Rapid Foot Tapping Ability Distinguishes between Multiple Sclerosis Sub-Types and Is Associated with Mobility Function

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Background

- EDSS is often used to track progression of MS, but has poor responsiveness in progressive MS individuals[1].
- Preliminary work from our laboratory (unpublished) suggests that while mobility measures such as the timed-up and go (TUG) and 25-foot walk test (25FWT) can distinguish individuals with MS from non-MS controls (CON), they cannot distinguish between non-progressive (MS-NP) and progressive (MS-P) MS sub-types.
- There is a critical need to identify a sensitive and non-ambulatory task that can distinguish MS sub-types.
- Tapping is a task that requires coordination and central motor drive to perform. It is a commonly used clinical test in neurological exams.
- Prior work has shown that people with MS have decreased foot tapping ability compared to healthy controls[2], but the difference in foot tapping ability between different MS-subtypes is unclear.

Aim 1: To determine whether rapid foot tapping ability can distinguish MS from controls and between the MS sub-types.

Aim 2: To assess relation of rapid foot tap ability to mobility and disabiliy levels.

Methods

Participants: 31 participants with MS-NP, 31 participants with MS-P, 31 age- and sex- matched controls.

Experimental paradigm:

- Each participant wore inertial sensors (APDM, Inc, Portland, OR) on the foot that measured angular velocity (Figure 1).
- Participants were instructed to tap their foot as fast as possible for 10s while seated at a self-selected knee and ankle angle.
- Average foot tap count was based on 3 trials on each foot.
- A successful "tap" was identified as ascending zero-crossing of angular velocity by using a custom MATLAB program (Figure 2).
- TUG and 25FWT were administered to relate mobility to rapid foot tapping.
- Most recent clinician-scored EDSS was obtained.

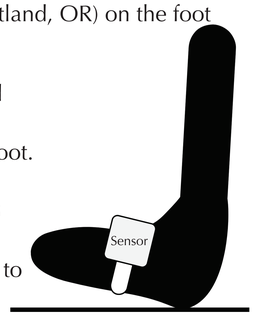


Figure 1. Experimental setup.

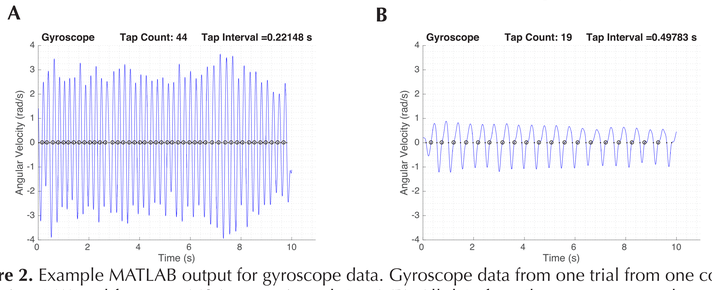


Figure 2. Example MATLAB output for gyroscope data. Gyroscope data from one trial from one control participant (A) and from one MS (progressive sub-type) (B). All data from the gyroscope was low-pass filtered at 6 Hz. Signal was cropped at 10 seconds after the first identified tap (1280 samples = 10s). Blue lines represent angular velocity (gyroscope output). Black dots represent points at which taps were identified.

Results

1. Foot tap count can distinguish between controls and MS, and between MS sub-types.

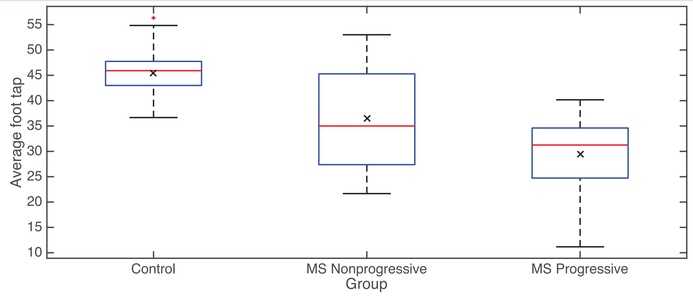


Figure 3. Box plots of tap count. Red line represents the median for the different experimental groups. Group means are represented by black Xs. Outliers are represented by red crosses.

