12 EXERCISE FOR PEOPLE WITH MULTIPLE SCLEROSIS

According to the National Multiple Sclerosis Society, 400,000 Americans and 2.5 million people worldwide have been diagnosed with multiple sclerosis (MS). Because the symptoms of this disease sometimes go unnoticed, especially early in its progression, many people who have MS have not been formally diagnosed.[1] Thus, the number of actual cases might be much higher. Diagnosis usually occurs between the ages of 20 and 50, and although MS is not normally fatal, it can dramatically interfere with quality of life.[2,3] MS tends to affect twice as many women as men and twice as many whites as other ethnicities.[1,2] Although it is not an inherited disease, the rate of occurrence among families is estimated at 20% (Table 12-1).[4]

The incidence of MS is increasing with nearly 200 new diagnoses each week.[1] Initial symptoms are blurred or double vision or red-green color distortion. Additional difficulties include lack of balance, incoordination, fatigue, general muscle weakness, speech disturbances, memory problems, and urinary incontinence (Table 12-2). In severe cases, partial paralysis results,[2,3,5,44] but over two thirds of those with MS remain relatively mobile and able to perform activities of daily living.[1]

MS is a progressive disorder that can cost sufferers considerably. The financial costs result from medical care and hospitalizations, but even more devastating are the personal costs associated with a diminished quality of life.[2] MS affects not only people afflicted with it but also everyone around them.

TABLE 12-1. Risk Factors for Developing MS

Risk Factor	Description
Sex	MS affects two to three times more women than men
Race	Whites are two times more likely to develop MS than are blacks
Age	MS typically occurs in those between the ages of 20 and 50; it rarely occurs in those younger than 15 or older than 60
Geographical location	MS is more prevalent in temperate regions than in tropical regions
Genetics	Experts believe that some people are genetically predisposed to react to environmental triggers in a way that promotes MS development
Diet	Countries that consume large quantities of saturated fat tend to have higher incidences of MS than do those that consume small quantities
Viral infection	Some viruses trigger demyelination and inflammation in genetically predisposed individuals; this is a major focus of current research

Data from Hamler B. Exercise for Multiple Sclerosis. A Safe and Effective Program to Fight Fatigue, Build Strength, and Improve Balance. Hatherleigh Press, 2006; National Multiple Sclerosis Society. www.nationalmssociety.org.

TABLE 12-2. Symptoms of MS

The symptoms of MS vary greatly and often resemble those of other disorders.

- Physical and mental fatigue
- Visual disturbances (blurred or double vision; loss of color vision; abnormal pupil response)
- Muscle spasticity, with or without pain
- Loss of balance and coordination
- Urinary incontinence
- Depression or mood swings; unexplained anxiety

ANATOMICAL AND PHYSIOLOGICAL CHANGES WITH MS

Experts do not yet know the precise cause of MS, but they classify it as an **autoimmune disorder** that affects the central nervous system (CNS). As mentioned in Chapter 2, the CNS includes nervous tissue found in the brain and spinal cord. Neurons are nervous system cells that initiate and propagate nerve impulses and ultimately influence **effectors** (e.g., other neurons, muscles, or glands). To function, these effectors require stimulation from neurons. Problems result when neurons are damaged since effectors will subsequently be unable to fulfill their roles.

In MS, the immune system attacks and destroys a structure called the **myelin sheath**; hence, MS is often referred to as a **demyelinating disease**. The myelin sheath surrounds various segments of the neuron's axon and speeds up impulse propagation along the axon (see Chapter 2 for further information on neuron structure). Without adequate myelin sheath, the rate of propagation slows and communication with effectors is impaired. See Figure 12-1 for a comparison of a myelinated to a demyelinated axon. Demyelination, which occurs during periods of relapse, is often followed by **remyelination**. Remyelination attempts to repair damaged myelin to restore axon function; however, it is a slow and often incomplete process that is usually accompanied by inflammation. After repeated bouts of demyelination, remyelination, and inflammation, sclerotic plaques form.[4,6] Over time, this vicious cycle can damage actual axons. Since axons in the CNS are unable to repair themselves, impulse propagation along a damaged axon eventually ceases altogether. Subsequently, its effectors no longer receive stimulation and cannot function. Because it is impossible to determine which neurons will be destroyed as MS develops, it is also impossible to predict which effectors will

Autoimmune disorder—a condition in which a person's immune system attacks normal body cells. The specific signs and symptoms vary depending upon which cells or organs are attacked, but all involve overactive T cells (see Chapter 2 for further information on the immune system and T cells).

