

## Peak Turning Velocity As a Marker of Balance Confidence and Walking Limitation in Persons with MS

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## Disclosures

- Wagner
  - Acorda Therapeutics (salary, stock, honorarium), Genzyme Corporation: Advisory board member
- Naismith
  - Consulting: Acorda, Bayer, Biogen, EMD Serono, Genentech, Genzyme, Novartis, Questcor



## Background

- **Ambulation in MS is commonly assessed in clinic and trials by the 25 foot timed walk (25FTW)**
  - Measure of straight-line walking velocity.
- **pwMS with impaired postural transitions reported more difficulties with balance and ambulation (Adusumilli et al, CMSC 2014)**
  - Assessed by Timed-Up and Go (TUG), Activities-Specific Balance Confidence Scale (ABC), MS Walking Scale-12 (MSWS12)
- **Turns are an important component of ambulation and balance, but are challenging to quantify.**



## Background

- **Turning may be impaired even in mild MS which may not be noticeable using stopwatch based assessments (Spain et al 2012).**
- **Body worn motion sensors are able to detect differences between MS and Healthy Controls when traditional timed tests do not (Spain et al, 2012).**
- **Impairments in turning may be related to self-perceived balance and walking (King et al, 2012).**



## Sensor Technology

- **Spatiotemporal gait analysis with APDM Opal wireless sensors**
  - IWalk software of Mobility Lab (APDM©, Portland, Oregon, USA)



The APDM Mobility Lab gait analysis system.

**Left:** Sensors worn on the ankles, wrists, lower back, and chest.

**Right:** Wireless device receives signals from sensors for storage on laptop.



## Sensor Technology (Cont.)

### Accelerometer

- Measures applied acceleration acting along a sensitive axis (Spain et al, 2012)

### Gyroscope

- Measure orientation around a fixed point (Ozdemir, 2014)
- Provides torque, angular momentum, and angular velocity

### Magnetometer

- Measures magnetic field disturbance as magnetic flux density (Ozdemir, 2014)
- Provides position of extremities in a magnetic field coordinate system



## Timed Up and Go (TUG)

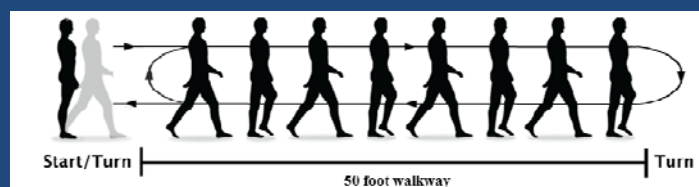
- Gait and Postural Transition Test (7 Meters)
  - 3 trials
- Sensor Technology:
  - Provides gait information occurring *during* each clinical measure
  - Able to analyze and output data derived from each stage of a clinical test
    - Straight path walking
    - Postural transitions
      - Sit-to-stand
      - Turn-to-sit
    - Turns



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## Six Minute Walk Test (6MWT)

- Test of Walking Endurance and Turning
  - Walk around two cones 50 feet apart



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# MS Sensor Study

- **Aim: Determine clinical measures that predict patient-reported balance and walking ability in MS patients**
  - Evaluate the contribution of turns and self-reported ambulation

## Tests:

Timed Up and Go (TUG)  
Six Minute Walking Test (6MWT)

## Clinical Disability:

Expanded Disability Status Scale (EDSS)

## Questionnaires:

Activities-specific Balance Confidence Scale (ABC)  
12-Item MS Walking Scale (MSWS-12)



## Activities-specific Balance Confidence Scale (ABC)

**The Activities-specific Balance Confidence (ABC) Scale\***  
For each of the following activities, please indicate your level of self-confidence by choosing a corresponding number from the following rating scale:

0% 10 20 30 40 50 60 70 80 90 100%  
no confidence completely confident

\*How confident are you that you will not lose your balance or become unsteady when you...

1. ...walk around the house? \_\_\_%
2. ...walk up or down stairs? \_\_\_%
3. ...bend over and pick up a slipper from the front of a closet floor \_\_\_%
4. ...reach for a small can off a shelf at eye level? \_\_\_%
5. ...stand on your tiptoes and reach for something above your head? \_\_\_%
6. ...stand on a chair and reach for something? \_\_\_%
7. ...sweep the floor? \_\_\_%
8. ...walk outside the house to a car parked in the driveway? \_\_\_%
9. ...get into or out of a car? \_\_\_%
10. ...walk across a parking lot to the mall? \_\_\_%
11. ...walk up or down a ramp? \_\_\_%
12. ...walk in a crowded mall where people rapidly walk past you? \_\_\_%
13. ...are bumped into by people as you walk through the mall? \_\_\_%
14. ...step onto or off an escalator while you are holding onto a railing? \_\_\_%
15. ...step onto or off an escalator while holding onto parcels such that you cannot hold onto the railing? \_\_\_%
16. ...walk outside on icy sidewalks? \_\_\_%

## MS Walking Scale 12 (MSWS 12)

### MSWS-12 Questionnaire

Over the last 2 weeks, how much has your MS:

1. Limited your ability to walk?
2. Limited your ability to run?
3. Limited your ability to climb up and down stairs?
4. Made standing when doing things more difficult?
5. Limited your balance when standing or walking?
6. Limited how far you are able to walk?
7. Increased the effort needed for you to walk?
8. Made it necessary for you to use support when walking indoors?
9. Made it necessary for you to use support when walking outdoors?
10. Slowed down your walking?
11. Affected how smoothly you walk?
12. Made you concentrate on your walking?