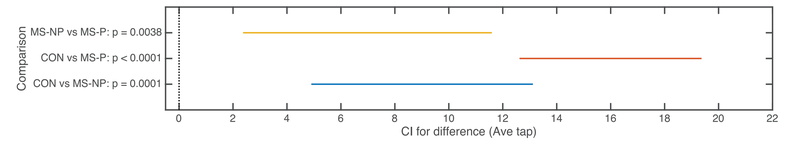
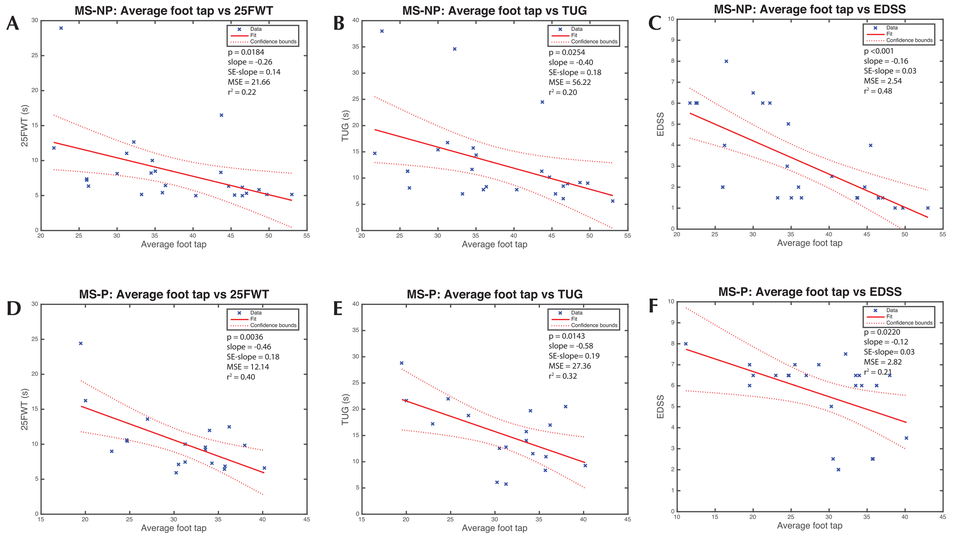


Figure 4. Confidence interval for difference between means for average foot tap. p- values are shown for each comparison. All comparisons do not cross the 0 line, and the biggest difference was seen between CON and MS-P.

- Average foot tap count in CON was significantly greater than the average foot tap count in MS-NP and MS-P, and average foot tap count in MS-NP was significantly greater than in MS-P (Figure 3 and 4).

2. Foot tap count is associated with mobility and disability measures



- The relationship between average foot tap and 25FWT and TUG was significant for both MS-NP (Figure 5A and 5B, respectively) and MS-P (Figure 5D and 5E, respectively).
- The relationship between average foot tap and EDSS scores was significant for both MS-NP (Figure 5C) and MS-P (Figure 5F).
- We tested for equal slopes and results showed that the slopes for regression between average foot taps and 25FWT times for MS-NP and MS-P were not significantly different (p = 0.3836). The same was true for the regression between average foot tap and TUG (p = 0.4864) and the regression between average foot tap and EDSS scores (p = 0.3468).

Figure 5. Linear regression plots between average foot tap and mobility measures. Blue Xs represent each data point, the red line is the line of best fit, and the dotted red lines are the 95% confidence bounds. Top row (A, B, C) shows regressions in the MS-NP group. Bottom row (D, E, F) shows regressions in the MS-P group. First column (A, D) shows regressions between average foot tap count and 25FWT, 2nd column (B, E) between average foot tap count and TUG, and the 3rd column between average foot tap count and EDSS. p is the p-value for testing 0 slope (equal to 0 correlation).

Discussion

- **Average foot tap count can differentiate between CON and MS and between MS-subtypes.**
- **Higher average foot tap count is associated with higher ambulatory ability (lower times for 25FWT and TUG) and lower disability levels in MS groups**
- **The association between foot tap ability and mobility measures suggest that rapid foot-tapping may be a useful marker to track or predict progression of disability and mobility dysfunction in people with MS, regardless of their ability to ambulate.**

References

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