Multiple Sclerosis Management for PTs: What to Expect and What to Do About It

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The problem of prediction in MS

- MS is a disease of profound variability
- Multiple subtypes, presenting with differing locations, intensities, and symptomatology, and progressions
- Given the variability of MS, using outcome measures for prediction is highly problematic

Prediction in MS- how can it help clinicians?

- Given what is know about the disease, what does the research tell us about what to expect
- Given a diagnosis of MS, what are the possible outcomes?
- How might this information affect clinical practice
- An understanding of possible outcomes for the disease both with and without PT management is essential to clinicians

What do we know

- Multiple Sclerosis is a progressive disease
- Patients will probably worsen over time
- The rate at which they worsen will be variable
- The rate can be affected by multiple intrinsic factors (disease expression) and extrinsic factors (medication, exercise, lifestyle)

Signs and symptoms

- MS can effect any structure in the CNS
- Any CNS sign/sx is therefore possible
- Some are more likely than others
- Certain types of presentations will predominate

Measurement of disease progression

- How we know that that progression has or has not occurred
- Allows us to measure the success or lack of success of interventions
- Does not tell us whether the interventions address intrinsic or extrinsic causes of disease.
- Are changes due to extrinsic or intrinsic factors
Multiple Sclerosis

- Disease of mobility≈90% CO gait issues
- Impaired control of balance and gait
- No stereotypical presentation but stereotypical losses

Common sign and symptom prevalence

- Fatigue 83.1%
- Heat sensitivity 80.0
- Difficulty w/walking and balance 67.2
- Stiffness & spasms 63.1
- Bladder problems 59.8
- Memory & other cognitive problems 55.8
- Pain & sensory loss 54.3
- Emotional & mood problems 37.5
- Vision problems 37.4

Demographic and disease-related characteristics of the NARCOMS cohort

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
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<tbody>
<tr>
<td>Number of participants</td>
<td>25728</td>
</tr>
<tr>
<td>Female%</td>
<td>74.5</td>
</tr>
<tr>
<td>Race%</td>
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</tr>
<tr>
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<td>89.3</td>
</tr>
<tr>
<td>African American</td>
<td>4.6</td>
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<tr>
<td>Hispanic</td>
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<tr>
<td>Other</td>
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</tr>
<tr>
<td>Age at symptom onset, mean (SD), y</td>
<td>31.4 (9.7)</td>
</tr>
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<td>Age at dx, mean (SD), y</td>
<td>37.3 (9.7)</td>
</tr>
<tr>
<td>Age at enrollment mean (SD), y</td>
<td>45.2 (10)</td>
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<tr>
<td>Unemployed</td>
<td>49.3</td>
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<td>On DMT’s</td>
<td>51.9</td>
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Mobility and disease duration

<table>
<thead>
<tr>
<th>Disease duration (yr)</th>
<th>No disability</th>
<th>Minimal disability</th>
<th>Mild disability</th>
<th>Moderate unilateral support</th>
<th>Moderate bilateral support</th>
<th>Severe unilateral support</th>
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<th>Bedridden</th>
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<tr>
<td>0</td>
<td>50%</td>
<td>25%</td>
<td>10%</td>
<td>8%</td>
<td>4%</td>
<td>3%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>1</td>
<td>55%</td>
<td>19%</td>
<td>13%</td>
<td>7%</td>
<td>3%</td>
<td>2%</td>
<td>5%</td>
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<tr>
<td>5</td>
<td>36%</td>
<td>19%</td>
<td>15%</td>
<td>14%</td>
<td>10%</td>
<td>3%</td>
<td>3%</td>
<td>22%</td>
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<tr>
<td>10</td>
<td>22%</td>
<td>19%</td>
<td>17%</td>
<td>16%</td>
<td>12%</td>
<td>6%</td>
<td>10%</td>
<td>97%</td>
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<td>20</td>
<td>12%</td>
<td>13%</td>
<td>17%</td>
<td>19%</td>
<td>13%</td>
<td>9%</td>
<td>17%</td>
<td>98%</td>
</tr>
<tr>
<td>30</td>
<td>9%</td>
<td>9%</td>
<td>13%</td>
<td>19%</td>
<td>14%</td>
<td>14%</td>
<td>22%</td>
<td>99%</td>
</tr>
</tbody>
</table>

- Gait deviations occur early in the course of the disease
- At 30 years 78% of persons with MS are still ambulatory
- Effects of disease type, medications, physical activity?