Effectors—cells that respond to impulses propagated by neurons. Effectors include muscles, glands, or other neurons.

Myelin sheath—a fatty covering that lines segments of neuron axons in both the CNS and peripheral nervous system (PNS). In the CNS, myelin sheath is formed by oligodendrocytes. In the PNS, it is formed by Schwann cells. Myelin sheath speeds up the rate of impulse propagation along a neuron allowing for more rapid communication with effectors. MS affects the myelin sheath of the CNS.

Demyelinating disease—any condition that damages the myelin sheath and, therefore, interferes with neuron functioning.

Remyelination—the process by which the myelin sheath is repaired. It occurs spontaneously but very slowly in some patients with MS.

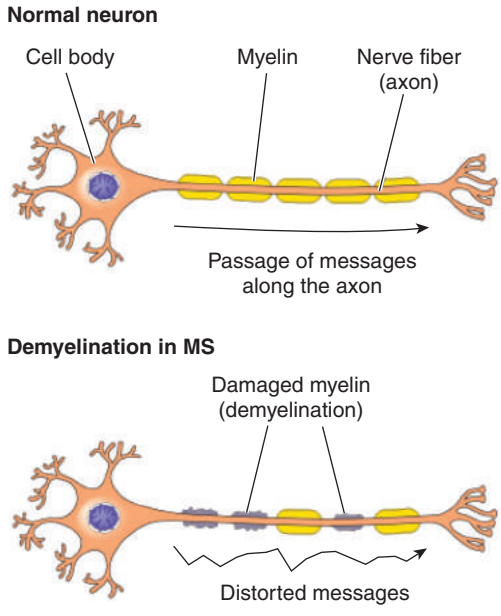


FIGURE 12-1 ■ This image shows the anatomy of a normal neuron with myelin sheath compared to a neuron with damaged myelin sheath. (Reprinted from Labus D, Cohen A. Lippincott Advisor (May 2016 release). Baltimore: Lippincott Williams & Wilkins, 2016, with permission.)

be impaired. Thus, symptoms vary widely from person to person, but common complaints are overall fatigue, loss of balance, paralysis, blindness, and the inability to concentrate.[1,4,6]

Researchers do not understand why remyelination occurs in some MS but not in others. They know, however, that demyelinated axons often die, and they believe that the progressive nature of MS likely results from cumulative axon loss. Researchers continue to investigate methods to stimulate remyelination in an attempt to slow disease progression and preserve axon function.[6–9]

QUICK REFERENCE

The axons of affected neurons are not always destroyed. When not destroyed, axons develop additional sodium channels in an effort to preserve functioning. This might explain why MS symptoms often oscillate.[1,4,7]

FACTORS THAT CONTRIBUTE TO THE DEVELOPMENT OF MS

Some experts believe that MS is caused by an unknown environmental trigger, perhaps a virus.[3] Although conclusive evidence does not currently exist, ongoing studies are investigating the relationship between MS and over a dozen viruses and bacteria since many pathogens trigger demyelination and systemic inflammation in genetically predisposed individuals. Examples of viruses that might play a role in the development of MS include Epstein-Barr, measles, and human herpesvirus 6.[1]

Because MS is more common in temperate areas rather than in tropical areas, researchers are investigating a possible link here as well. See Figure 12-2 for a map depicting worldwide distribution of MS. The inhabitants of sunny regions are continually exposed to ultraviolet (UV) radiation and therefore make larger amounts of vitamin D than do those in less sunny regions. Some experts believe that this higher vitamin D level provides protection against MS development and progression. This topic is addressed again in the nutrition section.

