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Multiple Sclerosis: Current Concepts in Pathophysiology, Evaluation, and Intervention for Rehabilitation

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Part 2: Evaluation and PT Management

- Clinical Evaluation of MS
- Gait impairment in Multiple Sclerosis
- Balance Impairment in Multiple Sclerosis
- Remediation and Management Strategies for gait and balance limitations in MS
As a result of this course, participants will be able to:

- Identify specific gait disturbances in persons with MS
- Identify specific balance limitations in persons with MS
- Determine appropriate tools for evaluating gait and balance limitations in persons with MS
- Develop and plan for treatment of gait and balance loss in persons with MS

Evaluation

- Global Measurement - the EDSS
- Primary vs. secondary findings
- The impact of fatigue
- Fatigue Measurement
- Gait evaluation
- Balance Evaluation
- Intervention Strategies for functional Limitations and Impairments
Measurement of disease severity: The Expanded Disability Status Scale (EDSS)

- Best-known and most widely used scale for quantifying MS disability.
- Ordinal rating scale from 0 (normal neurologic exam) through 10 (death from MS) in half point increments.
- Quantifies disability in eight Functional Systems (FS) and assigns a Functional System Score (FSS) in each of these.
- Functional Systems: pyramidal, cerebellar, brainstem, sensory, bowel and bladder, visual cerebral and other.

EDSS

- 1.0 to 4.5 refer to people with MS who are fully ambulatory, and are scored based on disability to the FS
- EDSS steps 5.0 to 9.5 are defined by the impairment to ambulation.
EDSS

- 0-3.5 mild disability
- 4-6.5 moderate disability
- 7-9.5 severe disability.
- Criticized for excessive emphasis on ambulation, insensitivity to non ambulatory clinical change

Physical Therapy Evaluation: A General Strategy

- MS can present in any number of ways
- Overall effect is a loss of mobility
- Thorough eval is needed to determine the limitations and how they result in mobility loss
Specific questions to ask

- To what extent do these findings contribute to the mobility deficit?
- Do these deficits worsen when fatigued?
- Do normal findings worsen when fatigued
- Is the fatigue subjective or objective?
- To what extent are the findings primary and to what extent are they secondary

Fatigue Measurement

- Differentiate subjective from objective fatigue
- Do not assume that presence of one indicates presence of the other
- Different constructs, different measurements
Subjective vs Objective fatigue

- Subjective fatigue - feelings of tiredness, sleepiness, overwhelmedness, anxiety, depression, lethargy
- Objective fatigue - worsening of physical performance over time
- Can occur in Gait, balance, sensation, cognition etc.

Subjective fatigue management

- Fatigue Severity Scale
- Fatigue Impact Scale
- Self report measures that ask about how fatigue has impacted a patient's life over the last several days or weeks
VISUAL ANALOG FATIGUE SCALE

Please indicate your current level of fatigue by drawing a vertical line on the scale below

_______________________________________
No Fatigue                                   Severe fatigue

Objective fatigability measurement

- Change in physical performance over time
- Example-distance covered in first minute of a 6 minute walk vs distance covered in the last minute of a six minute walk
Primary vs secondary findings

<table>
<thead>
<tr>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Due specifically to the disease itself.</td>
<td>A change in physical function that occurs as a result of the disease</td>
</tr>
<tr>
<td>Direct result of the demyelination or inflammation</td>
<td>Deconditioning</td>
</tr>
<tr>
<td></td>
<td>Sleep disorder</td>
</tr>
<tr>
<td></td>
<td>Contractures</td>
</tr>
<tr>
<td></td>
<td>Polypharmacy</td>
</tr>
<tr>
<td></td>
<td>Depression</td>
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<tr>
<td></td>
<td>Increased energy cost of movement</td>
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</tbody>
</table>

Primary findings - slower to remediate
Secondary findings - more remediable if the underlying issue is addressed
Primary vs secondary findings

- Much of the disability in MS may in fact be secondary
- This suggests that much of the disability in MS may be remediable
- Try to determine the secondary deficits and address them aggressively.

The significance of secondary findings

- Much of the disability that is seen in MS may not be directly due to the disease itself.
- If the secondary deficits are adequately addressed, significant improvements in mobility may occur.
Example - secondary deficits

- Patient presents with foot drop, leading to increased falls and progressively less walking.
- EDSS=6.5: Constant bilateral support (cane, crutch or braces) required to walk 20 meters without resting
- PT remediation to improve walking distance, patient improves to EDSS 5.5 (Ambulatory for 100 meters, disability precludes full daily activities)

Gait Evaluation

- Very different in MS than in other disorders
- Impact of fatigue
- Impact of temperature
- Multiple Clinical implications
Almost 9 Out of 10 People with MS Experience Some Limitation in Walking

- What percentage of people with MS experience limitations in their walking ability?