## Patient Reported Outcomes (PROs)

- Patient's perception of abilities at home and in community
- Clinical measures sometimes correlate poorly with PROs
- FDA, NIH, and Insurance Providers require clinical outcomes linked to patient experience and abilities

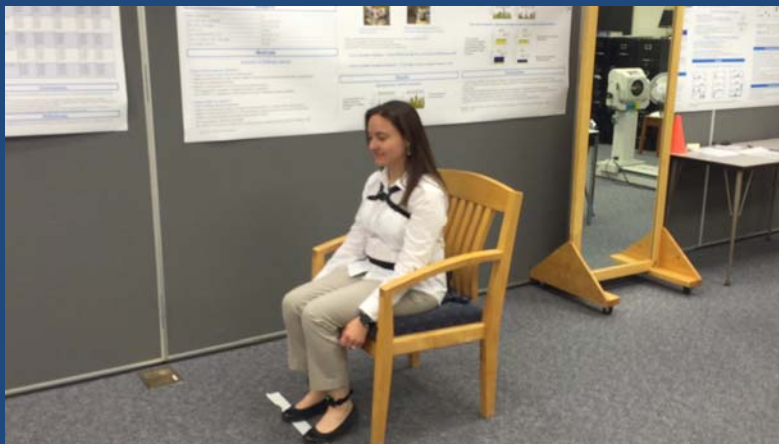


## Hypothesis

- Turns add important information to the assessment of walking and balance in MS patients.
  - Better correspond to PROs
  - Important clinical assessment of balance and gait stability
- How much does Peak Turn Velocity add to the prediction of ABC and MSWS-12 questionnaires?



## Methods



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## Analysis

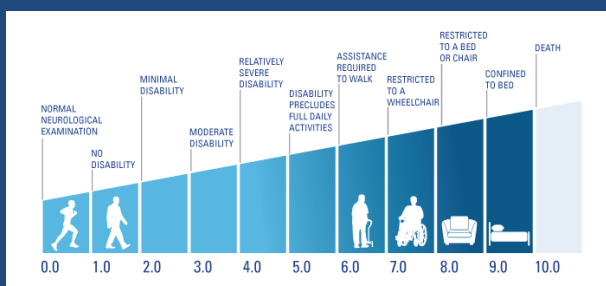
- Stride Velocity as a baseline predictive variable
- Spearman correlations to evaluation relation between variables
- Stepwise linear regression to determine predictive ability of gait parameters

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## Patient Characteristics

### 91 Subjects:

- EDSS 0-2.5 (n = 60)
- EDSS 2.5-4.5 (n = 26)
- EDSS 4.5-6.5 (n = 5)



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## Results

### Correlations:

- ABC and MSWS-12
  - $R = -0.80$  ( $p < 0.0001$ )
- 6MWT Stride Velocity (SV) and 6MWT Peak Turning Velocity (PTV)
  - $R = 0.53$  ( $p < 0.0001$ )
- TUG SV and TUG PTV
  - $R = 0.58$  ( $p < 0.001$ )

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## Results

### Prediction of ABC

Step 1: 6MWT SV;  $R^2 = 0.20$

Step 2: 6MWT SV + 6MWT PTV;  $R^2 = 0.33$

*65% improvement in predictive power ( $p < 0.0001$ )*

Step 1: TUG SV;  $R^2 = 0.19$

Step 2: TUG SV + TUG PTV;  $R^2 = 0.28$

*47% improvement in predictive power ( $p < 0.001$ )*



## Results (Cont.)

### Prediction of MSWS-12

Step 1: 6MWT SV;  $R^2 = 0.28$

Step 2: 6MWT SV + 6MWT PTV;  $R^2 = 0.41$

*46% improvement in predictive power ( $p < 0.0001$ )*

Step 1: TUG SV;  $R^2 = 0.27$

Step 2: TUG SV + TUG PTV;  $R^2 = 0.36$

*33% improvement in predictive power ( $p < 0.001$ )*



## Conclusions

- Turning is important in the assessment of gait and balance
- Similar results were found for TUG (1 turn) and 6MWT (multiple turns)
- Clinicians should incorporate a qualitative assessment of turning within their gait assessment



A clinician's goal is to efficiently collect enough clinical information to determine the best therapy.





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