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Improving Balance and Mobility in People with Multiple Sclerosis

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Improving Balance and Mobility in People with Multiple Sclerosis

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Department of Kinesiology

National Multiple Sclerosis Society
Overview

- Postural and gait impairments in MS
- Interventions to improve balance and gait

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Impaired Postural Control & Mobility

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

Symptomatic Fatigue
- Increased Symptomatic Fatigue
Postural control and walking in MS

Postural control

- Center of mass
- Pressure distribution
- Center-of-pressure trajectory

Control of walking

- Anteroposterior
- Mediolateral

- Early Swing
- Mid-swing
- Late swing
- Heel-strike
Postural Changes in MS

- Balance dysfunction has been reported by up to 90% of individuals with MS (Ford et al., 2001; Hemmet et al., 2004)

- Increased CoP sway (Chung et al., 2008; Fjeldstad et al., 2009); changes with level of disability (Boes et al., 2012; Corporaal et al., 2013); reduced temporal margins to stability boundary (Van Emmerik et al., 2010; Cattaneo et al., 2012)

- Delayed automatic postural responses (Cameron et al., 2008)

- Association between lower limb muscle power asymmetry and postural instability/fatigue (Chung et al., 2008)
Changes in stride parameters during walking

- Slower preferred speed
- Shorter stride length
- Wider stride width
- Longer dual support time

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

Benedetti et al. (1999); Martin et al., (2006); Kelleher et al. (2010); Remelius et al. (2012)
Longer dual support: all speeds

Remelius et al. (2012)
Archives of Physical Medicine and Rehabilitation
Swing phase of walking

Swing Time (ms)

1) early swing  2) mid swing  3) late swing

non-MS MS
non-MS MS
non-MS MS
non-MS MS

Unstable Equilibrium

fast preferred medium slow

Gait Speed Condition

22% Early Swing 40% Mid-swing 38% Late swing Heel-strike

Heel-strike
Approach of CoM/swing foot to unstable equilibrium

A) MS

CoM$_{\text{head}}$ +10 ms

CoM$_{\text{body}}$ -26 ms

B) Control

CoM$_{\text{head}}$ -5 ms

CoM$_{\text{body}}$ -34 ms

$B_p$ = physical (toe) boundary

unipedal
Imposed speeds: MS group:
Reduced temporal margin of CoM crossing boundary in relation to swing: less of a ‘controlled fall’ (p<.005)

Preferred: ns
Head motion: projection on ground

Distance PVI from CoM (mm)

Walking Speed (m/s)

Preferred 0.6 1.0 1.4

MS Control

536 mm

728 mm
Balance and mobility intervention research

- Review exercise interventions (aerobic exercise; flexibility; strength; balance training); while each has proven beneficial in MS, a more comprehensive intervention program for individuals with MS is needed that integrates all (Asano et al. 2009).

- An 8-week intervention that used a combination of aerobic, resistance, and balance training to reduce symptom severity: improved mobility and strength (Motl et al., 2012).

- Tai Chi intervention: Increases in 25ft walk speed; Hamstring flexibility; psychosocial wellbeing; Reduction in depression and improved balance (Husted et al., 1999; Mills et al., 2000).
Tai Chi and MS

- Tai Chi intervention: 3-week intervention (standing meditation; Tai Chi slow walking) with balance, gait, strength and neural drive assessments (Averill, 2013; n=8)

- Pre-post intervention comparisons of:
  - Sensorimotor and functional assessments – plantar sensation; chair rise time (strength) and toe taps (neural drive)
  - Postural control – static and dynamic
  - Psychosocial wellbeing (Multiple Sclerosis Impact Scale -MSIS-29)
  - Fatigue (Fatigue severity score – FSS)
Tai Chi intervention: pressure sensitivity

Increased plantar pressure sensitivity (decreased threshold) in more impaired foot after intervention ($p=.02$)
Tai Chi intervention: Functional assessments

Increased in neural drive
# foot taps (p=0.024)

Decreased time to complete 5 chair raises
-> increased muscular strength (p=0.025)
Tai Chi intervention: postural control

Static balance: tandem stance; Postural sway velocity decreased (p=.066), showing increased static balance control
Tai Chi intervention: Tandem Stance

Time to Contact (s)

P=.005

P=.045

Pre Tai Chi
Post Tai Chi

TtC AP
TtC ML
Tai Chi intervention: postural control

**Dynamic balance**: standing mediation with arms movement; CoP velocity increased (p=.022), showing increased dynamic balance control.
MSIS and symptomatic fatigue

- Total psychosocial wellbeing (MSIS) increased (p=0.032) after the Tai Chi intervention

- No changes in general fatigue or leg specific fatigue were observed after the intervention. Fatigue Severity score (FSS; Krupp et al., 1988)

<table>
<thead>
<tr>
<th></th>
<th>PRE</th>
<th>POST</th>
<th>P</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSS General Score</td>
<td>44.29±11.89</td>
<td>37.86±15.22</td>
<td>0.132</td>
<td>-2.59 to 15.45</td>
</tr>
<tr>
<td>FSS Leg Score</td>
<td>29.29±7.11</td>
<td>28.71±10.47</td>
<td>0.855</td>
<td>-6.76 to 7.90</td>
</tr>
</tbody>
</table>
Conclusions

- Developing body of knowledge of postural and gait impairments in people with MS

- Walking speed is decreased; this could be due to changes in neural drive, muscle contraction speed/atrophy, different use of vision, and/or fear of falling

- Functional adaptations exist through increased dual support times. However, this may result in a potentially less stable swing phase through altered coordination of center of mass and swing foot during the controlled forward ‘fall’

- Head motion is modulated in MS to have field of view closer to body and sooner after toe-off; possible compensation for loss of cutaneous and proprioceptive systems
Conclusions

- Tai Chi intervention can potentially improve multiple functional systems (somatosensation; neural drive; strength and balance) and reduce fear of falling.

- Larger scale intervention studies needed to assess the effects of integrated aerobic exercise, flexibility, strength and balance training programs.

- Physical activity and fitness are associated with lower incidence of morbidity and mortality from major chronic disease (DiPietro, 2001).
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