N=1011 adults (18+) with MS.

- No limitation
- Some limitation
- No response

Heterogeneous presentation

Is there a stereotypical gait in MS?

Multiple Sclerosis Gait

- Are there universal findings in MS that affect gait

Gait Fatigue

- Fatigue - most common MS finding
- In gait testing: shorter gait trials will not provoke fatigue
- To determine the effects of fatigue on gait, longer tests are needed

Greater Distance: Continuous vs intermittent 6 minute walk (Karpatkin et al, 2014)

- Distance decreases when walks are continuous
- Increases, then stabilized when intermittent
6 Minute walk test - Biomechanical findings in MS: 1st minute vs 6th minute

- Increased double support
- Increased stance time
- Increased step width
- Decreased step frequency
- Increased foot flat initial contact
- These are indicators of objective fatigue

6 minute walk - Minute 1
6 Minute walk - minute 6

Clinical Implications

- Do not assume shorter gait evals will uncover gait deficits
- Test gait in fatigued and unfatigued conditions
- 25 foot walk tests insensitive to persons with relatively minimal deficits
Intermittent vs continuous gait

- Most Gait programs in MS are continuous
- Accrual of fatigue leads to worsening of gait over time
- Increases in core temperature
- Limits ability to perform sufficient volume of walking to achieve improvements
- Walking with breaks (i.e. intermittent walking) may address this limitation

Intermittent vs continuous gait

- Less fatiguing than continuous walking
- Greater distance than continuous walking
- Better at improving gait endurance than continuous training
Continuous vs intermittent walking: Less fatiguing (Karpatkin et al IJMSC 2016)

- 29 patients with MS
- Randomized crossover design
- 6MW continuous vs intermittent (2 minutes walk/2 min seated)
- VASF increased less in the intermittent condition (from 37.93 mm to 44.83 mm; difference = 6.90 mm) compared to the continuous condition (from 34.33 mm to 54.43 mm; difference = 20.10 mm; P < .001)

**VISUAL ANALOG FATIGUE SCALE**

Please indicate your current level of fatigue by drawing a vertical line on the scale below

_______________________________________

No Fatigue                                 Severe fatigue
Greater Distance: Continuous vs intermittent 6 minute walk (JNP'T 2014)

- Distance decreases when walks are continuous
- Increased, then stabilized when intermittent

Intermittent vs Continuous walking as a training protocol (Karpatkin et al, Critical reviews in Physical Rehabilitation, 2016)

- 9 ambulatory patients with MS
- 6MWT pretest
- Randomized into 6 min continuous walk or 6 minute intermittent walk, 2x/week for 8 weeks
- 6MWT posttest
- 4 week washout
- Crossover
Results: INT vs CON on Distance

<table>
<thead>
<tr>
<th>Distance (ft)</th>
<th>Continuous Pre 6MWT</th>
<th>Continuous Post 6MWT</th>
<th>Intermittent Pre 6MWT</th>
<th>Intermittent Post 6MWT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000.00</td>
<td>1278.48</td>
<td>1219.32</td>
<td>1157.42</td>
<td>1300.44</td>
</tr>
<tr>
<td>1050.00</td>
<td></td>
<td></td>
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<td>1100.00</td>
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<td>1300.00</td>
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</table>

Continuous vs Intermittent Pre & Post 6MWT

Intermittent walking
Intermittent walking

Gait and temperature

- Findings in intermittent walking studies suggest that increasing body heat may be a causal factor in slowdown
- Exercise increases core temperature
- If we can mitigate body heat perhaps mitigate slowdown?
Effect of temperature on gait in MS
(Hunter College 2014)

- Randomized crossover design
- Cooling vest vs uncooled condition
- Subjects performed 6 minute walks 1x/week for three weeks in each condition.
- Vest put on immediately before walk
Effect of temperature on gait in MS
(Hunter College 2014)

- Subjects did not feel less fatigued in cooled condition
- Did not feel like they walked farther
- 100’+ increase in 6MWT performance without extra training
- Cooling vest can increase volume of exercise

Other thoughts on cooling

- A small number of pwMS do not benefit from cooling.
- Cooling can be achieved with air conditioners, fans, cooling drinks
- Dehumidifiers can be effective
- Free cooling vests can be obtained from the Multiple Sclerosis Foundation and the Multiple Sclerosis Association of America
Precooling
Balance loss in MS is multifactorial

- Strength
- Range
- Sensation
- Motor Control
- Vision
- FATIGUE

Balance testing in MS

- Use standardized tests
- Normal/good/fair/poor tests lack validity, reliability, consistency
- Standardized tests such as the Berg Balance Scale give can act as a screen and as a means of identifying specific areas of limitation, thus leading to treatment planning
Balance loss in MS: Specific Balance tools

- Berg Balance Scale - determines falls risk and identifies specific tasks that the individual has difficulty with.
- Treatment then becomes practice of those tasks.
- Grades patients from 0-56. Below a 42 suggests a high falls risk.