Severe MS disability: Unfavorable prognosis

- Male sex
- Onset of symptoms after the age of 40
- Initial symptoms involving the cerebellum, mental function, or urinary control
- Initial symptoms that affect multiple regions of the body
- In the first years after onset, attacks that are frequent, or a short time between the first 2 attacks
- Incomplete remissions

LT prognosis: initial presentation

- Relapsing-Remitting presentation: better prognosis than progressive
- Unifocal presentation-better prognosis than multifocal
- Afferent pathway involvement better prognosis than efferent
**Comorbidities**

- Faster initial rate of progression for progressive disease
- Rate of progression from 4.0 similar for the 2 groups
- When transition from RR to SP faster progression

**Smoking**

- Increases risk of developing MS
- Increases speed of disease progression
- Increases symptom frequency and severity
- Increases likelihood of being dxed with progressive vs RR

**Smoking and MS**

- People with MS smoke more than the general population
- Quitting or reducing smoking may slow disease progression
- No risk noted with “smokeless” tobacco

**Obesity and MS**

- Genetically elevated BMI associated with increased risk of MS, suggesting causal role in MS etiology
- Elevated body (BMI) may promote a “proinflammatory state” affecting the immune system.
- Change in BMI from overweight to obese - which is equivalent to an average adult woman increasing in weight from 150 to 180 pounds - was linked with an increase of 40 percent in MS risk
- While obesity has been associated with many late-life outcomes, these findings suggest an important consequence of childhood and/or early adulthood obesity.

**Death due to MS**

- Median life expectancy was 74.7 years for MS and 81.8 years for the general population (p<0.001)
- 77.2 years for women with MS and 72.2 years for men with MS (p<0.001)
- Life expectancy for patients with relapsing remitting MS (RRMS) was 77.8 years and 71.4 years for primary progressive MS (PPMS) (p<0.001)
- Median survival from disease onset was 41 years
### Death due to MS
- Pneumonia commonly due to aspiration—refer to SLP!!
- Infections: bedsores, UTI’s, URI’s
- Falls/fear of falling
- Suicide: pwMS are 7.5 times more likely to commit suicide than the general population.
- Heart disease—due to inactivity
- All of these modifiable!

### Primary vs secondary disability
- Primary causes: How much of the disability is due to the disease?
- Secondary Causes: How much of the disability is due to deconditioning/learned non-use
- Disability due to learned non use is going to be more remediable than disability due to disease activity

### Disease activity vs learned disuse
- No way of knowing what percentage of the disability is due to each
- Assume a significant amount of the disability is due to nonuse.
- That amount is going to be more quickly remediated by exercise programs
- Good news!

### How physically active are persons with MS?
- Individuals with RRMS are less physically active than non-diseased populations (Motl et al, Phys Ther, 2013)
- Larger effects are observed with objective versus self-report measures of physical activity, suggesting that pwMS may over-report their PA
- Larger effects in primary progressive versus remitting MS
- Suggests that some of the mobility deficit is secondary

### Is physical exercise in multiple sclerosis disease modifying treatment?
Exercise and physical activity have been associated with:
- Reduced relapse rate
- Decreased mobility disability and its progression
- Decreased lesion volume, and improved neuroperformance, particularly walking outcomes.

### The safety of exercise training in multiple sclerosis: A systematic review (Pilutti et al 2014)
- Rusk- 1976- persons with MS should not exercise as it may lead to a relapse
- Systematic review by Pilutti et al:
  - Rate of relapse lower for exercising pwMS (6.3) than controls (4.6)
  - Rate AE’s was 1.2 for controls and 2.0 for exercisers
Let’s Talk About Prevention

What is Prevention?

