Wearable Sensors for Quantitative Motor Assessments in Multiple System Atrophy

Daniel O. Claassen[1], Jessica Iregui[1], Amy Wynn[1], Charles S. Davis[3], Cynthia Wong[2], David Stamler[2]
[1] Vanderbilt University Medical Center, Nashville, TN, USA; [2] Alterity Therapeutics, Newark, CA, USA; [3] CSD Biostatistics, Oro Valley, AZ, USA

VANDERBILT UNIVERSITY MEDICAL CENTER

OBJECTIVE

- To determine the utility of quantitative wearable sensors in multiple system atrophy (MSA).

BACKGROUND

- MSA is a rapidly progressive parkinsonian disorder that variably presents with parkinsonism, ataxia, and autonomic impairment.
- Motor impairment results from Parkinsonism and ataxia, contributes to gait disturbance and falls, and reduces quality of life in MSA.
- Wearable sensors have potential to characterize motor disability in an outpatient setting and to serve as clinical trial outcomes.
- PAMSys is a validated wearable sensor for continuous monitoring of gait and activity parameters

METHODS

- Participants enrolled in biomarkers of progression in MSA (bioMUSE) were diagnosed with early MSA (<3 years of motor symptoms) by clinical assessment.
- All had neurologic exam, neuroimaging and fluid biomarkers.
- The motor exam of the Unified MSA Rating Scale (UMSARS II), Parkinson Plus Scale (NNIPPS), and Tandem Walk (TW), were completed at Baseline (BL) and every 3 months.
- PAMSys actigraphy sensors were worn continuously for up to 12-months, allowing assessment of gait parameters (step count, bouts of walking, steps per bout, cadence/variability), postures (minutes of sitting, lying, standing, or walking) and postural transitions (sit-to-stand).
- Clinical assessments were obtained at BL and months 3, 6, 9 and 12. At each time point, sensor parameters were obtained by averaging data over 14-day epochs.
- Pearson correlation coefficients between each clinical variable and each sensor variable were estimated at each time point. The two-sided p-value from the test of the null hypothesis that the true correlation equals zero was computed.

Table. Baseline Demographic and Clinical Data

N	12
Sex (M/F)	6/6
Age (years), mean	64.2
UMSARS II Total (baseline), mean	13.8
NNIPPS Motor score (baseline), mean	28.4

RESULTS

- There was a strong alignment between the sensor parameters and motor assessments.
- Daily step count negatively correlated ($|r| > 0.6$) with UMSARS II and NNIPPS Motor score at months 3, 6, 9, and 12 indicating that a greater motor impairment was correlated with fewer steps
- Bouts of walking negatively correlated ($|r| > 0.7$) with UMSARS II and NNIPPS Motor score across months 3, 6, 9, and 12, indicating that fewer bouts of walking was associated with greater clinical severity.
- Greater time spent lying positively correlated ($r > 0.7$) with both clinical outcome measures across months 3, 6, 9, and 12. See Figure 1.
- We created a 'mobility ratio' which assessed the ratio of active movement (standing and walking) to immobility (sitting and lying). This ratio negatively correlated ($|r| > 0.7$) with clinical severity at months 6, 9, and 12.
- Tandem walk assessments were strongly correlated with total number of steps, bouts of walking, minutes lying down, and mobility ratio ($r > 0.6$) across months 3, 6, 9,and 12

Figure 1: 60-day average data over 12 months

Legend: Data represent the moving average from baseline to one year follow-up. Note the decline in the slowly progressive patient between 6 and 12 months in step count and walking time.

Clinical data (NNIPPS Motor score, UMSARS II) were obtained at BL at 3, 6, 9 and 12 months

Rapidly progressive patient (upper row):
- NNIPPS: 23, 66, 68, 70, 84; UMSARS II : 27, 26, 25, 27, 31

Slowly progressive patient (lower row):
- NNIPPS: 35, 43, 45, 44, 50; UMSARS II : 13, 19, 19, 19, 20

Figure 2: Patient-level data for rapidly (left) and slowly (right) progressive patients for step count, bouts of walking, walking time and lying time over 12 months, presented as daily values and 7- and 30-day averages.

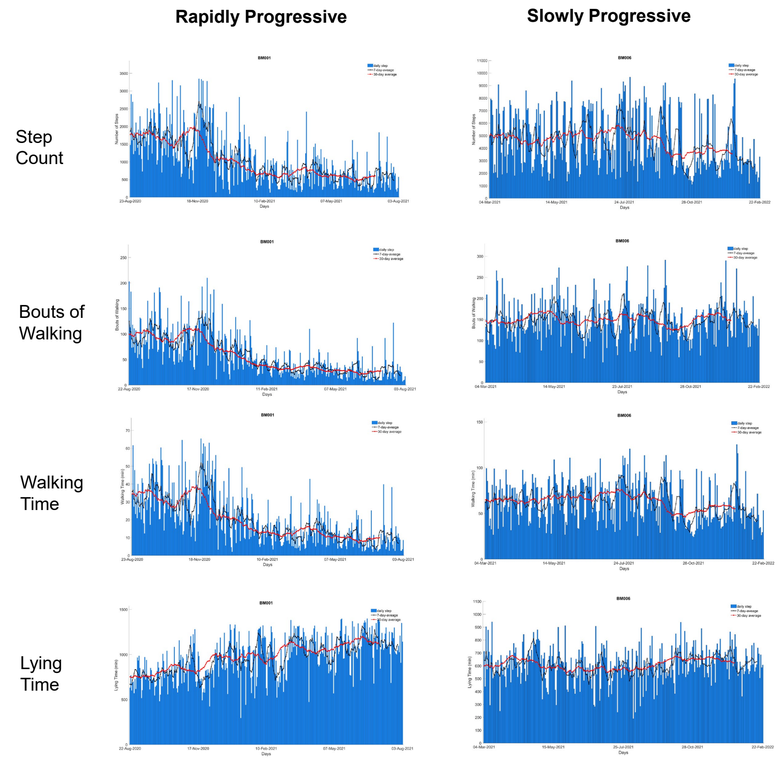
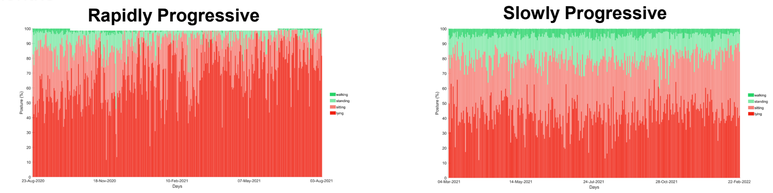


Figure 2: Posture plots present % of time with active movement (walking or standing, green) with immobility (sitting or lying, red) in rapidly and slowly progressive patients over 12 months



CONCLUSIONS

- Sensor parameters correlate strongly with clinical scales of motor impairment and are largely driven by changes in gait stability
- Novel quantitative motor measures provide important clinical data in MSA patients that is not captured by neurological examination
- Step count and walking time are sensitive measures of disease progression in early MSA
- These results will inform future trials in MSA as potential outcome measures for disease modifying therapies

Ref: Payan CA et al; NNIPPS Study Group. Disease severity and progression in progressive supranuclear palsy and multiple system atrophy: validation of the NNIPPS--Parkinson Plus Scale. PLoS One. 2011;6(8):e22293.