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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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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?
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
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

Sway Referenced

Sway Referenced

Eyes Open

Eyes Closed

Surround Moves

SOT 1

SOT 2

SOT 3

SOT 4

SOT 5

SOT 6

Vision

Vestibular

Somatosensation

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

Tasks that rely on somatosensation greatly impacted in MS

(Fjeldstad 2009)

Sway Referenced
Eyes Open
SOT 1
SOT 4
Eyes Closed
SOT 2
SOT 5
Surround Moves
SOT 3
SOT 6
Somatosensation

Center of Pressure
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)

![Postural Response Latencies Chart]

**Postural Response Latencies**

- **MS**
- **CON**

Latency (ms)

0 50 100 150 200
• 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

Impaired Postural Control & Mobility

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

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

- Impaired sensation explained variance in single leg stance time
  
  \[(\text{Citaker et al., 2011})\]
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

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

**Average COP Velocity - SR Effects**

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