Actions taken to prevent the onset of disease (or disability), to stop its progress, and to minimize its consequences

[Harris & Weinstein, IV STEP Proceedings, 2016]

Main objective for this section

- Summarize likely complications experienced by people with MS, and formulate examination and intervention plans to prevent these complications
- We’ll cover prevention through three stages of MS
  - Mild disease -- low disability
  - Moderate disease -- worsening disability
  - Severe disease -- advanced disability
- Pretty good idea of what to do in the mid-stage, but not so much about early and late

What concerns are there for those with low MS-related disability?

- For EDSS scores of up to a 4.0, signs are only in the Functional Systems Scores
  - Pyramidal, Cerebellar, Brainstem, Sensory, Bowel and Bladder, Vision, Cerebral/Mental
- This simply doesn’t tell the whole story
- Even in those with little disability, there is a high likelihood that problems exist
- There is “no impairment to walking”, but there are many possible problems that are in the scope of practice of PTs

What problems are present in those with low disability?

- Strength
- Flexibility/range of motion
- Respiratory strength
- Fatigue and fatigability
- Bladder function/incontinence

Strength Deficits

- 60% of people with MS have weakness (MMT of ≤ 3/5) in one or more muscle groups
  - Ankle – 51.3%
  - Knee – 52.6%
  - Hip – 50.0%
  - Shoulder – 60.9%
  - Elbow – 61.2%
  - Wrist – 61.5%
Lost Flexibility/Passive ROM

• 56.4% of people with MS have a contracture in at least one major UE or LE joint
  – Ankle - 43.9%
  – Hips - 28.8%
  – Knees - 17.0%
  – Shoulders - 13.1%

Recommendations for Strengthening Exercise

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Petajan &amp; White</th>
<th>White &amp; Dressendorfer</th>
<th>Dalgas, Stenager and Ingemann-Hansen</th>
<th>Latimer-Cheung, Martin Ginis et al</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Strengthening</td>
<td>Strengthening</td>
<td>Strengthening</td>
<td>Strengthening</td>
</tr>
<tr>
<td>Frequency</td>
<td>Not specified</td>
<td>2-3x/wk</td>
<td>2-3x/wk</td>
<td>2x/wk</td>
</tr>
<tr>
<td>Intensity</td>
<td>~12RM</td>
<td>~15RM</td>
<td>~15RM, 8-15RM up to ~15RM</td>
<td>~15RM</td>
</tr>
<tr>
<td>Time</td>
<td>3 sets, 10-12 reps</td>
<td>1-3 sets, 8-15 reps</td>
<td>1-3 sets, 8-15 reps, then 5-10 reps</td>
<td>2-4 sets, 1-2 reps between sets</td>
</tr>
</tbody>
</table>

Recommendations for Stretching/Flexibility Exercise

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Petajan &amp; White</th>
<th>White &amp; Dressendorfer</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Stretching</td>
<td>Stretching</td>
<td>Stretching</td>
<td>Stretching</td>
</tr>
<tr>
<td>Frequency</td>
<td>Daily</td>
<td>Daily</td>
<td>Not specified</td>
<td>Not specified</td>
</tr>
<tr>
<td>Intensity</td>
<td>Apply stretches slowly to minimize effect of any spasticity</td>
<td>Slow, low intensity below painful levels</td>
<td>Not specified</td>
<td>Not specified</td>
</tr>
<tr>
<td>Time</td>
<td>Not specified</td>
<td>Hold for 10-15 sec.</td>
<td>Not specified</td>
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</tr>
</tbody>
</table>

Special considerations for strengthening exercises for people with MS

• May need to limit the number of repetitions at a particular muscle group or overall due to fatigability and/or fatigue
• Adapt to any cognitive deficits
• DMT side effects
• Side effects of symptom-managing or comorbidity treating drugs
• Weakness, abnormal motor control or dyscoordination may impede ability to perform exercises

Flexibility Considerations for the Person with MS

• Lack of normal strength and mobility means that the risk of contracture is ongoing – restoration will need to transition to prevention
• Those with greater disease severity have a greater risk of losing flexibility
• Other MS-related problems or comorbidities may prevent effective self-stretching
• Contracture prevention and remediation may require equipment (e.g. splints, casts) which bring along the risk of integument damage and its consequences
• "An ounce of prevention is worth a pound of cure" – Ben Franklin
Diminished Respiratory Muscle Strength

- Compared to healthy controls, even people with low MS-related disability may have impaired inspiratory and expiratory muscle function

What kind of intervention program might be appropriate?

