

Digital Biomarkers Of Physical Activity Enable Longitudinal Measurement Of Disease In Progressive Supranuclear Palsy (Session: P4-06)

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Introduction

- Progressive Supranuclear Palsy (PSP) is a rare, rapidly progressive neurodegenerative disorder resembling Parkinson's disease (PD).
- Patients experience progressive motor impairment, gait and balance problems, falls, and reduced physical activity.
- Clinical assessments are infrequent, subjective, and may not capture day-to-day variability or early changes.

LIMITATIONS OF CURRENT PHYSICAL ACTIVITY ASSESSMENTS

SUBJECTIVE & VARIABLE



Inter-rater variability¹ and recall bias lead to inconsistent assessments.

SNAPSHOT IN CLINIC



Brief clinic visits capture only a moment in time and miss day-to-day fluctuations and real-world function.²

INFREQUENT ASSESSMENT



Infrequent evaluations limit ability to detect meaningful change and complicate monitoring in clinical trials.^{2,3}



PROBLEM: Current assessment approaches lack sensitivity to detect subtle changes in physical activity, gait, and falls—important outcomes in PSP—limiting their utility in monitoring disease progression and evaluating therapies.



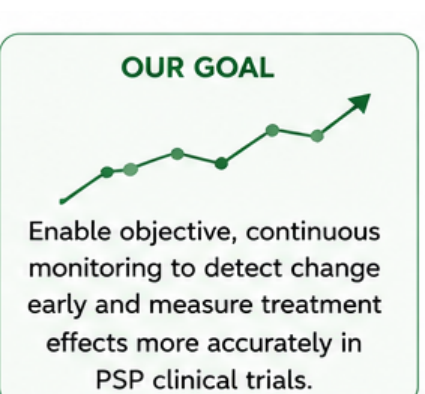
CONTINUOUS, OBJECTIVE MEASUREMENT
Captures physical activity, gait, posture, and falls in the home environment—day and night.



SENSITIVE DIGITAL ENDPOINTS
Measures such as step duration variability and standing percentage change track clinical progression and functional decline.



CLINICAL TRIAL VALUE
Provides frequent, quantitative, and reproducible outcomes that reduce sample size, increase statistical power, and lower trial cost and duration.



OUR GOAL
Enable objective, continuous monitoring to detect change early and measure treatment effects more accurately in PSP clinical trials.

Study Design and Patient Characteristics

Cohort Characteristics at Baseline (N = 38)

1 Demographics

Participants, n	38
Age, years, mean ± SD	69.3 ± 6.2
Sex, n (%)	
• Female	18 (47.4%)
• Male	19 (50.0%)
• Unknown/Missing	1 (2.6%)
Height, cm, mean ± SD	168.6 ± 10.4
Highest Education, n (%)	
• High school or less	6 (15.8%)
• Some college/Associate	7 (18.4%)
• Bachelor's degree	14 (36.8%)
• Graduate/Professional degree	11 (28.9%)

2 Clinical Characteristics

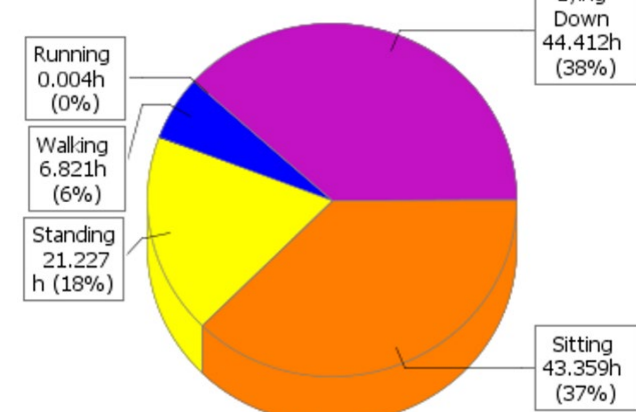
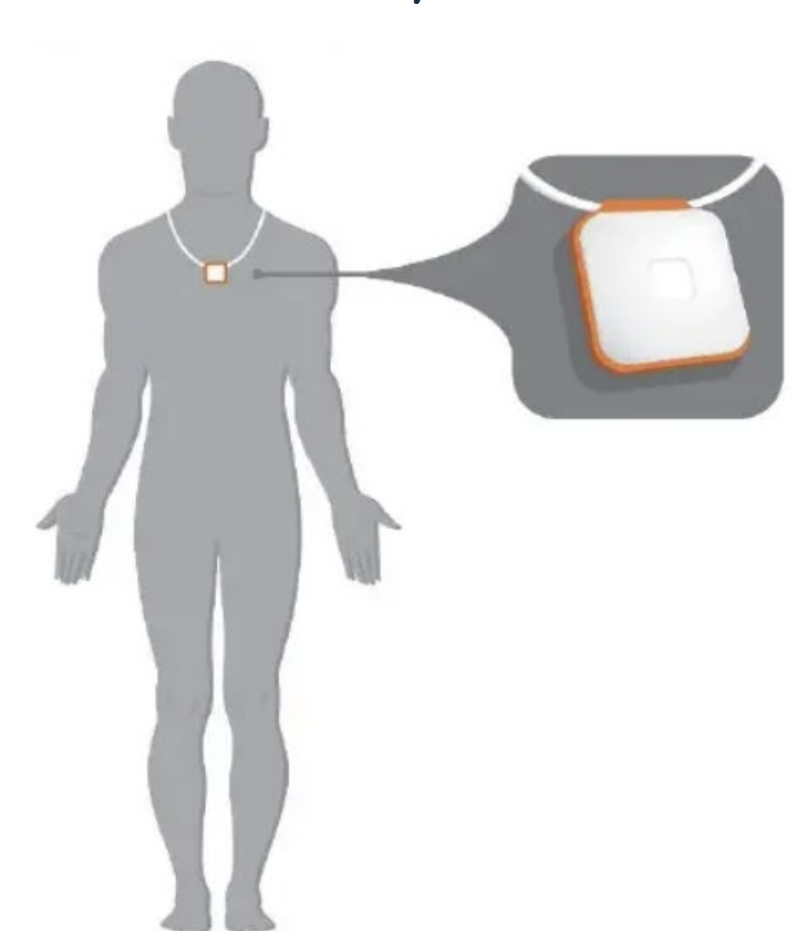
PSPRS Total Score, mean ± SD	33.4 ± 11.2
Motor CBFS Score, mean ± SD	19.1 ± 8.0
CBFS Total Score, mean ± SD	31.8 ± 15.3
MoCA Total Score, mean ± SD	23.1 ± 3.3
Apathy Total Score, mean ± SD	55.6 ± 9.4
EQ-5D Utility Index, mean ± SD	0.60 ± 0.20
EQ VAS (0–100), mean ± SD	65.5 ± 26.4

