PULMONARY FUNCTION AND REHABILITATION IN MS

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Motor deficits in multiple sclerosis affect not only the limb muscles, but also the ventilatory muscles, in terms of both decreased strength and endurance.[1–9] Just as muscular weakness in the limbs occurs early in the disease and increases as the disease progresses, the same progressive weakening occurs in the ventilatory muscles. Ultimately, respiratory complications are considered the major cause of morbidity and mortality in individuals with advanced MS.[1,2,10–13]

Measures of Ventilatory Muscle Strength and Endurance

Ventilatory muscle function is measured indirectly by the following pulmonary function tests. Outcome values on these tests are typically stated as a percentage of the predicted values determined by assessing the height, weight, and age of the individual.

- Muscle strength
    - Maximal inspiratory pressure (MIP), which is the pressure achieved with maximal forced inspiration
    - Maximal expiratory pressure (MEP), which is the pressure achieved with maximal forced expiration
- Muscle endurance
    - Maximal voluntary ventilation (MVV), which is the maximum amount of air a person is able to breathe in and out as hard and as fast as possible for 1 minute

Ventilatory Muscle Strength and Endurance in Severely Involved Persons with MS

In more disabled persons with MS Expanded Disability Status Scale or (EDSS >6.5) who are nonambulatory, MIP values range from 27–74% of predicted values and MEP values range from 18–51% of predicted values.[1,14–16] MVV has not been extensively studied in people with MS. However, one study documented MVV values at only 68% of predicted values in 40 persons with MS disability ranging from ambulatory to bed-bound.[17]

Ventilatory Muscle Strength in Minimally to Moderately Involved Persons with MS

Fewer reports are available on pulmonary muscle strength in people who have MS and are ambulatory with only minimal to moderate disability (EDSS <6.5c). In this population MIP values range from 50–77% of predicted and MEP values range from 34–60% of predicted, suggesting significant pulmonary muscle weakness even in less disabled persons with MS.[4,16] In one study of people with EDSS of 0–2, MIP values were normal, but mean MEP values were 67% of predicted values indicating very early ventilator muscle weakness.[9]

Examination of Ventilatory Muscle Strength and Endurance

Given the extent of involvement, even in less disabled persons with MS, it is appropriate to evaluate ventilatory muscle strength and endurance as follows:

- Physician monitoring
    - Baseline evaluation at time of diagnosis
    - Re-evaluation every 1–3 years, depending on severity of pulmonary impairment
    - Following significant pulmonary infection or pneumonia, new onset of dyspnea with exertion, or with a significant change in person's functional status
- Physical therapist monitoring
    - As part of the initial evaluation with each referral
    - Following new onset of dyspnea with exertion or significant change in person's functional status

Both high tech and low tech means exist to test MIP, MEP, and MVV. MIP, MEP, MVV and other functions can be tested on standard metabolic carts (high tech), e.g., the VMax metabolic cart from Sensor Medics Corporation. They may also be tested with portable hand-held respiratory pressure meters (low tech), which are reasonably priced and require minimal time for clinical assessment, e.g., MicroRPM (Respiratory Pressure Meter) and MicroRMA (Respiratory Muscle Analyser) from Micro Medical.

A complete examination of pulmonary function in the context of rehabilitation should also include assessment of:

- History
    - Smoking history
    - Pulmonary disorder and infection history
    - Shortness of breath, e.g., Dyspnea Index
- Systems screen
    - Cardiovascular
    - Pulmonary

- Clinical tests
    - Oxygen saturation (O_2Sat) as measured by pulse oximetry
    - Chest x-ray
    - Pulmonary Function Tests (PFT)
- Lab values
    - Blood gases
    - Red blood count (RBC)
    - Hemoglobin
    - Hematocrit
- Physical exam
    - Vital signs
    - Observation and inspection
        - Posture
        - Spine and rib mobility
        - Nail clubbing
        - Speech, e.g., time how long one can vocalize the word "ah" in one breath
        - Cyanosis
    - Palpation and percussion
    - Auscultation of lung sounds
- Aerobic capacity
    - E.g., 6-minute walk test or Symptom Limited Graded Exercise Test