Consider a program of respiratory muscle strengthening to minimize the expected decline in respiratory muscle strength

Fatigue and Fatigability

- Fatigue – the symptom
  - "a subjective lack of physical and/or mental energy that is perceived by the individual or caregiver to interfere with usual and desired activities"
  - (Multiple Sclerosis Council for Clinical Practice Guidelines, 1998, p.2)
  - May be noted whether or not the person is engaged in activity

- Fatigability – the sign
  - A measurable change in physical performance after sustained or repeated use
  - Typically refers to a specific movement or task within or after a work bout

Fatigue and Fatigability

- What kind of problems related to fatigue and fatigability might be present?
  - Fatigue is a very common complaint
  - Issues related to fatigability might be present, too
    - Need to examine in fresh and fatigued states
    - Look carefully as fatigability may manifest in several ways

How might we address these changes?

- Specific problems (e.g. gait deviations, changes in balance, etc.) should be addressed with traditional PT interventions

- If problems are not focal, then a therapeutic exercise program including strengthening and aerobic conditioning programs may be an appropriate plan of care

For those with low disability, consider endurance training to improve fatigability

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Fatigue &amp; White</th>
<th>White &amp; Dressendorfer</th>
<th>Dalgas, Stenågar and Ingemar-Hansen</th>
<th>Latimer-Cheung, Martin Ginis et al. <strong>a</strong></th>
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</thead>
<tbody>
<tr>
<td>Type</td>
<td>Aerobic</td>
<td>Aerobic</td>
<td>Aerobic</td>
<td>Aerobic</td>
</tr>
<tr>
<td>Frequency</td>
<td>3-5 x/wk</td>
<td>2-3 x/wk</td>
<td>2-3 x/wk</td>
<td>2-3 x/wk</td>
</tr>
<tr>
<td>Intensity</td>
<td>65% VO2 Max (~75% MaxHR)</td>
<td>50-70% VO2 Max (~65-75% MaxHR)</td>
<td>50-70% VO2 Max (~60-80% MaxHR)</td>
<td>5-6 on 10-point RPE (~70-80% MaxHR)</td>
</tr>
<tr>
<td>Time</td>
<td>20-30 minutes (or two 10-15 minute bouts)</td>
<td>20-30 minutes (or two 10-15 minute bouts)</td>
<td>10-40 minutes Gradual increase to 30 minutes</td>
<td></td>
</tr>
</tbody>
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37 38 39 40 41 42
Bladder and Bowel Dysfunction are also Common

- Nearly 30% of people with MS for fewer than 3 years report at least mild bowel and bladder dysfunction (Kister et al)
- Greater time since dx (Kister) and disease severity/EDSS (Zecca) were correlated with worse bladder dysfunction
- Includes both hyper and hypo function

Managing Bowel and Bladder Dysfunction

- Pelvic floor muscle training (with or without NMES) resulted in improvements in incontinence and in pelvic floor strength.
- Consider implementing a pelvic floor muscle training program to reduce/delay issues related to incontinence.
  - May need to refer to a pelvic floor specialist
  - The patient may benefit from the input of their health care team members
    - Urologist, Dietician, etc.