3 Functional Characteristics

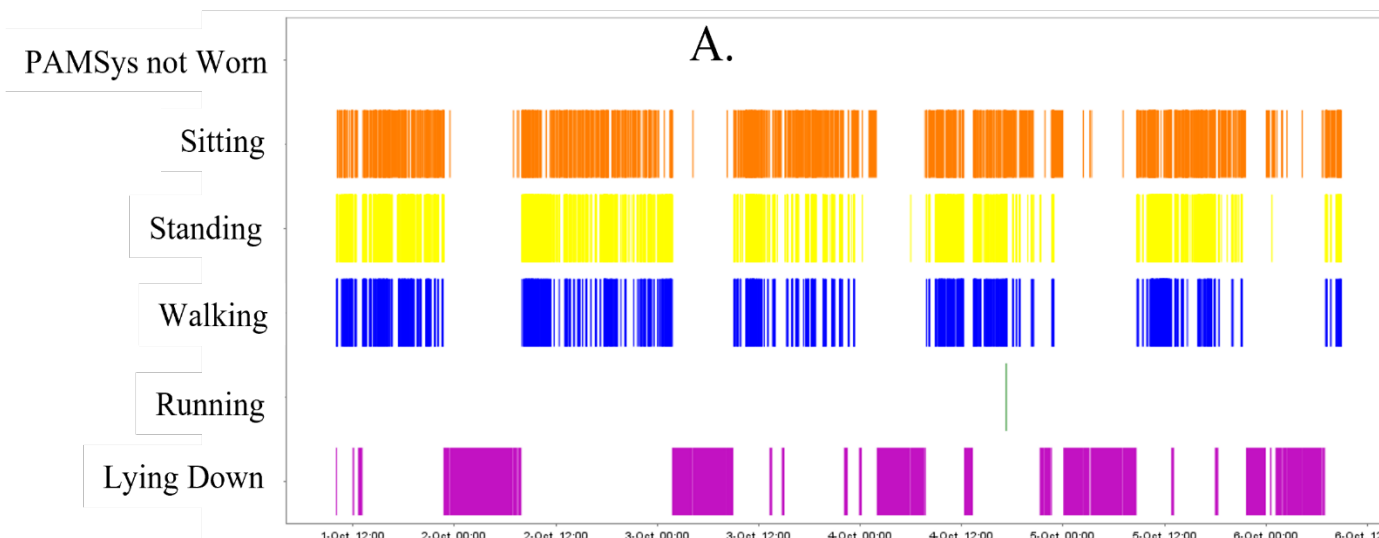
2-Minute Walk Distance (m), mean ± SD	82.5 ± 41.4
Walking Aid Use, n (%)	
Walker	17 (44.7%)
Cane	8 (21.1%)
None/Not recorded	10 (26.3%)
Values are mean ± SD or n (%). Percentages may not sum to 100 due to rounding.	

PSPRS: Progressive Supranuclear Palsy Rating Scale; CBFS: Corticobasal Functional Scale; MoCA: Montreal Cognitive Assessment; EQ-5D: EuroQol 5-Dimension; VAS: Visual Analogue Scale.

