Prediction of Falls and Gait Assistance through Postural Sway in Parkinson's Disease

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Background

- Up to 87% of people with Parkinson's disease have suffered at least one fall by the time they have had the disease for 20 years[1].
- The cause of falls is often multifactorial and varied but multiple clinical risk factors have been studied including a history of falls, freezing of gait, cognitive impairment, and those with the postural instability gait difficulty subtype of PD[2].
- Dynaport is a wearable three-dimensional accelerometer and gyroscope capable of calculating a variety of gait parameters.
- This study aims to assess whether Dynaport postural sway parameters of **jerk index (JI)**, **root mean square of center of mass displacement (RMS Disp)**, or **displacement mean velocity (MV Disp)** in **eyes open (EO)** and **eyes closed (EC)** stance can predict conversion to a faller or the new need of an assistive gait device.

Methods

- Longitudinal study of 318 PD patients at the University of Maryland from October 2015 to March 2020
- UPDRS, MOCA, demographic information, and Dynaport postural sway parameters were measured at initial appointment.

Falls Assessment

- Follow up of at least 500 days was available for 72 patients
- Patients were divided into 3 groups based on their report of falls on questions 13 of the UPDRS
  - **Converters (CV)**: reported no falls at initial appointment but reported falls at follow up
  - **Non-Fallers (NF)**: never reported falls
  - **Fallers (F)**: reported falls at initial visit
- Differences between populations in JI, RMS Disp, and MV Disp during postural sway were assessed through ANOVA

Assistive Device Assessment

- 62 patients were available who did not report use of assistive device (AD) at initial appointment (cane, walker, wheelchair) and were divided into 2 groups
  - **AD:** reported needing an assistive device at follow up
  - **No AD:** never required assistive device during follow up
- Differences between populations in JI, RMS Disp, and MV Disp during postural sway assessed through two-tailed T Test

Results

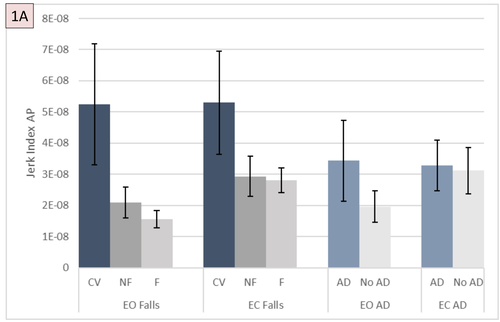
Fall Assessment

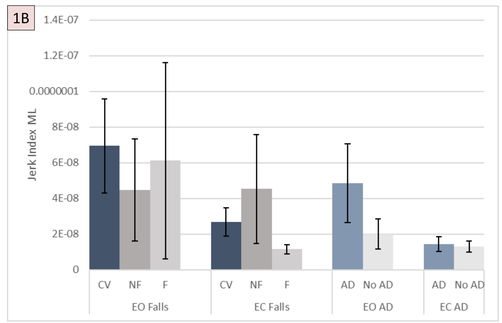
Fall Study	CV Mean	CV SEM	NF Mean	NF SEM	F Mean	F SEM	P Value CV vs NF	P Value CV vs F	P Value F vs NF
EO JI AP	5.24E-08	1.93E-08	2.09E-08	4.94E-09	1.56E-08	2.77E-09	**0.081**	0.076	0.94
EC JI AP	5.29E-08	1.66E-08	2.93E-08	6.47E-09	2.81E-08	3.90E-09	0.197	0.25	0.996
EO JI ML	6.94E-08	2.63E-08	4.47E-08	2.87E-08	6.12E-08	5.49E-08	0.87	0.99	0.95
EC JI ML	2.69E-08	8.03E-09	4.53E-08	3.06E-08	1.15E-08	2.49E-09	0.85	0.92	0.604
EO RMS Disp AP	1.28E-01	2.68E-02	1.50E-01	2.03E-02	1.68E-01	3.13E-02	0.798	0.568	0.869
EC RMS Disp AP	1.25E-01	2.56E-02	1.46E-01	1.95E-02	1.76E-01	2.98E-02	0.795	0.366	0.657
EO RMS Disp ML	4.19E-02	8.71E-03	4.48E-02	7.14E-03	5.96E-02	1.38E-02	0.972	0.455	0.515
EC RMS Disp ML	3.62E-02	7.00E-03	4.56E-02	7.08E-03	5.90E-02	1.44E-02	0.737	0.261	0.567
EO MV Disp AP	8.74E-05	9.99E-06	6.77E-05	4.35E-06	7.61E-05	7.60E-06	**0.103**	0.559	0.679
EC MV Disp AP	9.05E-05	7.64E-06	7.31E-05	7.36E-06	8.44E-05	7.55E-06	0.238	0.871	0.56
EO MV Disp ML	4.87E-05	5.89E-06	3.42E-05	3.36E-06	3.25E-05	5.59E-06	**0.066**	0.078	0.968
EC MV Disp ML	4.01E-05	3.99E-06	3.60E-05	5.29E-06	3.31E-05	4.22E-06	0.823	0.648	0.913