Preventing a Decline in those with Moderate Disability

- In general, worsening disability is when the person starts to have more notable problems with walking and balance
- Common issues at this point may include
  - Problems in walking/gait, including increasing issues with fatigability
  - Impaired balance and the need for fall prevention
  - Changes in vestibular/oculomotor function
  - Development of hypertonia

Problems with walking and gait

- Gait deviations span the spectrum of possibilities, so a careful gait analysis is warranted
  - Remember likely body structure/function-level contributors include changes in
    - Strength
    - Flexibility
    - Muscle tone
    - Coordination
    - Respiratory muscle function

Interventions for Gait and Walking Dysfunction

- Task-specific training related to walking
  - May include simple walking practice to over-ground/treadmill walking retraining activities
  - Consider using body-weight support as needed
Interventions for walking fatigability

- Don’t neglect body structure/function-level contributors
  - e.g. limited strength or flexibility, hypertonia, etc.
- Consider utilizing intermittent walking training to improve dose volume

Intensity and Duration

- Continuous vs. Intermittent Activity
  - People with MS walk farther and faster when doing so intermittently compared to continuously

Intensity and Duration

- Using the intermittent model for training has also shown superior results compared to cont

Balance and Fall Prevention

- Risk of falling in people with MS peaks between EDSS scores of 4.0 and 6.0
- A large percentage have had at least two falls within a 3-month period

What about measuring balance?

- The recently published CPG for a core set of outcome measures for use across neurologic PT practice advocated for the use of
  - Berg Balance Scale to measure balance
  - Activities-Specific Balance Confidence Scale to measure balance confidence
  - Functional Gait Assessment to examine dynamic walking balance
- Other tools are useful for people with MS (e.g. MiniBEST, DGI, FES, but there is limited evidence of their ability to predict falls
- Only the Berg Balance Scale has good evidence of predictiveness
  - In those who can walk 6m and stand for at least 3 seconds, a score of 44 or less differentiated fallers from non-fallers

Balance and Fall Prevention

- As with gait and walking, functional retraining and impairment level interventions are appropriate
- Fall prevention programs (e.g. Free From Falls and Building Better Balance)
- A good fall prevention program should include a variety of elements including
  - Education about why falls happen and what can be done about them
  - Activities that address likely contributors to falls (e.g. strength and flexibility)
  - What to do after a fall, including a plan to seek help if needed
Visuo-Vestibular Problems: Efferent visual pathway disorders

- Efferent visual pathway disorders
  - Found in 40-76% of people with MS
  - Ophthalmoplegia
  - Skew deviation
  - Gaze palsy
  - Nystagmus
  - Smooth pursuit
  - VOR and VOR suppression

An MS problem, or something else?

- A careful examination must be conducted for the people with vertigo as the problem may be central or peripheral
- In one study, 86% of people with MS with new onset vestibular abnormalities were found to have a peripheral condition
- A retrospective study found that over 50% of people with MS who experienced new onset vertigo had BPPV that resolved with intervention rather than central dysfunction

Vestibular interventions

- If the problem is peripheral, treat accordingly
  - BPPV with debris repositioning techniques
  - Unilateral dysfunction with adaptation/retraining
- If the problem is central, treat with habituation training and balance retraining based on the rest of the PT exam
  - Habituation (Motion Sensitivity Quotient)
  - Oculomotor training
  - Optokinetic stimulation
  - Balance and Postural Control Exercises
  - Substitution if permanent

Addressing hypertonia

- 84% of people with MS reported some spasticity, with a direct correlation between higher levels of spasticity and worse disability
- Counterintuitively, fatigue does not worsen spasticity.

What interventions might work?

- A recent meta-analysis reviewed the following:
  - Looked at exercise therapy
  - FES and TENS
  - Focal and whole-body vibration
  - Standing in a standing frame
- Conclusions:
  - Very low to low evidence for many interventions except:
    - Moderate evidence for "outpatient exercise programs" to improve muscle tone
    - High evidence of robot-guided training improved self-perceived spasticity
    - TENS improves self-reported spasm

So what to do?