PAMSys Sensor

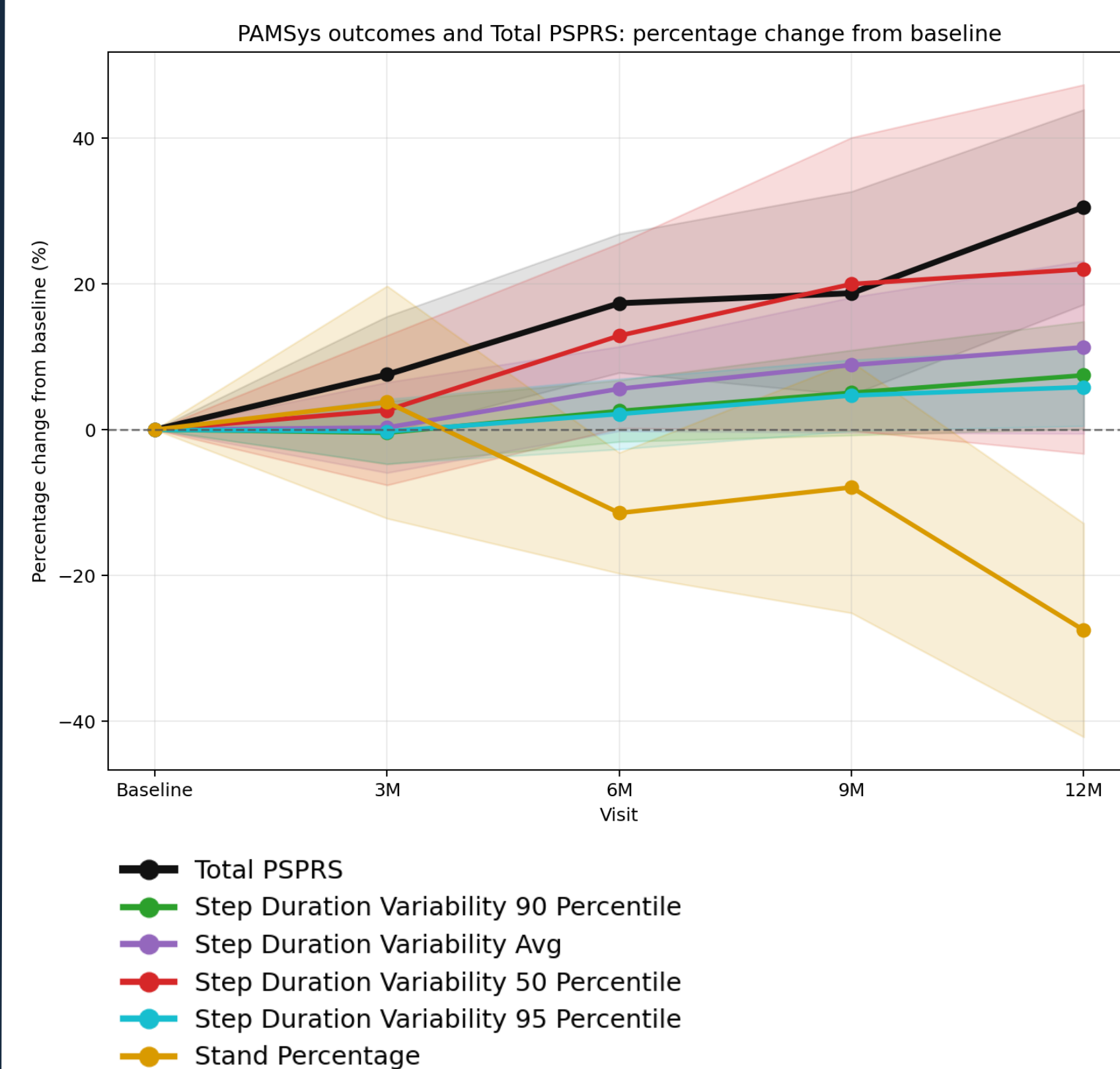


PAMSys is a Class II FDA-listed wearable device for monitoring physical activity, posture and falls.



- Speech assessment - Motor assessment - Cognitive assessment (Completed at each visit)	- Speech assessment - Motor assessment - Cognitive assessment (Completed at each visit)	- Speech assessment - Motor assessment - Cognitive assessment (Completed at each visit)	- Speech assessment - Motor assessment - Cognitive assessment (Completed at each visit)	- Speech assessment - Motor assessment - Cognitive assessment (Completed at each visit)
- PSP Rating Scale (PSPRS) - Corticobasal Functional Scale (CBFS) - PSG-QoL - EQ-5D-5L - Other clinical assessments (As per protocol)	- PSP Rating Scale (PSPRS) - Corticobasal Functional Scale (CBFS) - PSG-QoL - EQ-5D-5L - Other clinical assessments (As per protocol)	- PSP Rating Scale (PSPRS) - Corticobasal Functional Scale (CBFS) - PSG-QoL - EQ-5D-5L - Other clinical assessments (As per protocol)	- PSP Rating Scale (PSPRS) - Corticobasal Functional Scale (CBFS) - PSG-QoL - EQ-5D-5L - Other clinical assessments (As per protocol)	- PSP Rating Scale (PSPRS) - Corticobasal Functional Scale (CBFS) - PSG-QoL - EQ-5D-5L - Other clinical assessments (As per protocol)