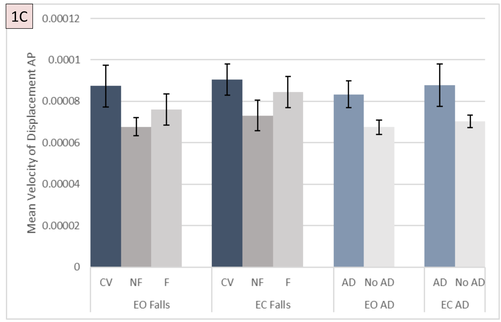
Assistive Device Assessment

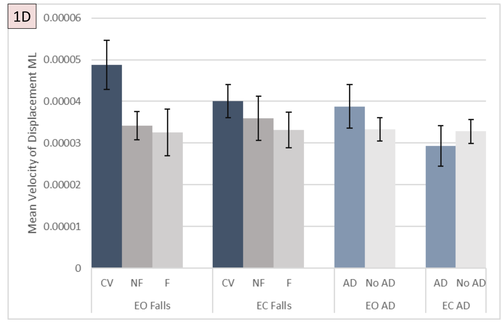
Assistive Device	AD Mean	AD SEM	No AD Mean	No AD SEM	P Value AD vs No AD
EO JI AP	3.43E-08	1.30E-08	1.96E-08	5.10E-09	0.22
EC JI AP	3.28E-08	8.15E-09	3.12E-08	7.44E-09	0.91
EO JI ML	4.86E-08	2.20E-08	2.01E-08	8.41E-09	0.15
EC JI ML	1.44E-08	4.22E-09	1.30E-08	3.12E-09	0.82
EO RMS Disp AP	1.62E-01	3.51E-02	1.52E-01	1.80E-02	0.803
EC RMS Disp AP	1.31E-01	2.39E-02	2.39E-02	1.75E-02	0.56
EO RMS Disp ML	3.69E-02	9.59E-03	5.13E-02	6.78E-03	0.302
EC RMS Disp ML	3.21E-02	1.00E-02	5.08E-02	6.70E-03	0.19
EO MV Disp AP	8.34E-05	6.56E-06	6.75E-05	3.42E-06	**0.034**
EC MV Disp AP	8.78E-05	1.02E-05	7.03E-05	3.06E-06	**0.031**
EO MV Disp ML	3.88E-05	5.22E-06	3.33E-05	2.81E-06	0.36
EC MV Disp ML	2.93E-05	4.89E-06	3.28E-05	2.90E-06	0.58

Figure 1: (A)Mean and SEM of jerk index in anteroposterior directions. (B) Mean and SEM of jerk index in mediolateral directions. (C) Mean velocity of center of mass displacement in anteroposterior directions. (D) Mean Velocity of center of mass displacement in mediolateral directions.









Demographics

Fall Study	Converters	Non-Fallers	Fallers
number	21	33	18
Gender (% Male)	71%	59%	67%
Age	70	66	65
Time from Sx Onset (Yrs)	9	7	13
Hoehn and Yahr	2.29	2.09	2.53
Schwab and England	75.7	86.4	76.4
UPDRS 29	1.1	0.81	1.33
UPDRS 30	0.48	0.25	0.83
UPDRS Part 3	24	23	27
Total UPDRS	37	30	44
MOCA	26	27.5	27.35
Mean follow up duration (days)	1008	862	858
Mean to report of fall (days)	736		

Assistive Device Study	AD	No AD
number	13	33
Gender (% Male)	85%	54%
Age	70	66
Time from Sx Onset (Yrs)	13	8
Hoehn and Yahr	2.35	2.01
Schwab and England	82	86
Reports Falls	38%	23%
UPDRS 29	1.23	0.72
UPDRS 30	0.38	0.26
UPDRS Part 3	24	20
Total UPDRS	37	30
MOCA	27.2	26.4
Mean follow up duration (days)	1014	804

Discussion

- Prior studies using Dynaport and similar devices have identified postural sway (jerk and center of mass deflection), stride length variability, reduced cadence, and slower walking speed as factors associated with falls[3].
- A recent UMMC cross sectional study of postural sway identified anterior-posterior jerk, root mean square of the center of mass displacement, and mean velocity in the mediolateral direction as postural sway parameters associated with Parkinson's patients reporting falls.
- In this study there were **positive trends for velocity of displacement in the mediolateral and anteroposterior directions and jerk index in the anteroposterior direction** between those who were non-fallers but went on to fall and those who remained non-fallers throughout the study, significance was not reached.
- **Significance was reached for the association of mediolateral and anteroposterior velocity of displacement** for the prediction of new need of assistive device, with positive trends in other variables.
- Interpretation of this data should be guarded given the demographic differences between the groups but does demonstrate some postural sway parameters that are promising targets for predicting new falls risk in Parkinson's patients.

References

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2. Paul SS, Sherrington C, Canning CG, Fung VS, Close JC, Lord SR. The relative contribution of physical and cognitive fall risk factors in people with Parkinson's disease: a large prospective cohort study. *Neurorehabil Neural Repair*. 2014;28(3):282-290. doi:10.1177/1545968313508470
3. Matinolli M, Korpelainen JT, Korpelainen R, Sotaniemi KA, Virranniemi M, Myllylä VV. Postural sway and falls in Parkinson's disease: a regression approach. *Mov Disord*. 2007;22(13):1927-1935. doi:10.1002/mds.21633