- MiniBESTest - for higher level patients - has gait and balance components
- Dynamic Gait Index to determine balance loss in walking
- Multiple Sclerosis Walking Scale-12 for self report
## Berg Balance Scale

<table>
<thead>
<tr>
<th>ITEM DESCRIPTION</th>
<th>SCORE (0-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting to standing</td>
<td></td>
</tr>
<tr>
<td>Standing unsupported</td>
<td></td>
</tr>
<tr>
<td>Sitting unsupported</td>
<td></td>
</tr>
<tr>
<td>Standing to sitting</td>
<td></td>
</tr>
<tr>
<td>Transfers</td>
<td></td>
</tr>
<tr>
<td>Standing with eyes closed</td>
<td></td>
</tr>
<tr>
<td>Standing with feet together</td>
<td></td>
</tr>
<tr>
<td>Reaching forward with outstretched arm</td>
<td></td>
</tr>
<tr>
<td>Retrieving object from floor</td>
<td></td>
</tr>
<tr>
<td>Turning to look behind</td>
<td></td>
</tr>
<tr>
<td>Turning 360 degrees</td>
<td></td>
</tr>
<tr>
<td>Placing alternate foot on stool</td>
<td></td>
</tr>
<tr>
<td>Standing with one foot in front</td>
<td></td>
</tr>
<tr>
<td>Standing on one foot</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>________</strong></td>
</tr>
</tbody>
</table>

### Berg Balance Scale eval and treatment examples

- If the patient scores below a 4 on item one (Sit to Stand) - practice sit to stand
- Examine biomechanics (trunk, hip, or knee flexion, ankle dorsiflexion)
- Higher or lower seating surfaces
- Softer or firmer seating surfaces
Berg Balance Scale eval and treatment examples

- Item 7 - standing with feet together.
- LOB with narrow base of support is common
- Practice standing with feet progressively closer together.
- Use light touch as a balance aide if needed

Dynamic Gait Index

- 8 item test each item graded from 0-3, max score 24
- Scores below 18 indicate high falls risk
- Like the Berg can be used as a screen and as a way to determine difficulties with specific task
- Treatment then becomes practice of the task(s) that the subject has difficulty with
Dynamic Gait Index

1. Gait level
2. Change in gait speed
3. Gait with horizontal head turns
4. Gait with vertical head turns
5. Gait and pivot turn
6. Step over
7. Step around obstacles
8. Steps

Mini-BESTest (MBT)

- For higher level patients
- Combines gait and balance
- 4 sections: Anticipatory, reactive, sensory orientation, dynamic gait
- 14 items graded 0-2
- 19/28= falls risk
MiniBESTest items

1. SIT TO STAND
2. RISE TO TOES
3. STAND ON ONE LEG
4. COMPENSATORY STEPPING CORRECTION- FORWARD
5. COMPENSATORY STEPPING CORRECTION- BACKWARD
6. COMPENSATORY STEPPING CORRECTION- LATERAL
7. STANCE (FEET TOGETHER); EYES OPEN, FIRM SURFACE
8. STANCE (FEET TOGETHER); EYES CLOSED, FOAM SURFACE
9. INCLINE- EYES CLOSED
10. CHANGE IN GAIT SPEED
11. WALK WITH HEAD TURNS – HORIZONTAL
12. WALK WITH PIVOT TURNS
13. STEP OVER OBSTACLES
14. TIMED UP & GO WITH DUAL TASK

Balance loss in MS: Findings and Interventions

Evaluate for specific underlying impairments

- Strength
- Range
- Sensation
- Motor Control
- Vision
- Vestibular
- FATIGUE

Interventions for specific impairments

- Specific strengthening
- Stretching
- Sensory weighting
- Task Practice
- Visual Fixation
- Vestibular rehab
Balance loss in MS: The Impact of fatigue

- Testing persons with MS in an unfatigued state can result in a false negative
- Test balance in fatigued and unfatigued conditions to determine true falls risk and the impact of fatigue in balance

Unfatigued vs Fatigued Berg Balance Scale (Karpatkin et al 2013)
Intervention strategies for gait disorders in MS: Underlying Impairments

- Range of Motion
- Strength
- Sensation
- Posture

Underlying Impairments

- Limitations in strength, range, sensation etc. results in gait deviations and compensations.
- Increase in “energy cost” of walking
- Identifying and addressing these underlying impairments should be part of the PT intervention
Underlying Impairment - foot drop

- Foot drop in MS
- Common reason for limiting mobility
- Results in gait deviations such as circumduction, hip hiking, vaulting, lateral lean etc.