Digital biomarkers capture progression across repeated visits

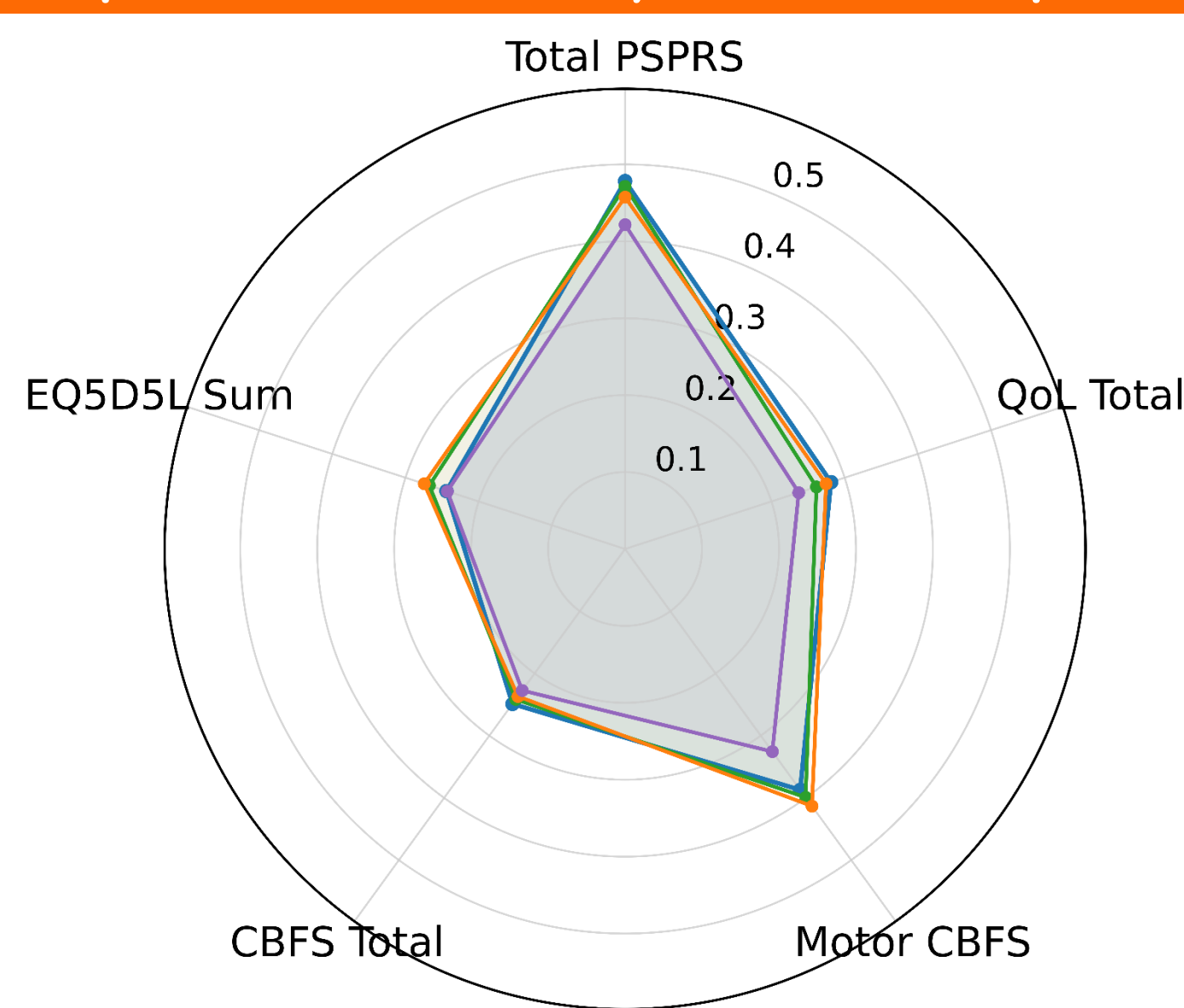


IRB : MGB + JHU
ClinicalTrials.gov:
NCT05956834

Take Home Message

- PSPRS increased ~30% over 12 months, confirming progressive clinical deterioration.
- Step duration variability increased throughout follow-up, reflecting worsening gait instability.
- Standing percentage declined by ~27%, suggesting reduced mobility and functional capacity.
- Wearable biomarkers tracked the direction of PSPRS progression, supporting their validity as objective digital biomarkers..
- The largest changes occurred after 6–12 months, indicating this interval is likely most informative for detecting disease progression.

Step duration variability reflects multiple dimensions of disease severity



- #1 SDV 90th Pct (mean |r|=0.33, min |r|=0.24)
- #2 SDV Avg (mean |r|=0.33, min |r|=0.24)
- #3 SDV 50th Pct (mean |r|=0.33, min |r|=0.24)
- #4 SDV 95th Pct (mean |r|=0.29, min |r|=0.23)

