



The Role of Progressive Resistance Training in the Management of Multiple Sclerosis

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INTRODUCTION AND PATHOPHYSIOLOGY

Multiple sclerosis (MS) is a chronic, inflammatory, autoimmune disease that affects the central nervous system. About 1 million individuals in the United States and nearly 3 million individuals worldwide are living with this disease (1). Diagnosis normally occurs between the ages of 20 and 50 years, and it affects more than twice as many females as it does males (2).

MS begins with an immune-mediated attack on the myelin sheaths, the protective covering on nerve axons (Figure 1). After the attack and associated damage, nerve impulses are not properly conducted. Neural signals are either altered or lost, and hardened plaques begin to form on white and gray matter.

COURSES OF THE DISEASE

There are four disease courses that define this condition (2):

1. Clinically isolated syndrome (CIS). This is the first episode of neurologic symptoms that are caused by inflammation and demyelination in the central nervous system and lasts at least 24 hours. The CIS episode can be monofocal or multifocal consisting of multiple signs/symptoms. Because it is an

isolated event, it is distinct from MS in that it may lead to multiple episodes (MS) or may never occur again.

2. Relapsing–remitting. This is the most common disease course and is characterized by clearly defined attacks of new or increasing neurologic symptoms. These attacks, which are called relapses or exacerbations, are followed by periods of partial or complete recovery (remissions). During remissions, all symptoms may disappear, or some symptoms may continue and become permanent. However, there is no apparent progression of the disease during the periods of remission.
3. Secondary progressive. This stage follows an initial relapsing–remitting course and is characterized by a progressive worsening of neurologic function, or the accumulation of disability over time. Approximately 50% of those in the relapsing–remitting stage will progress to secondary progressive.

Additionally, this stage includes subcategories:

- Active (a relapse or new MRI activity) with progression in symptoms and/or disability
- Active without progression in symptoms or disability
- Nonactive with progression in symptoms or disability
- Nonactive without progression in symptoms or disability



MEDICAL REPORT

4. Primary progressive. This stage is characterized by worsening neurologic function from the onset of symptoms, without early relapses or remissions (Table 1).

DISEASE MANAGEMENT

Disease management should occur within the context of lifestyle medicine. Lifestyle medicine includes the following six pillars (3):

Although this article's focus is on exercise, and more specifically the role of progressive resistance training in the management of MS, the reader should note that to optimize the management of this disease, each of the six pillars should be addressed and appropriate corrections made if necessary (Table 2).

Because MS is a disease that negatively affects the nervous system, engaging in exercise that has the potential to positively affect the nervous system is critical. This is where a properly designed progressive resistance training program comes in to play.

Changes and adaptations that occur in the nervous system with resistance training, which may contribute to a positive effect on neurological diseases such as MS, include the following (4–6):

- motor neuron firing frequency
- rate coding/speed of muscle contraction
- recruitment of motor neurons
- motor unit synchronization
- rate of force development
- inter- and intramuscular coordination
- neural plasticity

Additionally, resistance training may create new signaling pathways resulting in a gain of functional neural connectivity, or more simplistically expressed, “What trains together, gains together” (7). Therefore, resistance training not only trains

TABLE 2: Six Pillars of Lifestyle Medicine

1. Physical activity and exercise
2. Healthy nutrition
3. Stress management
4. Adequate sleep
5. Social support
6. Cessation of smoking and other harmful products

muscles but also trains the nervous system. Apart from or along with pharmacological agents, to improve the health of the nervous system and potentially reverse the course of the disease and/or the associated symptoms, the nervous system needs to be trained. For a training effect to occur, the intensity must be such that it elicits neurological or metabolic fatigue. In resistance training, this occurs when sets are taken to “at or near repetition maximum” (see Side Bar).

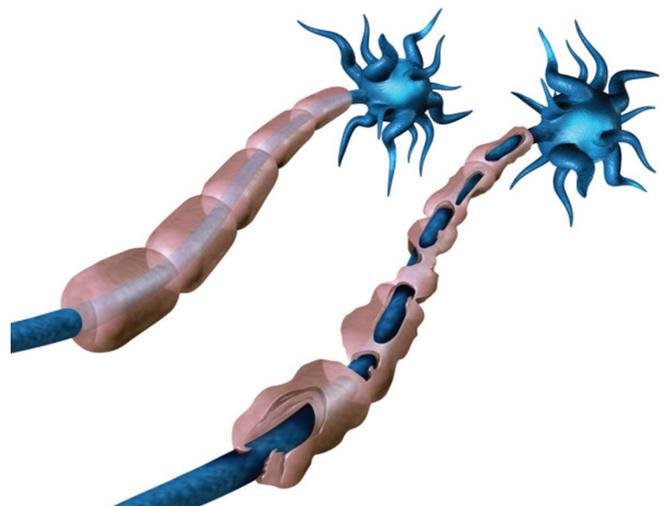
Henneman's size principle, a well-established principle of exercise, dictates that in controlled movements, such as activities of daily living and most resistance exercises, motor units are recruited based on need, in order of size, and according to both the intensity of the task and the proximity to muscle failure (Figure 2). Simply stated, lower-intensity activity, such as nonexercise physical activity (*e.g.*, casual walk, gardening, and household chores), recruits fewer motor units, and higher-intensity activity, such as progressive resistance training, recruits a much larger pool of motor units.