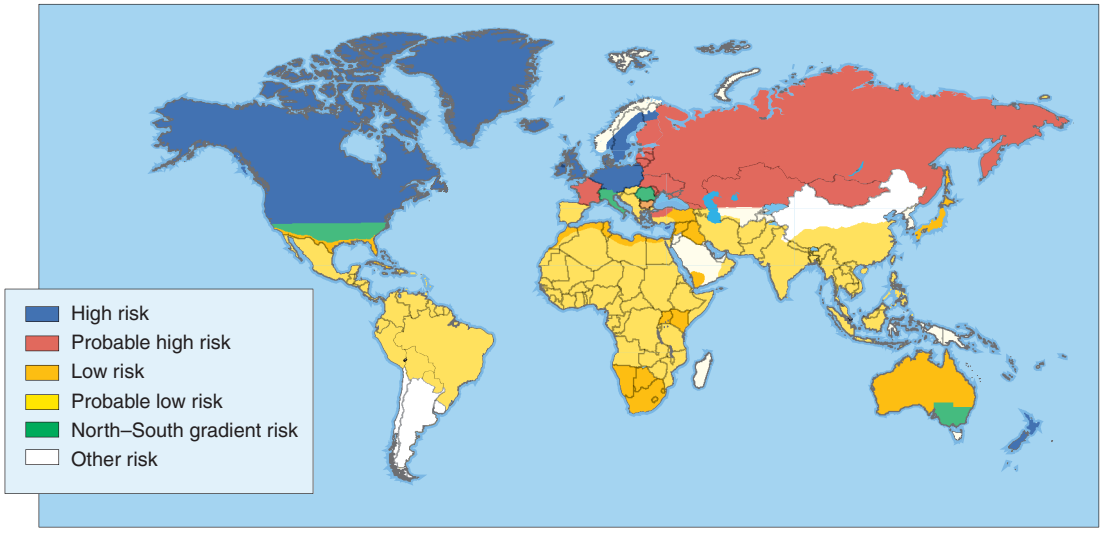


FIGURE 12-2 ■ Worldwide distribution of MS. (Reprinted from Braun C, Anderson C. Applied Pathophysiology. 3rd Ed. Baltimore: Lippincott Williams & Wilkins, 2016; Fig. 10-18, with permission.)

Some experts believe that MS might develop more readily in people born with a "… genetic predisposition to react to some environmental agent that, upon exposure, triggers an autoimmune response."[1,4] Experts have not been able to pinpoint any specific gene involved with MS.

Most likely, a combination of genes acting together predisposes individuals to MS.[10] Technological advances will hopefully help discover the role genes play in MS development.[1]

CATEGORIES OF MS

In 1996, scientists from around the world established four categories of MS. *Relapsing–remitting MS* is the most common form upon initial diagnosis and is responsible for 85% of all MS cases. Those affected exhibit periods of acute flare-ups during which neurological functioning deteriorates as the body's immune cells destroy existing myelin. This causes inflammation and lesions. A relapse can last from a few days to a few months and is followed by a period of remission during which symptoms might completely disappear as inflammation subsides and remyelination occurs. Remission can be almost instantaneous, or it can be slow and gradual.[1,11,12]

Primary progressive MS is a relatively rare form that often develops in those in their late 30s or early 40s; it is responsible for 10% of cases. Those affected experience a steady decline with no relapses or remissions, but the actual rate of deterioration varies. Improvements are infrequent and minor.[1,11,12]

Secondary progressive MS traditionally occurs in 50% of those diagnosed with relapsing–remitting MS. Its onset is usually within 10 years of initial diagnosis. After several years of relapses and remissions, those affected begin to experience a slow but steady worsening of symptoms with or without flare-ups. In other words, the disease progresses in between relapses until relapses essentially merge into a continual progression of disease with no remissions.[1,11,12]

Progressive relapsing MS is the rarest form and is responsible for about 5% of all MS cases. It is essentially primary progressive MS with periods of relapse and remission in between. Unlike the relapsing–remitting form, this form is marked by progressive deterioration.[1,11,12] See Figure 12-3 for graphs that represent the different types of MS.

There is currently no cure for MS; however, medications can slow progression once diagnosis has been made. Diagnosing MS, however, is not an easy task for many reasons. First, the

