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Somatosensory Impairment and Balance Dysfunction in Multiple Sclerosis

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Somatosensory Impairment and Balance Dysfunction in Multiple Sclerosis

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Sensory-Motor Control Laboratory
Department of Kinesiology
Multiple Sclerosis: Progressive Mobility Impairment

The Expanded Disability Status Scale (EDSS)

Increasing Mobility Impairment

⇒ 80% will develop progressive form of MS within 20 years of Dx
<table>
<thead>
<tr>
<th>Symptom</th>
<th>% occurrence</th>
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</thead>
<tbody>
<tr>
<td>Fatigue</td>
<td>83.1%</td>
</tr>
<tr>
<td><strong>Walking difficulties</strong></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?
Impaired Mobility in People with MS

- 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

- ↑ Center of Pressure (COP) and trunk sway
- ↑ 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

<table>
<thead>
<tr>
<th></th>
<th>Eyes Open</th>
<th>Eyes Closed</th>
<th>Surround Moves</th>
</tr>
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<tbody>
<tr>
<td>SOT 1</td>
<td></td>
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<td>SOT 2</td>
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<td>SOT 5</td>
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<td></td>
</tr>
<tr>
<td>SOT 6</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Sway Referenced

Fixed Surface

Somatosensation

Vision

Vestibular

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

Tasks that rely on somatosensation greatly impacted in MS

*(Fjeldstad 2009)*

Sway Referenced

Fixed Surface

Eyes Open

SOT 1

SOT 2

SOT 3

SOT 4

SOT 5

SOT 6

Eyes Closed

Surround Moves

Center of Pressure

Somatosensation
Impaired Postural Control in People with MS: Postural Responses

Automatic postural responses

70-100ms latency
Impaired Postural Control in People with MS: Postural Responses

- 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)
Impaired Postural Control in People with MS: Postural Responses

- Reduced reactive scaling but enhanced predictive scaling

(Cameron et al., 2008)

Appropriate timing and scaling of postural responses thought to depend on proprioceptive feedback

(Stapley 2002)

Suggests somatosensory rather than cerebellar impairment
Detection of Instability

**Sensory Contributions**
- Somatosensory
  - Impaired Cutaneous Sensation
  - Impaired Proprioception
- 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

Vibration Detection Threshold of Feet

- 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

Vibration Threshold Vs. Functional Loading Position

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

Priplata. 2006
Improvement of Balance using Stochastic Resonance (SR)

- Reduced COP velocity may indicate greater stability

Potential use as an ambulatory aid? Increase mobility??
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