The American College of Sports Medicine (ACSM) guidelines for resistance training suggest that individuals new to training begin in the 8 to 12 repetition range and progress

TABLE 1: Common Symptoms or Complications of MS

Decreased gait and balance
Weakness and fatigue
Muscle spasms
Numbness and tingling
Visual disturbances
Mobility issues
Sleep disruption
Loss of bladder and bowel control
Decrease functional ability
Pain
Cognitive and emotional impairments

Figure 1. Healthy and damaged myelin sheaths.



Side Bar: Terminology for Set End Points (8)

Nonrepetition maximum warm-up: Set terminated when a lifter completes a predetermined number of repetitions although further repetitions could be completed, where the last repetition was not in close enough proximity to muscle failure to elicit an adaptation.

Nonrepetition maximum working set: Set terminated when a lifter completes a predetermined number of repetitions although further repetitions could be completed, where the last repetition was in close enough proximity to muscle failure to elicit an adaptation.

Repetition maximum: Set terminated when a lifter completes the final repetition possible whereby if the next repetition was attempted, they would definitely achieve muscle failure.

Momentary muscle failure: Set terminated when a lifter reaches the point where, despite attempting to do so, they cannot complete the concentric portion of their current repetition without deviation from the prescribed form of the exercise.

to spending most of their time training across the 6 to 15 repetition spectrum (1). At the higher end of this spectrum (*e.g.*, 10 to 15 repetitions), type II (strength) motor units may not need to be recruited until toward the end of the set. As the repetitions decrease and the corresponding load increases, there is an increased need to produce force, an increase in neural drive, and therefore the recruitment of a larger fraction of the nervous system.

If we think of the nervous system as an electrical grid, even a moderate intensity, total body resistance training program will recruit a significant portion of this grid and, along with the other components of lifestyle medicine, will greatly increase the potential for healing and the reversal of symptoms (Figure 3).

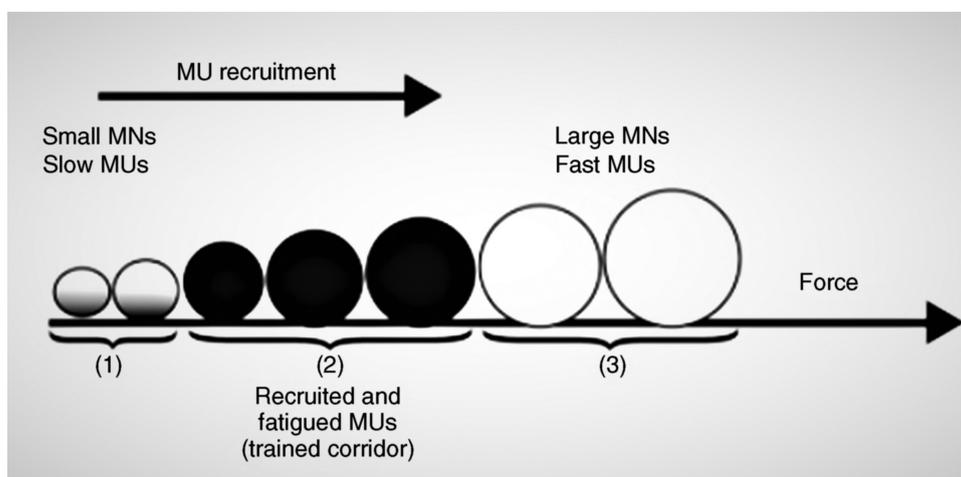
PROGRESSIVE RESISTANCE TRAINING PROGRAM DESIGN GUIDELINES

Overall program design should always occur within the framework of established ACSM guidelines and the most current evidence (9). As *ACSM's Guidelines for Exercise Testing and Prescription, 11th edition* notes, exercise prescription for individuals with minimal disability is “generally consistent with those outlined for healthy adults”, and “individuals who are not able to meet recommended exercise guidelines should engage in regular physical activity according to their abilities with support from their health care providers”. Table 3 lists the variables and general guidelines involved in designing a resistance training program.