Foot drop in MS

- Combination of plantiflexor contracture and spasticity, dorsiflexion weakness
- Primary and secondary factors
- Primary-spasticity, weakness, sensory loss
- Secondary factors- Disuse
Foot drop interventions:

- Plantarflexor Stretching
  - Can be done passively via resting splint
- Combine with dorsiflexion strengthening
- Use in gait sequence

Night splint

How often does your patient stretch?

- 30 seconds, 5 x a day, =21/2 minutes over 24 hours to reverse something that’s been present for multiple hours a day possibly for years.
- Too small a dosage!
- Night splints can be worn for hours a day
Push off

- Recent evidence indicates that diminished push off in gait is a critical factor for gait stability
- Diminished late stance hip extension or plantiflexion

Techniques to enhance push off

- Cueing
- Walking up a hill
- Resisted walking- use pulley’s, theraband, or manual resistance
Strength

- Primary vs secondary?
- If remediation is relatively fast, probably secondary.
- How to perform enough volume of strength training if patient is fatigued

Continuous leg raises
Intermittent Leg raises

Intermittent vs continuous leg lift study
(Hunter College 2012)

- 21 subjects using a randomized crossover design
- SLR raises done continuously (1 every three seconds)
- SLR raises done intermittently (2 consecutively with 10 second rest)
Intermittent vs continuous strengthening

- Mean continuous SLR: 31 (26.3)
- Mean intermittent SLR: 114 (54.3)
- Greater volume performed in INT condition
- So what about using this as an intervention?
- Will improving strength lead to improved gait?
Maximal Intermittent Strength Training in MS

- Strength training has been used in MS to address mobility deficits
- Relatively low loads and intensities, presumably to limit fatigue
- Improvements seen generally attributed to improved force production
- Higher loads are thought to result in greater CNS activation (Fimland, 2010)
- Improvements seen with MST in other CNS populations
- Little research on high intensity strength training in MS

MST training in MS
(Karpatkin et al. Multiple Sclerosis International, 2016)

- 7 subjects with MS
- 85-90% of 1RM for unilateral leg press
- Intervention: 4 sets, 4 reps 2x/week, 60-120 sec recovery between sets for 8 weeks
- Outcome measures: LE strength, BBS, 6MWT
Results

**Berg Balance Scale**
Pretest ($M=44.29, SD = 8.34$)
Posttest ($M=49.57, SD = 5.83$)
$p = .008$

**6-minute walk test**
Pretest ($M=1040.04, SD = 429.3$)
Posttest ($M=1190.7, SD = 579.9$)
$p = .045$
Sensory loss in MS

- Common finding
- Worsens with fatigue
- Contributes to gait and balance deficits

Effects of fatigue on sensation in pwMS (Hunter College 2015)

- 17 pwMS
- Randomized crossover study
- Sensation tested using biothesiometer
- 6 minute walk or 6 minute rest
- Repeat Sensation test
Can sensation be improved in persons with MS?

- Can sensory loss be secondary rather than primary
- Consider: patient presents with Positive Romberg sign (LOB with EC) but sensation testing minimally impaired
- Patient may have become “visually dominant” for balance
- Treatment-balance training with EC to “force use” of non-visual sensory apparatus.
Posture in MS

- COG shifted forwards during gait due to forward head, excessive thoracic kyphosis, eyes looking at ground
- Diminished hip extension $\Rightarrow$ diminished push-off $\Rightarrow$ shortened stride and step length
- Increased energy cost of walking
- Postural reeducation exercises

Posture - Uncorrected

Initial Evaluation
Summary of points for evaluation

- MS can present with tremendous variability
- No “typical "evaluative findings
- Expect to be surprised
Summary points for evaluation

- Fatigue will always be prominent
- Test in fatigued vs unfatigued state
- Determine what issues are primary and what are secondary

Summary Points for Intervention

- The volume problem- to achieve sufficient improvement, a certain volume of work needs to be performed.
- Using intermittent training and cooling can increase volume by limiting thermosensitivity
- Addressing underlying impairments can decrease energy cost of movement


Bibliography
