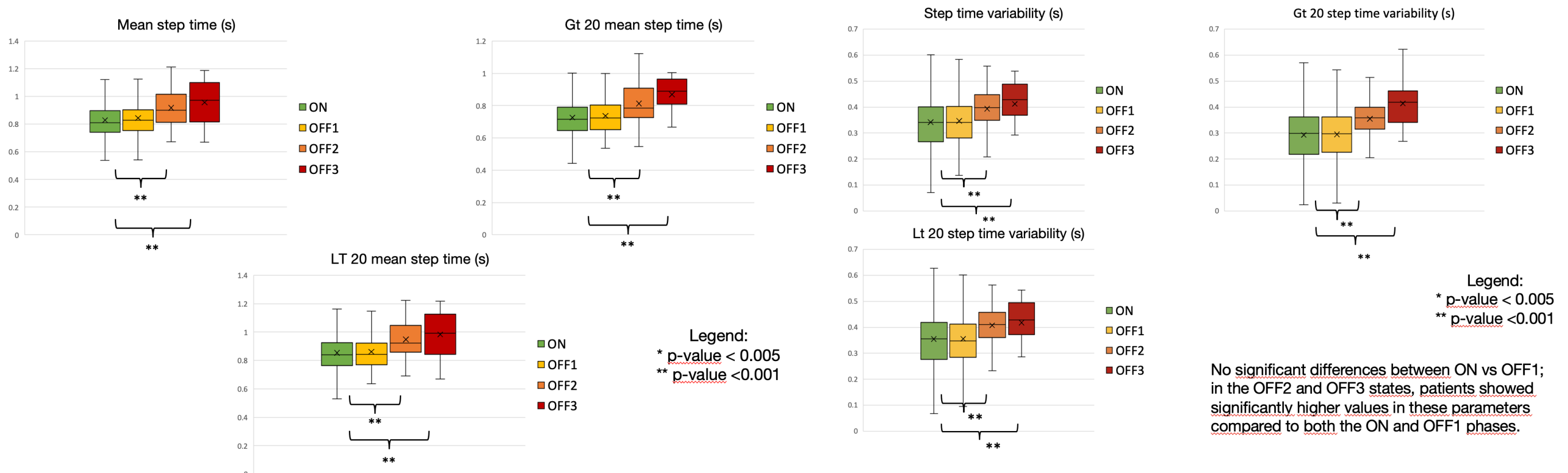
Twenty-nine PD patients with motor fluctuations and thirty-nine PD controls without fluctuations were enrolled. Exclusion criteria: atypical parkinsonism, dementia, orthopedic/physiatric/neurological comorbidities. Participants underwent clinical evaluations including motor cognitive and Hauser diaries and 4-day continuous MHT unsupervised monitoring in ecological settings.