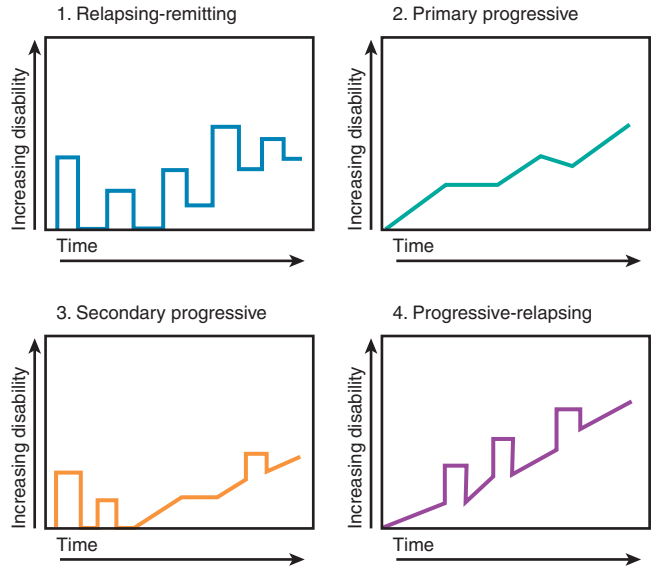


FIGURE 12-3 ■ Types and courses of multiple sclerosis (MS). 1. Relapsing–remitting (RR) MS is characterized by clearly acute attacks with full recovery or with sequelae and residual deficit upon recovery. Periods between disease relapses are characterized by lack of disease progression. 2. Primary progressive (PP) MS is characterized by disease showing progression of disability from onset, without plateaus and temporary minor improvements. 3. Secondary progress (SP) MS begins with an initial RR course, followed by progression of variable rate, which may also include occasional relapses and minor remissions. 4. Progressive relapsing (PR) MS shows progression from onset but with clear acute relapses with or without recovery. (From Lublin FD, Reingold SC. Defining the clinical course of multiple sclerosis: Results of an international survey. Neurology 1996;46(64):907–911, with permission.)

symptoms of MS vary and resemble those of other conditions[1] such as spinal cord tumors, stroke, Lyme disease, neurosyphilis, systemic lupus erythematosus, complicated migraine, diabetes, myasthenia gravis, and herpes simplex.[10] Thus, physicians have to "rule out" these other conditions before suggesting a diagnosis of MS. Further complicating diagnosis is the fact that symptoms often come and go, which makes it difficult to pinpoint triggers. Additionally, since there is no one diagnostic test for MS, diagnosis relies on a battery of tests that includes a full medical history, a neurological exam, magnetic resonance imaging (MRI), visual evoked potential (VEP) tests, lumbar puncture (spinal tap), and blood tests. The medical history and neurological examination help discover the presence of symptoms—and the triggers—that might indicate MS. MRI scans can locate plaques or lesions in the CNS. VEP tests can stimulate visual sensory pathways, record time of response, and determine electrical activity within the brain. A spinal tap withdraws and analyzes cerebrospinal fluid, the fluid that circulates throughout the brain and spinal cord. Blood tests help rule out other causes of symptoms.[1]

TREATMENT FOR MS

Treatment for MS involves managing current symptoms and slowing progression. Those with MS can often manage symptoms with physical therapy, occupational therapy, exercise, and diet; however, pharmacological intervention is generally required to slow progression.[1,13]

HIGHLIGHT Clinically Isolated Syndrome[47]

According to the National Multiple Sclerosis Society, clinically isolated syndrome (ICS) is a CNS demyelinating event strongly associated with future development of MS. It is defined as a single, initial episode of an MS-associated neurological symptom(s) that results from demyelination of CNS neurons, persists for a minimum of 24 hours, and completely resolves. Some people affected experience a single symptom during this one-time event, while others experience multiple symptoms. Clinical symptoms are really the same between CIS and MS since they both result from damage to the myelin surrounding axons of CNS neurons, so a distinction is made based on whether or not the symptoms persist and reoccur.[1,9]

Not everyone who has a CIS develops MS; however, those who experience an initial episode *and* have MRI-detected brain lesions that resemble the lesions found in patients with MS have a 60% to 80% chance of a second CIS and subsequent MS diagnosis. Furthermore, a diagnosis of MS can now be made for a person when CIS is accompanied by MRI confirmation of previous lesions and scars. For those who have an increased risk of developing MS, it is critical to begin disease-modifying treatments as soon as possible to prevent the onset of another CIS or progression to MS. See Figure 12-4 for actual images of MS lesions.

Seventy percent of those diagnosed with CIS are between the ages of 20 and 40. Not surprisingly, women are two to three times more likely to develop CIS than are men, but anyone can be at risk.[1,9]