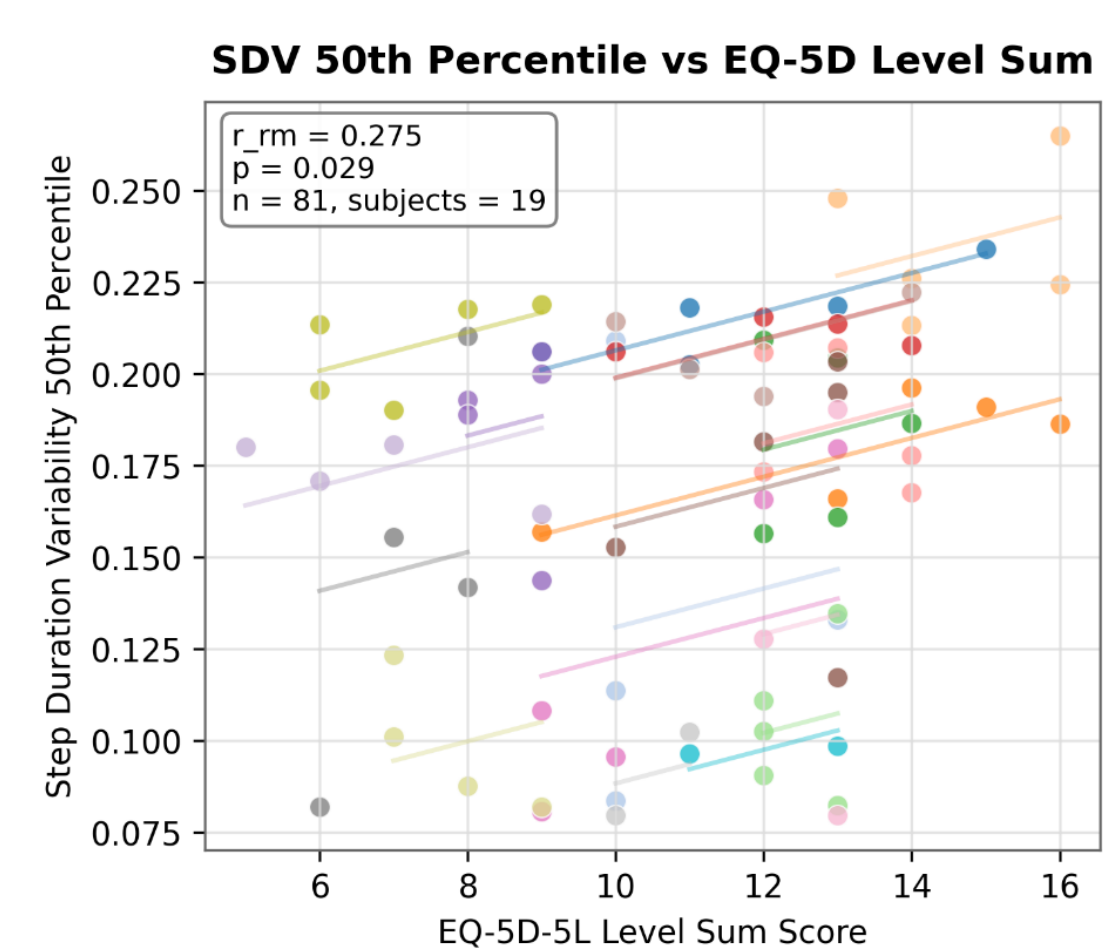
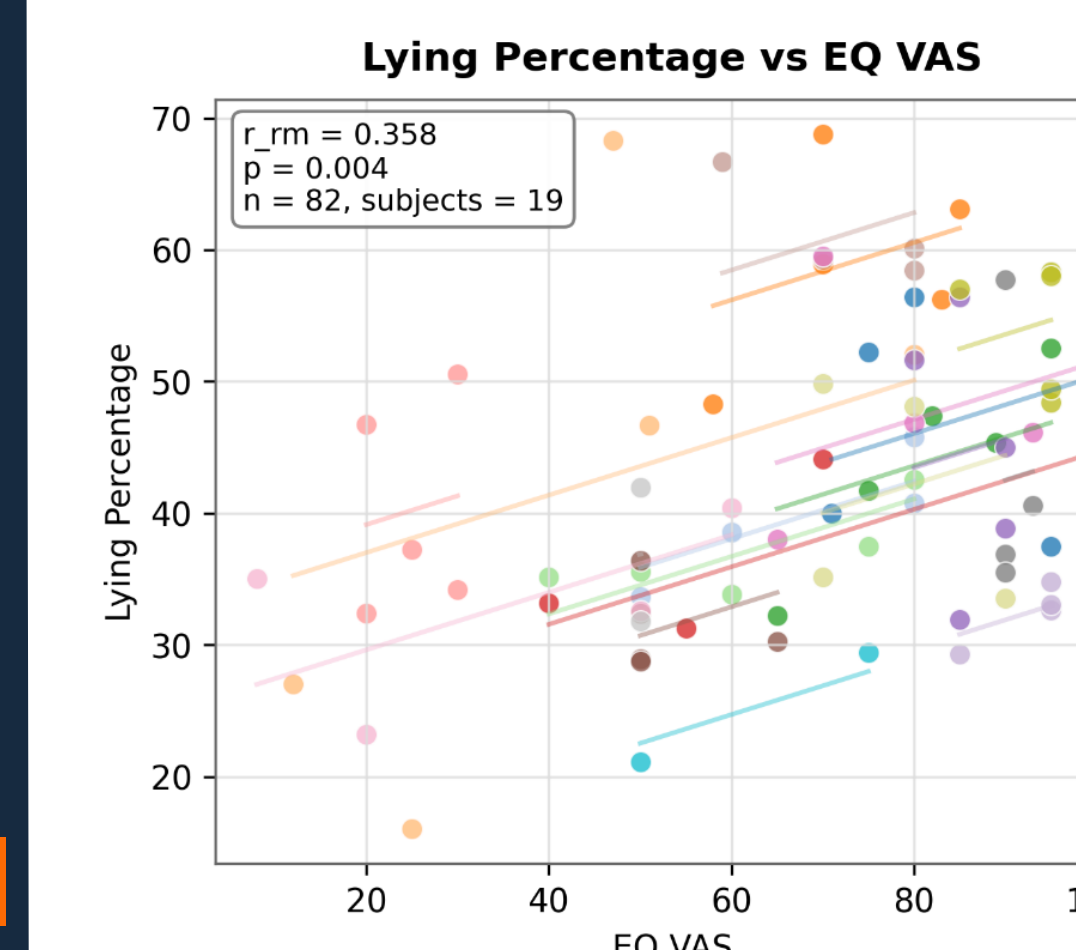
