Background
- People with multiple sclerosis (MS) commonly experience a decline in walking performance evidenced by decreased walking velocity (WV) during the 6-minute walk test (6MWT).
- In addition, increases in heart rate (HR) and the rate of oxygen consumption (VO2) have been observed during the initial three minutes of the 6MWT which is followed by an apparent steady-state.
- However, the direct relationship between HR and WV during prolonged walking has not been well studied.

Objective
- To explore the relationship between changes in HR (i.e., cardiovascular demand) and WV during prolonged walking in people with moderate MS-related disability.

Methods
- Nineteen participants with MS (Table 1) completed a 12-minute walk test (12MWT) on an oval track with an embedded instrumented walkway.
- WV data was collected with PKMAS Gait Analysis Software (Protokinetics, Havertown, PA) and parsed into 12, 1-minute time increments.
- HR was continuously measured with a Polar H7 wireless sensor (Polar Electro, Inc., Lake Success, NY) and average HR was calculated for each 1-minute time increment.
- Per-minute HR and WV data were first analyzed visually to identify gross patterns of change.
- Pearson correlation coefficients were used to evaluate the relationship between HR and time, WV and time, and the ratio of mean HR to mean WV (HR:WV) and time.

Results

Table 1. Participant Characteristics
<table>
<thead>
<tr>
<th>Sex</th>
<th>14 women, 5 men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>57 (Range 35-65, SD 6.7)</td>
</tr>
<tr>
<td>Years since diagnosis</td>
<td>13.8 (Range 4-31, SD 8.7)</td>
</tr>
<tr>
<td>Disease Steps</td>
<td>3 (Range 1-3, IQR = 1)</td>
</tr>
<tr>
<td>Patient-Determined Disease Steps</td>
<td>3 (Range 1-5, IQR 1.5)</td>
</tr>
<tr>
<td>12-Item MS Walking Scale</td>
<td>63.1 (Range 35-90, SD 16.6)</td>
</tr>
<tr>
<td>Modified Fatigue Impact Scale (Total)</td>
<td>41.9 (Range 3-58, SD 12.3)</td>
</tr>
</tbody>
</table>

Figure 1. Walking Velocity x Time

Figure 2. Heart Rate x Time

Figure 3. Heart Rate : Walking Velocity Ratio x Time

Conclusions
- A combination of decreasing WV in the presence of steady-state HR appears to have resulted in a significant positive correlation of HR:WV ratio over time in our sample of people with MS during the prolonged walking.
- The observation that a concomitant decline in HR did not accompany the decline in WV suggests that cardiovascular demand may have remained consistent at a lower work rate.
- The negative effect of fatigue on physical performance in people with MS is well-known; however, this data suggests the decline in performance during prolonged walking activity may also increase the cardiovascular demand.
- Further study is warranted to fully evaluate the effect of fatigue-related changes on the metabolic cost of walking using objective physiologic measurements to assess the metabolic cost of prolonged walking.
- A clearer understanding of these effects will enable rehabilitation professionals to better target the multiple contributors to the decline in performance during prolonged activities observed in people with MS.

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Heart Rate Response and Changes in Walking Velocity during the 12-Minute Walk Test in People with Multiple Sclerosis
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Results
- No significant correlation was found between WV and time (figure 1). Visual analysis indicates that WV during the 12MWT followed an attenuated U-shaped pattern, similar to that found during 6MWT in people with MS.
- A significant linear correlation between HR and Time ($r(10) = .828$, $p = .001$) was found as illustrated in figure 2.
- A significant linear correlation between HR:WV and time ($r= .928$, $p=.000$) was found as illustrated in figure 3.