- General exercise training seems to have some effect
- The combination of passive and active ROM in conjunction with anti-spasmsotics may be useful
  - Monitor anti-spasmodic drug use, consider referring for oral, injectable or indwelling spasticity management
  - Improve ROM to minimize stretch reflex – contracture prevention here.
Preventing a Decline in those with Severe Disability

As a person with MS becomes more disabled, the focus of PT shifts to a more palliative model

Need to consider the secondary complications that are likely to develop as the EDSS score gets into the 7.0-9.5 range

The focus should be on preventing loss of quality of life andlife-shortening complications

Some of the critical issues

Severe limitations in mobility/transfers

Protect integument

Maintain best respiratory function

Prevent the development of contractures

Safety in Functional Mobility

Issues are two-fold

- Injury prevention for patient and caregiver
- Skin protection (TBD)

Consider equipment needs

- Bed/frame equipment (e.g. rails)
- Transfer equipment (e.g. sliding board or mechanical lift)

Consider personnel needs

- Does the person with MS need physical assistance?
- If so, appropriate training is critical

Integument Issues—protecting the skin

One study found a 20% occurrence rate of pressure sores in people with MS, but there was no analysis of the relationship between disease severity and likelihood

It seems logical that higher rates would correlate with greater severity
Equipment Related to Mobility and Skin Protection
- Consider both mobility aids and seating/positioning
- Equipment might include
  - Hospital bed
  - Wheelchair/scooter
  - Mechanical lift or other transfer aid
- Seating/positioning might include
  - Special mattress
  - Splints and other positioning devices
  - Pressure relieving cushions/backs for wheelchair or scooter

Maintaining Respiratory Function
- As noted earlier, respiratory muscle weakness begins early in the disease
- A thorough examination of the chest should be conducted
- Consider using strengthening devices presented earlier
- Administer “Chest PT” including postural drainage, training stronger cough, etc
- Consider referral for swallowing rehabilitation if aspiration is present

Contracture Prevention
- Maintaining maximal flexibility will facilitate easier/optimal seating and lying positioning
- Enables caregivers access to the perineum
- Here, in particular, “an ounce of prevention is worth a pound of cure”

Neuroplasticity
- Defined by the APTA as
  - “the capacity of cerebral neurons and neural circuits to change, structurally and functionally, in response to experience.”
- Plasticity is the ability of the nervous system to adapt to the ever-changing conditions of the environment, encountered during development and learning
- Normally applied to Stroke and TBI
- Evidence for Plasticity in MS?

Evidence for plasticity in MS
- Plasticity limits the clinical impact of damage, by establishing patterns of brain activity
- Changes in activation patterns occur with the resolution of active inflammation
- Not all of the changes in brain activity occurring in MS are adaptive
- Plasticity can also be maladaptive and thus contribute to or sustain disability
- Maladaptation may help to explain the functional differences that are observed between clinical stages and forms of MS

Neuroplasticity in MS: Clinical implications for Rehab
- Unique nature of MS
- Different clinical strategies needed from other neurologic diseases
- Physical therapy for CVA, TBI, PD, SCI is not the same as for MS
- The issues regarding neuroplasticity are not the same either
Barrier to neuroplasticity in MS

**Fatigue**
- For meaningful improvement in mobility skills to occur in pwMS, a certain volume of work must be performed.
- In MS, fatigue prevents that volume from occurring
- Without volume, neuroplasticity is limited
- “Dosage problem”

What is fatigue

- Most common MS symptom
- Primary causes - due to disease
- Secondary causes - due to deconditioning
- Subjective Fatigue (lassitude)
- Objective Fatigability (motor fatigue)

Evidence for fatigue/fatigability affecting mobility in MS

- Progressive slowdown seen in 6MWT
- Poorer performance in Berg Balance Scale when fatigued vs Unfatigued
- Progressive weakness in strengthening activities
- Increasing sensation impairment when fatigued

Unfatigued vs Fatigued Berg Balance Scale

Continuous vs Intermittent 6MWT

Clinical Implications

- Short gait tests (25 foot walk test, TUG) may not show impact of fatigue - longer tests are needed
- Balance testing when unfatigued may not give accurate information regarding falls risk
- MMT in pwMS may not give accurate information on strength - if someone is 5/5 for the first few reps and 3/5 after a few more, what is their strength?
- Ability to use sensory modalities when fatigued is impaired in MS
Strategies for neuroplasticity in MS

- For remediation to occur, a volume of work must be performed. Fatigue prevents this in pwMS
- Strategies used in other diagnoses may not be tenable- pwMS maybe not be able tolerate the workload
- Given the limitations that MS fatigue imposes on training volume, how what clinical strategies can be used?