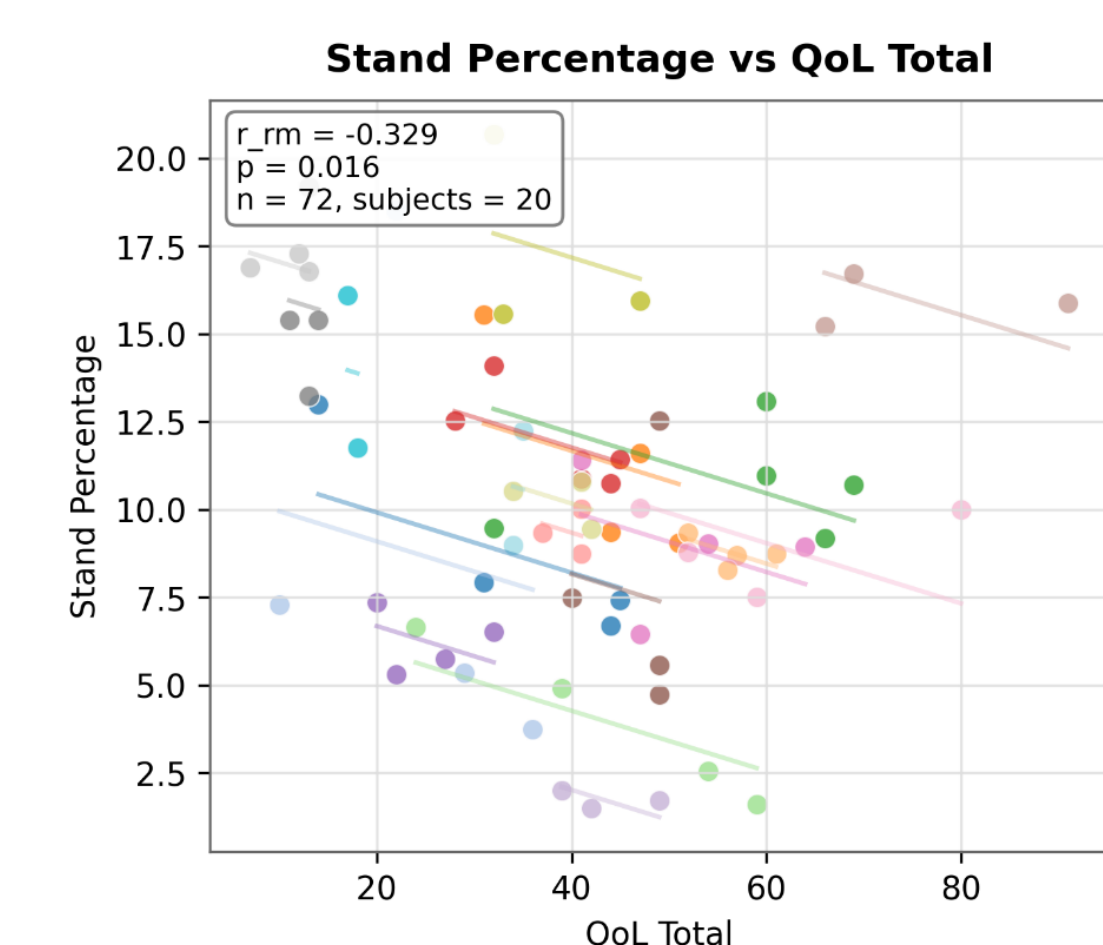
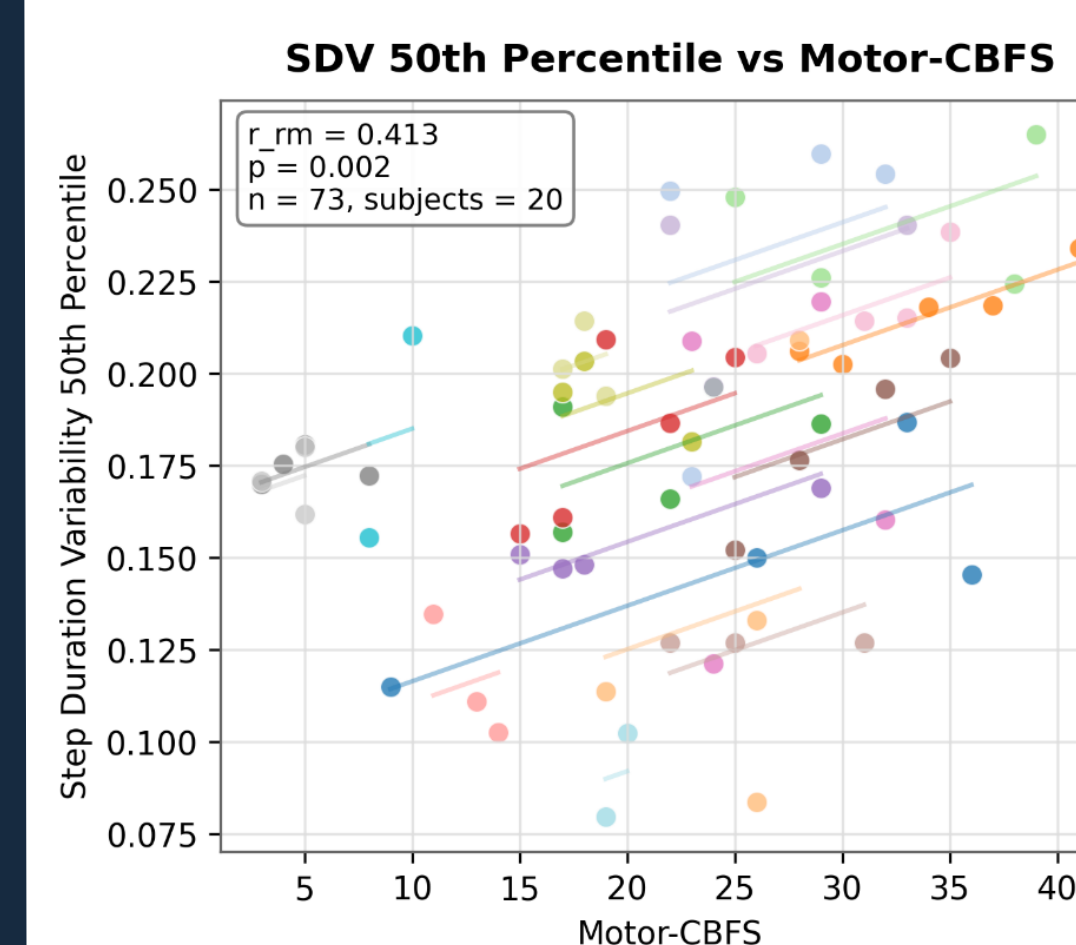
