Standing, Walking, and Thinking in Persons with Multiple Sclerosis

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Introduction

• Multiple sclerosis (MS) is a chronic neurologic disease that is common among adults.
• MS involves intermittent bursts of focal inflammation that eventually leads to demyelination and transection of axons throughout the nervous system.
• This axonal damage leads to conduction delay and block of electrical impulses along neuronal pathways throughout the nervous system leading to widespread dysfunction.
• Walking is impaired in persons with MS with upwards of 85% of persons reporting impaired gait as a primary limitation (Scheinberg, L., et al., 1980).
• Postural Control is also a common impairment in persons with MS (Frizovic, Morris, & Vowels, 2000).
• Approximately 65% of persons with MS also show signs of cognitive dysfunction (Maurelli, M., et al., 1992; Chiaravalloti & DeLuca, 2008).
• Cognitive factors have been shown to play a role in the stability of both posture and gait in various populations (Woollacott & Shumway-Cook, 2002).
• This interaction between cognition and mobility has recently been observed in persons with MS (Hamilton, F., et al., 2010; Kalron, Divr, & Achiron, 2010).
• Walking and postural control have been investigated separately.
• This study examines the effect of simultaneously performing a cognitive task on postural control and gait in persons with MS across a range of disability.
• This study evaluates the relationship between the cost of a cognitive task in balance and the cost of a cognitive task in gait in persons with MS.

Data Collection

• Gait was assessed by calculating cadence and normalized walking velocity (NWV). The leg length of each participant was used to calculate the NWV.
• Postural control was assessed by calculating the range of the center of pressure (COP) trajectory in the anteroposterior (AP) direction and median velocity (MV) of the COP in the AP direction.
• The effect of a cognitive task on the gait and postural control parameters was measured by calculating the dual task cost (DTC) of each parameter.
• Dual task refers to the effect of simultaneously completing a physical and cognitive task.
• The two trials of each condition were averaged to improve the reliability of the measure.
• The DTC is calculated by the following equation:

\[
DTC = \frac{S - D}{100}
\]

- Where \( S \) is equivalent to the single task performance and \( D \) is equivalent to the dual task performance of the specified parameter.
- Statistical analyses were completed in SPSS version 17.0 (SPSS Inc. Chicago, IL).
- A two-sided test was performed to confirm significance of the DTC for each parameter when compared to 0 (the value that would be expected if there was no difference in parameter value for the trials involving the WLG task).
• The association between balance and gait DTC as well as EDSS was determined using Spearman rho (p) correlation analysis.

Results

- Only the AP direction of the balance task was analyzed because it relates to the direction of motion in the gait task parameters.
- Quiet measures are just the averaged values from the quiet trials of each participant.
- There is a correlation to EDSS between DTC of gait, but not postural control. EDSS was correlated with MV in quiet within EDSS.
- The quiet parameters for gait are also strongly correlated with EDSS.

Discussion

- The postural control parameters both have a negative DTC showing that the WLG task caused the participant to sway farther and faster in the AP direction than in the trials without the WLG task; The gait parameters have a positive DTC showing that the WLG task caused a decrease in both the cadence and the NWV.
- There is a significant difference between the dual task and single task conditions in all four parameters tested. A cognitive task affects the performance of a physical task in persons with MS, regardless of whether it is a stationary or ambulatory task.
- The relationship between the DTC gait parameters and EDSS is very strong, whereas the DTC postural control parameters do not have a significant correlation. This may be due to the dependence of EDSS score on walking ability.
- Since only the AP MV in quiet postural control is related to EDSS, this parameter must be a more sensitive measure for predicting EDSS scores from postural control.
- Correlations between parameters existed for all related parameters, such as AP MV and AP Range, and there were also correlations between DTC parameters of cadence and AP MV, and quiet parameters of NWV and AP MV, once again demonstrating the sensitivity of using AP MV as a measurement parameter as opposed to AP Range.

Methods

Participants

- 36 community living persons with a neurololgist confirmed diagnosis of Multiple Sclerosis (MS).
- 15 Males/ 21 Females
- Expanded Disability Status Scale (EDSS) scores ranged from 2.0-6.5 with a median of 4.5.
• A score of 0 on the scale shows no disability, 4.0 is the onset of walking impairment, 6.0 is the use of a walker, and 10.0 is death due to MS.

Tasks

- The cognitive task used in this study was a modified word list generation (WLG) task.
- A different list was used for each trial.
- Name as many animals as you can
- List words that begin with the letter "D."
- Each participant completed 4 walking trials on a 26-foot GAITRite™ electronic walkway at a comfortable pace with or without an assistive device.
- The first 2 trials were quiet walking, the second 2 trials were completed with a WLG task.
- Each participant completed 4 - 30 second standing trials on a 3-axis force platform (AMTI, Watertown, MA).
- The first 2 trials were quiet standing, the second 2 trials were completed with a WLG task.

Figure 1. Center of Pressure (COP) traces from force platform. a) a characteristic COP trace from a quiet standing trial. b) a characteristic trace from the same subject during a WLG trial. Notice the increase in AP range between the two conditions.

Figure 2 (left). Gait Lab Setup. In the foreground is the GaitMat, electronic walkway. In the background is the force platform setup used for postural control.

Figure 3 (below). Foot fall output of GaitMat. A characteristic footfall output pattern from the GaitMat.

Table 1. DTC T-Test Values compared to 0

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postural Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP Range</td>
<td>-27.9</td>
<td>79.2%</td>
<td>0.042</td>
</tr>
<tr>
<td>AP MV</td>
<td>-28.0%</td>
<td>68.3%</td>
<td>0.019</td>
</tr>
<tr>
<td>Gait</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cadence</td>
<td>7.7%</td>
<td>6.0%</td>
<td>0.001</td>
</tr>
<tr>
<td>NWV</td>
<td>12.2%</td>
<td>7.9%</td>
<td>0.001</td>
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</tbody>
</table>

Spearman Correlations

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Correlation Coefficient</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiet Postural Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP MV</td>
<td>0.458</td>
<td>0.004</td>
</tr>
<tr>
<td>NWV</td>
<td>0.435</td>
<td>0.006</td>
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<tr>
<td>Quiet Gait</td>
<td></td>
<td></td>
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<tr>
<td>Cadence</td>
<td>-0.715</td>
<td>0.001</td>
</tr>
<tr>
<td>NWV</td>
<td>-0.733</td>
<td>0.001</td>
</tr>
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</table>

Figure 1 (below). DTC and NWV parameters.

Table 2. Other Spearman Correlations

<table>
<thead>
<tr>
<th>Parameter 1</th>
<th>Parameter 2</th>
<th>Correlation Coefficient</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadence</td>
<td>AP MV</td>
<td>0.398</td>
<td>0.013</td>
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<tr>
<td>Quiet Measures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NWV</td>
<td>AP MV</td>
<td>-0.385</td>
<td>0.017</td>
</tr>
</tbody>
</table>

For the statistical analysis, a 6.0% significance level was set as the cutoff value. Only the AP direction of the balance task was analyzed because it relates to the direction of motion in the gait task parameters.


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