How to solve that problem

Clinical strategies to limit fatigue

- Cooling
- Intermittent training
- Remediation of underlying deficits
- Wellness?

MS thermosensitivity

- Elevated temperature decreases conduction through demyelinated nerves in MS (ADCB)
- Exercise raises core temperature
- As core temperature raises, decreased ability to perform large volumes of exercise
- Can we exercise without raising core temperature

Effect of temperature on gait in MS

(Hunter College 2014)

![Bar chart showing mean 6MWT distance with and without cooling]

Cooling and gait in MS

- Improved 6MWT in cooled vs uncooled condition (Karpatkin et al 2014)
- Improved 25FWT in precooled vs uncooled condition (White et al 2000)
- No interventional studies- can cooling lead to more practice?
- -can cooling lead to better outcomes?

Cooling

- By preventing heat buildup, cooling may allow for greater quantity of practice
- Can be done before, during and after tasks
- Cooling vests, air conditioning, cooling drinks
Intermittent training

- AKA interval training, fractionated training, “taking breaks”
- Interspersing periods of practice of a specific activity or task with periods of rest
- Allows for accomplishing greater volume of practice
- Less heat buildup?

Decreased subjective fatigue

- 29 patients with MS
- Randomized crossover design
- 6MW continuous vs intermittent (2 minutes walk/2 min seated)
- VASF pre and post 6MW
- 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; $P < .001$)

Greater Distance walked intermittently vs continuously

(Karpatkin 2016)

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

Intermittent vs continuous walking as an intervention

(Karpatkin 2016)

- 8 week randomized crossover pilot study
- 6MWT diminished in continuous group (1287-1219)
- Increased in the intermittent group (1157-1300, $p=.015$)

Remediation of underlying impairments

- Volume of practice of gait and balance tasks can be limited by impairments
- Can increase energy cost of activities, increasing fatigue
- Impairments can limit the ability to optimally practice functional tasks
- Example-Foot drop increases energy cost of walking, decreases pushoff power
- During recovery from more arduous tasks, patients can perform static stretching.
Fitness? Wellness?
- Physical activities to increase overall fitness
- Not specific to deficits
- Patient becomes “fitter” but are there improvements in function? (“fitness without function”)
- Due to fatigue, limited amount of time patient can spend on exercise program-are “fitness activities” the best way of using this time?

Repetition and Intensity
- Repetition-Induction of plasticity requires sufficient repetition. (“practice a lot”)
- Intensity-Induction of plasticity requires sufficient training intensity. (practice hard)

Repetition and Intensity
- For improvements to occur, a certain volume of work must be achieved
- Neurogenic fatigue can prevent this volume from occurring
- Intermittent training, temperature management, and treatment of impairments can mitigate these effects

Repetition and Intensity in MS
- “persons with MS should not exercise intensively as it may lead to an exacerbation”
  - Howard Rusk(1977)
- Can persons with MS tolerate high intensity and repetitions?
- Can they benefit from high intensity and repetitions

Increasing Repetitions and Intensity in MS
  - 52.5 hours over 15 consecutive weekdays of LE CIMT training(3.5 hrs/day)
  - task practice included- partial body weight supported treadmill training, overground ambulation, stair climbing, stepping over obstacles, and balance training
  - Improvements noted in LE-MFT, LE-MAL, 6MWT, 25FWT, VAS
  - Gains retained at 4 years

Increasing Intensity
- Fimland et al 2010 – suggested Maximal Strength Training (MST) enhanced CNS adaptations-4 x 4 repetitions of unilateral dynamic leg press and plantar flexion 5 days a week for 3 weeks. No functional tests
- Karpatkin et al 2016-Maximal Strength Training(4 sets/4 reps/8 weeks LE strength training at 85-90% of 1RM). Improvements in 6MW, BBS.
- No adverse reactions to high training load
- Salience?