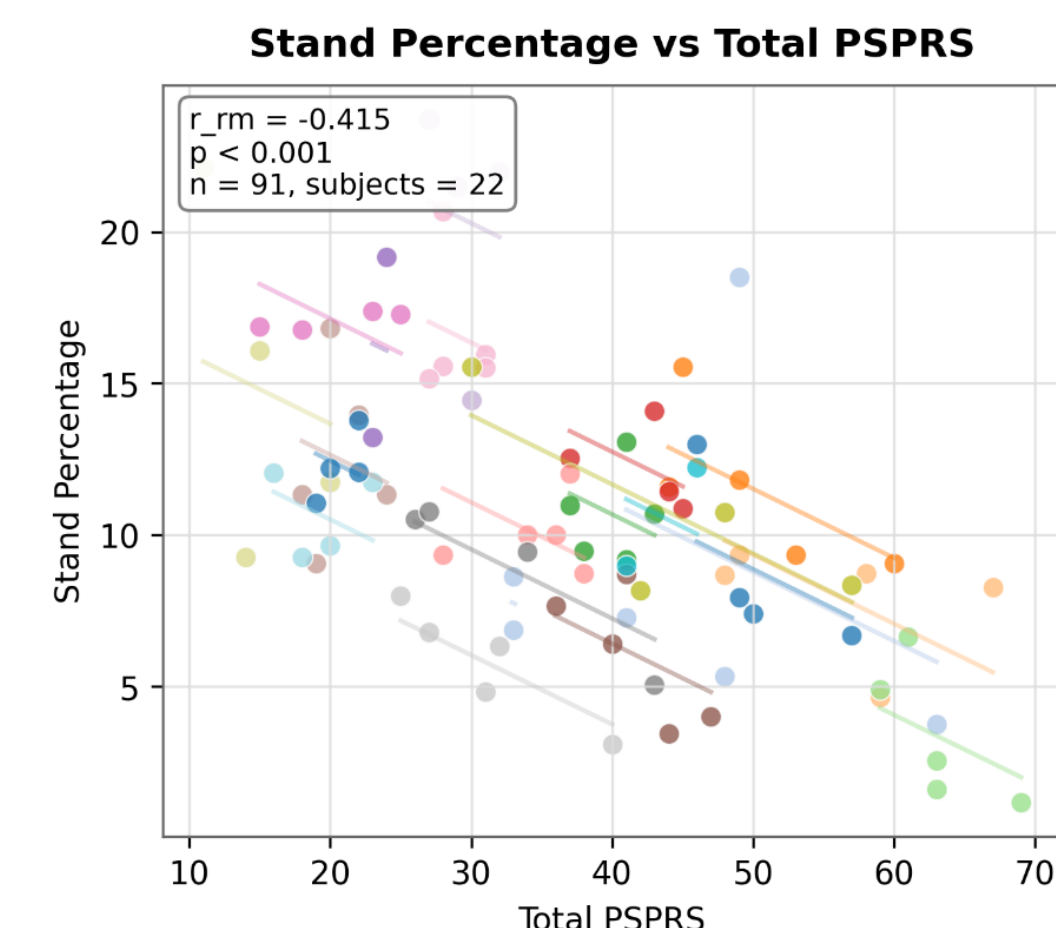
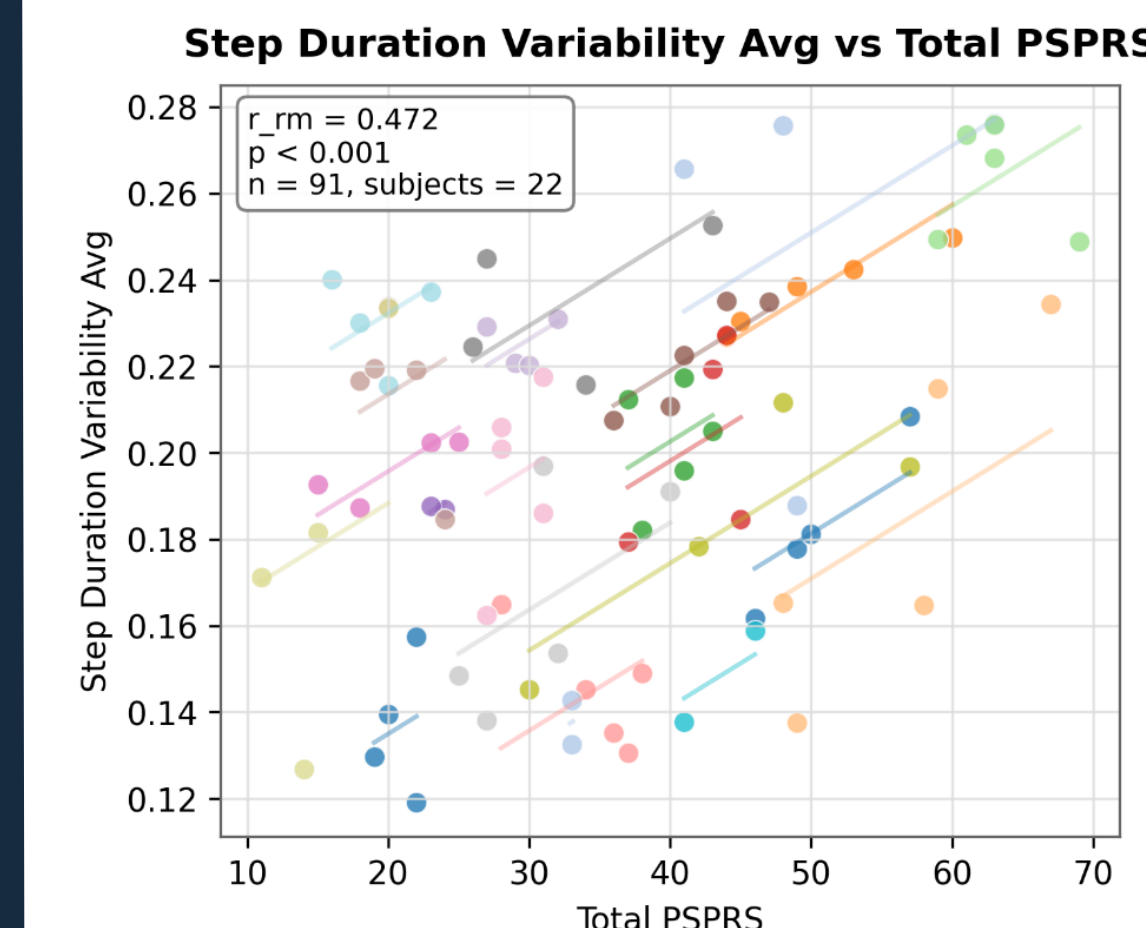
Take Home Message