Resistive Ventilatory Muscle Training Devices

Inexpensive ($25–120) hand-held devices used to strengthen ventilatory muscles through breathing exercises are readily available and simple to use. Resistive trainers operate by adjusting the aperture of the hole through which one breathes, e.g., Pflex from Phillips Respironics or Ultrabreathe. While these devices offer resistance to inspiration and expiration, the amount of resistance is altered by the speed at which the client breathes. Thus, one can reduce the level of resistance simply by breathing slower. Without full control of the amount of resistance a device provides, it is difficult to implement a progressive resistance exercise program. A better alternative are the pressure threshold resistance trainers that have spring-loaded valves requiring clients to inspire or expire at specific pressure levels, e.g., Threshold IMT from Phillips Respironics (lighter resistance) and Powerbreathe from Gaiam Ltd (heavier resistance). The pressure level may be incrementally adjusted to progress a client to higher resistance levels to increase ventilatory muscle strength. These devices are referred to as Threshold IMT (inspiratory) or Threshold EMT (expiratory) devices.

Expiratory Muscle Training

Research evidence exists to support use of expiratory muscle training to increase MEP in both less and more disabled people with MS using threshold expiratory trainers.[1,10,18] In one study, expiratory training also significantly increased MIP.[1] Exercise protocols varied slightly in these studies as documented in the table below.

Expiratory Muscle Training: Research Findings					
Study	**Subjects**	**Exercise**	**Progression**	**Duration**	**Result**
Smeltzer[8]	15 with EDSS >6.5	3 sets of 15 reps twice daily	Initial based on MEP, progression not stated	12 weeks	Sig. ↑ _in MEP; Trend to ↑ _in MIP
Gosselink[1]	18 with EDSS >7.0	3 sets of 15 reps twice daily	Initial at 60% MEP, progression not stated	12 weeks	Trend to ↑ _in MEP; Sig. ↑ _in MIP
Chiara[18]	17 with EDSS >6.5	4 sets of 6 reps once daily for 5 days/week	Week 1 = 40% MEP; Week 2 = 60% MEP; Weeks 3–8 = 80% MEP	8 weeks	Sig. ↑ _in MEP

Inspiratory Muscle Training

Research evidence also exists to support use of inspiratory muscle training to increase MIP in both less and more disabled people with MS using threshold inspiratory trainers.[15,19] In one study, MEP also increased significantly with inspiratory muscle training.[15] In another study, inspiratory muscle training resulted in significant increases on a single limb/tandem stance balance test and a non-significant trend toward increases in distance walked on a six minute walk test.[20]

Inspiratory Muscle Training: Research Findings					
Study	**Subjects**	**Exercise**	**Progression**	**Duration**	**Result**
Klefbeck[15]	15 with EDSS >6.5	3 sets of 10 reps every other day	Initial based on 40–60% MIP, progression based on MIP and RPE	10 weeks	Sig. ↑ _in MIP; Sig. ↑ _in MEP
Fry[19]	46 with EDSS >6.5	3 sets of 15 reps once daily	Initial at 30% MIP, progression weekly based on RPE and symptoms	10 weeks	Sig. ↑ _in MIP; Trend to ↑ _in MEP and MVV

Summary

In both less and more disabled persons with MS, resistive ventilatory muscle training has been shown to increase ventilatory muscle strength. In these studies training was generally task-specific, i.e., expiratory training increased MEP and inspiratory training increased MIP. In a few studies there was evidence of carry-over to the opposite ventilatory function, i.e., expiratory training not only increased MEP, but also increased MIP and vice versa.[1,15] In one study there was evidence of carry- over to physical performance function, specifically gait and balance.[17]

All cited training protocols progressively advanced the resistance of the training devices following some form of testing (MEP, MEP, RPE, clinical symptoms) and consultation with a healthcare professional. Two of the studies used the Borg 6–20 RPE Scale[21] and self-reported symptoms which could be administered through phone consultation rather than in-person visits.[15,19] Administering exercise progression through phone contact using RPE and symptom monitoring enables treatment to be primarily home-based, which drastically reduces the cost of treatment and relieves transportation issues which sometimes limit access to medical care for persons who have MS.

Recommendation

Pulmonary function should be assessed in all persons who have MS and ventilatory muscle training included in physical therapy programs when ventilatory function is deficient. Persons with MS with mild to severe disability benefit from threshold inspiratory and expiratory muscle training.

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