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Somatosensory Impairment and Balance Dysfunction in Multiple Sclerosis

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Somatosensory Impairment and Balance Dysfunction in Multiple Sclerosis

Stephanie Jones, PhD
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Multiple Sclerosis: Progressive Mobility Impairment

80% will develop progressive form of MS within 20 years of Dx
<table>
<thead>
<tr>
<th>Symptom</th>
<th>% occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatigue</td>
<td>83.1%</td>
</tr>
<tr>
<td>Walking difficulties</td>
<td>67.2%</td>
</tr>
<tr>
<td>Stiffness and spasms</td>
<td>63.1%</td>
</tr>
<tr>
<td>Cognitive problems (memory)</td>
<td>55.8%</td>
</tr>
<tr>
<td>Bladder problems</td>
<td>55.8%</td>
</tr>
<tr>
<td>Pain</td>
<td>54.3%</td>
</tr>
<tr>
<td>Emotional and mood problems</td>
<td>37.5%</td>
</tr>
<tr>
<td>Vision problems</td>
<td>37.4%</td>
</tr>
<tr>
<td>Dizziness and vertigo</td>
<td>36.2%</td>
</tr>
<tr>
<td>Bowel problems</td>
<td>34.5%</td>
</tr>
</tbody>
</table>


Contributors? Can we intervene to maintain/improve mobility?
Slower preferred speed

Shorter stride length

Wider stride width

Longer double support time

The Normal Gait Cycle, adapted from Sutherland et al., 1994

(Benedetti 1999; Martin 2006; Kelleher 2010; Remelius 2012)

Adaptations to increase stability ????
Impaired Postural Control in People with MS: Clinical Balance Tests

- ↓ performance on timed balance tasks
  - altered base of support configurations

(Frzovic 2000; Soyuer 2006)

Standing
Stride Stance
Tandem Stance
Single Leg Stance

10 cm
Impaired Postural Control in People with MS: Posturography

• \(\uparrow\) Center of Pressure (COP) and trunk sway
• \(\uparrow\) COP velocity during standing

- worsened with increased task difficulty
  - BOS restrictions
  - self-generated perturbations (Van Emmerik 2010)
  - dual task (Boes 2012; Negahban 2011)
  - altered sensory conditions (Findling 2011; Porosinksa 2010; Spain 2012; Fjeldstad 2009; Cattaneo 2009)

Consistent with decreased stability
Impaired Postural Control in People with MS: Posturography

- Sensory Organization Test
  - Manipulate sensory conditions
  - Understand contribution of different sensory modalities

Eyes Open  Eyes Closed  Surround Moves

- SOT 1
- SOT 2
- SOT 3

Sway Referenced  Fixed Surface

- SOT 4
- SOT 5
- SOT 6

- Vision
- Vestibular

Somatosensation

Center of Pressure
Impaired Postural Control in People with MS: Posturography

Tasks that rely on somatosensory greatly impacted in MS
(Fjeldstad 2009)

Sway Referenced
Fixed Surface
SOT 1
SOT 4

Eyes Open
Eyes Closed
Surround Moves
SOT 2
SOT 3
SOT 5
SOT 6

Somatosensation

Center of Pressure
Impaired Postural Control in People with MS: Postural Responses

Automatic postural responses

70-100ms latency
A range of strategies can be used depending on many factors

- Environmental context, constraints/impairments, behavioural goals

Initiated by feedback from the Somatosensory System
Impaired Postural Control in People with MS: Postural Responses

- Significantly delayed automatic postural responses

(Cameron et al., 2008)
Impaired Postural Control in People with MS: Postural Responses

- Reduced reactive scaling but enhanced predictive scaling
  
  (Cameron et al., 2008)

(A) Predictive Scaling

↓ ability to predictively scale

↑ ability to predictively scale

Increasing Perturbation Size
Impaired Postural Control in People with MS: Postural Responses

- Reduced reactive scaling but enhanced predictive scaling
  
  \[ \text{(Cameron et al., 2008)} \]

\[ \text{Appropriate timing and scaling of postural responses thought to depend on proprioceptive feedback} \]

\[ \text{(Stapley 2002)} \]

\[ \text{Suggests somatosensory rather than cerebellar impairment} \]
Detection of Instability

- Somatosensory
  - Impaired Cutaneous Sensation
  - Impaired Proprioception

- Sensory Contributions
  - Visual
    - Blurred vision
    - Double vision
  - Vestibular
    - Vertigo

- Motor Contributions
  - Reduced Strength Due to Reduced Central Activation?
  - Increased Strength Asymmetry

- Impaired Postural Control & Mobility

- Symptomatic Fatigue
  - Increased Symptomatic Fatigue
Somatosensory loss and balance in MS

- Impaired sensation explained variance in single leg stance time
  
  (Citaker et al., 2011)
Novel Functional Assessment of Cutaneous Sensation

- Traditional sensation testing performed in supine
  - Unloaded

Are sensory thresholds the same in functional (loaded) positions?

Tactors Embedded in Shoes
- Detect vibration thresholds while standing
Novel Functional Assessment of Cutaneous Sensation

- Vibration threshold increased with increasing load

On-going Project: Will these thresholds differ in those with MS?
Enhancement of Cutaneous Sensation in MS

- Direct manipulation of cutaneous sensation to impact balance

**Use tactors to enhance sensation**

Threshold
Signal + Noise (too Low)

**Increase likelihood of detecting signal**

Demonstrated increases in sensation and reduced sway in older adults, stroke, diabetic neuropathy
Improvement of Balance using Stochastic Resonance (SR)

- Reduced COP velocity may indicate greater stability

Potential use as an ambulatory aid? Increase mobility ??

Average COP Velocity - SR Effects

![Graph showing the effect of SR on COP velocity over time.](image-url)
Improve detection of instability?

Future Work - SR to improve mobility??
Thank you!

UMass Motor Control Lab Website:
http://www.umass.edu/motorcontrol/

National MS Society Website:
http://www.nationalmssociety.org