- Step duration variability (SDV) captured multiple facets of PSP progression, including disease severity, motor disability, functional status, and quality of life.
- Increases in gait timing variability tracked worsening motor disease severity over time.
- Strongest repeated measure correlations were observed with Total PSPRS (|r|≈0.44–0.46) and Motor CBFS (|r|≈0.39–0.42).
- SDV captures longitudinal disease progression rather than isolated gait abnormalities.

Acknowledgment

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Repeated-measures correlations between digital and clinical outcomes



Take Home Message

- Gait Variability Reflect Disease Severity:** Higher step duration variability significantly correlate with worse clinical progression, worsening overall disease severity (Total PSPRS) and motor-balance function (CBFS).
- Reduced Mobility Strongly Impacts Quality of Life:** As PSP symptoms progress and quality of life (QoL Total) declines, patients show a significant decrease in standing time, indicating a clear transition toward more sedentary behavior.
- Digital Biomarkers Objectively Track PSP Progression:** Sensor-derived physical activity metrics demonstrate strong repeated measures correlations (repeated measure correlation up to 0.48, p < 0.05) across motor, quality of life, and health-state assessments, highlighting their value for longitudinal, objective clinical monitoring.

References

- Sharma, Mansi, et al. "Remote at-home wearable-based gait assessments in Progressive Supranuclear Palsy compared to Parkinson's Disease." BMC neurology 23.1 (2023): 434.
- Kang, Kyurim, et al. "Utilizing speech analysis to differentiate progressive supranuclear palsy from Parkinson's disease." Parkinsonism & Related Disorders 115 (2023): 105835.
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