Within this framework, the individual or coach should insert the special considerations for this disease (1,2). These considerations include the following:

- Emphasize hydration before, during, and after exercise sessions to keep the body's thermostat regulated and reduce or negate the risk of overheating.
- Rest periods between sets should be long enough to allow heart and breathing rate to return to “at or near normal”, reducing the risk of overheating as well. The individual also should feel mentally ready to perform the next set.
- Avoid exercising in hot/humid environment; ensure training in a cool environment.
- Include exercises that challenge static and dynamic balance to maintain or improve balance and spatial awareness.
- Consider the timing of ingestion of medication, as it may create symptoms that could affect an exercise session.
- During an acute exacerbation, volume and intensity should be reduced to the individual's level of tolerance. Depending on the severity, exercise may not be able to be performed.

Figure 2. Henneman's size principle.



MEDICAL REPORT

Figure 3. Nervous system.



TABLE 4: Linear Periodization

Linear Periodization Example		
Repetition Range	Phase Length	Primary Purpose
12 to 15 reps/set	3 to 4 weeks	Progress in strength or RPE by the end of the phase if possible
10 to 12 reps/set	3 to 4 weeks	Progress in strength or RPE by the end of the phase if possible
8 to 10 reps/set	3 to 4 weeks	Progress in strength or RPE by the end of the phase if possible

Other Considerations:

- Vary session intensities (RPE) so that some sessions are lighter and some are more challenging. Be flexible based on the individual's physical and mental status going into the session.
- Increase variety of exercise selection.
- Increase set volume with a goal of 10 to 15 sets per large muscle group (legs, back, chest, and shoulders) per week, when appropriate.

- When possible, include functional activities (*e.g.*, sit-to-stand, rising from the floor, stair climbing) within the program.
- Ensure the individual's "readiness to train" before each session by asking the questions suggested in Table 5.

CONCLUSION

MS is a disease that can have widely varying effects on individuals, both physically and emotionally. Within the context of program design, the trainer will need to take into consideration where the individual lies on a continuum of severity along with how they feel from session to session. Despite the varying effects on people with this condition, Tables 2 and 3 show that overall

TABLE 3: Resistance Training Recommendations for Individuals with MS

Frequency	<ul style="list-style-type: none"> • Begin with 1 to 2 days per week • Progress to 3 (total body) or 4 (split routine) days per week
Objective intensity (repetition ranges and corresponding loads)	<ul style="list-style-type: none"> • Begin with 6 to 10 reps/set at low RPE (see below) • Progress to 8 to 15 reps/set in a linear periodization fashion (see Table 4)
Subjective intensity (RPE)	<ul style="list-style-type: none"> • Begin at 4 to 5 RPE on a 0 to 10 OMNI scale • Progress to 6 to 8 RPE on a 0 to 10 OMNI scale
Sets per muscle group per session	<ul style="list-style-type: none"> • Begin with 1 to 2 sets • Progress to 3 to 5 sets when appropriate
Sets per muscle group per week	<ul style="list-style-type: none"> • Begin with 1 to 4 sets • Progress to 10 to 15 sets when appropriate
Rest periods between sets	<ul style="list-style-type: none"> • Allow heart and breathing rates to return to at or near resting level • This typically equates to ~2 to 3 minutes
Rest periods between sessions	<ul style="list-style-type: none"> • Allow ~48 to 72 hours of rest for trained muscle groups • Also allow the individual to be mentally prepared to train
Type of exercise	<ul style="list-style-type: none"> • Bodyweight, machine, free weights

TABLE 5: “Readiness to Train” Questions

• How do you feel?
• How did your body respond to the last session?
• Have you eaten and if so, what and when?
• Are you hydrated?
• Have you taken your medications?
• Are you on any new medications?
• Is there anything else you would like me to know before starting the session?

program design is actually quite similar across the continuum. The primary differences lie with the following:

- initial loads and corresponding rate of perceived effort
- rate of progression
- mobility and available pain-free range of motion
- exercise selection and access to equipment
- readiness to train from session to session

If a muscle can contract, it can be strengthened. Muscles that can be strengthened can be progressed in strength. Progress in strength simultaneously trains and positively affects the nervous system. Therefore, a progressive resistance training program, tailored to the individual as suggested in this article, may improve the health, well-being, and quality of life for individuals with MS (10–12).

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