2 Method:

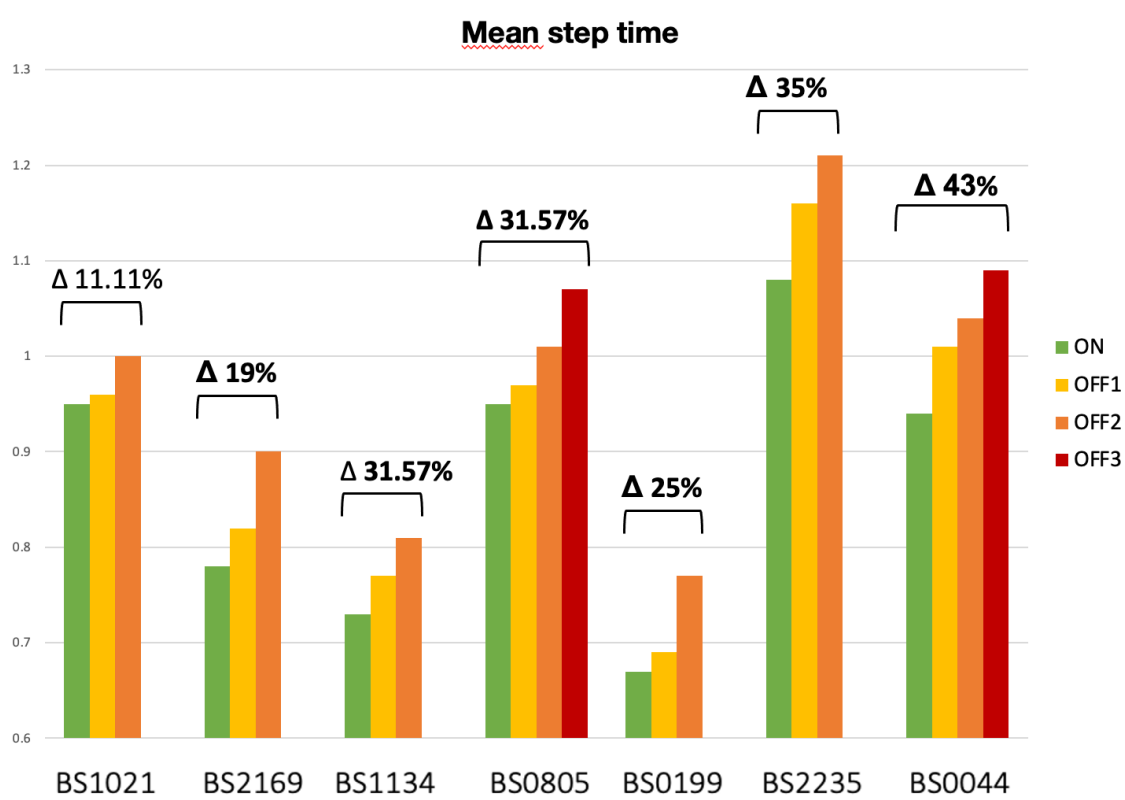
Method: Wearable inertial sensors (Axivity®/Movisens®) were placed at L4-L5 to capture several gait parameters (including mean step time, variability, asymmetry, cadence, duration, step count); motor status was classified according to Expanded Hauser diary as ON, OFF1, OFF2, OFF3 states. Walking episodes were stratified into short (<20 steps) and long (≥20 steps) walking bouts. Statistical analysis used covariate-adjusted models (age, sex, LEDD) with Bonferroni correction for multiple comparisons.

3 Results:

Subgroups analyses



Single patient analyses



PATIENT	Mean step time				%ON-OFF1	%ON-OFF2	%ON-OFF3
	ON	OFF1	OFF2	OFF3			
BS1021	0.95 ± 0.10	0.96 ± 0.10	1.00 ± 0.09	-	2	11.11	-
BS2169	0.73 ± 0.02	0.77 ± 0.14	0.81 ± 0.04	-	8,6	19	-
BS1134	0.78 ± 0.06	0.82 ± 0.09	0.90 ± 0.04	-	8,6	31.57	-
BS0805	0.95 ± 0.12	0.97 ± 0.10	1.01 ± 0.10	1.07 ± 0.09	4.1	13.63	31.57
BS0199	0.67 ± 0.03	0.69 ± 0.10	0.77 ± 0.14	-	4.1	25	-
BS2235	1.08 ± 0.14	1.16 ± 0.13	1.21 ± 0.10	-	19	35	-
BS0044	0.94 ± 0.16	1.01 ± 0.08	1.04 ± 0.11	1.09 ± 0.10	16.27	25	43

References: Brognara L, Palumbo P, Grimm B, Palmerini L. Assessing gait in Parkinson's disease using wearable motion sensors: A systematic review. *Diseases*. 2019;7(1):18. Hauser RA, Koller WC, Friedman JH. Validation of a questionnaire for assessing motor fluctuations in Parkinson's disease. *Clin Neuropharmacol*. 2000;23(5):276-280. Stocchi F, Olanow CW, Poewe W. Defining motor fluctuations in Parkinson's disease. *Mov Disord*. 2006;21(5):641-645.

4 Discussion:

Mean step time robustly discriminates ON-OFF states, even in early OFF phases (OFF1), and differentiates PD with/without fluctuations. The heterogeneity in OFF-phase definitions and potential diary-sensor discrepancies (e.g., underreported OFF1 periods) highlight the need for individualized assessment of MHT and fluctuations. Limitations include the small sample size and lack of validated step time thresholds.

5 Conclusion:

Step time is a practical, unsupervised marker for detecting motor fluctuations. Future studies should validate step time thresholds for clinical use, integrate digital diaries to reduce subjectivity, and combine gait with postural metrics (e.g., turning, transitions) for comprehensive monitoring.