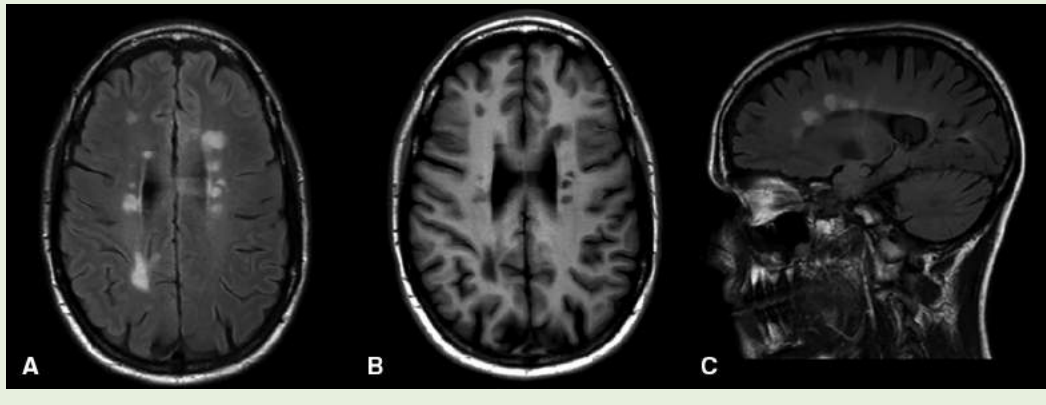


FIGURE 12-4 ■ Multiple sclerosis. **A.** Characteristic white matter lesions of multiple sclerosis depicted on an axial FLAIR image. **B.** Low signal intensity of the lesions on T1-weighted images suggests chronic lesions. **C.** Sagittal FLAIR image depicts the radial orientation of white matter lesions characteristic of multiple sclerosis. (From Louis ED, Mayer SA, Rowland LP. Merritt's Neurology. 13th ed. Baltimore: Lippincott Williams & Wilkins, 2015; Fig. 21-6, with permission.)

PRECAUTIONS DURING EXERCISE

Those with MS face many physical challenges on a daily basis, including generalized fatigue, muscle spasticity, poor balance, incoordination, pain, and incontinence. Consequently, they must be cautious when participating in activities since activities might exacerbate these symptoms. This section explores concerns when working with clients who have MS.

FATIGUE

The most common symptom associated with MS is fatigue. Fatigue can range from a general lack of energy to total physical and mental exhaustion. Most people with MS claim that their generalized fatigue interferes with normal activities and decreases their quality of life more than any other symptom they experience.[14] For some, fatigue develops suddenly and severely for no apparent reason. For others, it only results from prolonged exertion or overheating. For many others, it is a side effect of antidepressants or other medications used to manage MS. No matter what the cause, personal trainers and other health professionals need to be aware of this symptom and make daily adjustments to the exercise routine based on energy levels. Additionally, moderation in exercise is important in this particular population since overexertion is a trigger for debilitating fatigue in many MS patients.[1,5,10,14–16]

Some experts classify the fatigue seen in MS into two types: fatigability and lassitude. Fatigability occurs within a specific muscle or group of muscles after continual use; it is alleviated with rest. Lassitude, on the other hand, is a persistent feeling of exhaustion that does not subside with rest. Some individuals experience both fatigability and lassitude at the same time, whereas other individuals experience one without the other. Nevertheless, fatigability and lassitude can interfere with exercise ability. Exercise tends to be most effective when fatigue is a secondary symptom of MS that results from inactivity.[17]

QUICK REFERENCE

High-intensity activity and activity in a hot environment can exacerbate MS symptoms and cause debilitating fatigue by dramatically increasing core body temperature. Experts believe that an elevated core body temperature temporarily interferes with the communication between demyelinated axons and their effectors, thereby worsening symptoms.[18]

MUSCLE SPASTICITY

Muscle spasticity is a common complaint among those with MS. It often occurs in the lower extremities and can be quite dangerous during exercise. Imagine what might happen if a client is holding a pair of dumbbells overhead when a thigh starts to spasm; severe injury could result. Many people with MS take muscle relaxants to manage spasticity, but these medications can interfere with exercise ability as well. Health professionals should consider these factors when designing exercise programs. Flexibility training seems to reduce the severity and frequency of spasticity and should be a major component of the exercise prescription.[1,10]

MUSCLE WEAKNESS, POOR BALANCE, AND INCOORDINATION

Muscle weakness, poor balance, and incoordination in a person with MS often result from one of two reasons. First, many people with MS become inactive once diagnosed because despite the benefits provided by exercise, some physicians continue to discourage exertion. It is common for doctors to suggest that MS patients avoid stairs and take elevators; that they park close to a store instead of farther away; and that they avoid walking longer than necessary because

overexertion can worsen symptoms. These suggestions are the exact opposite of what is recommended to the general population! Although the intent is to minimize the risk of triggering symptoms, the result is loss of muscle mass, strength, and flexibility, which ultimately results in overall weakness and imbalance. Health and fitness professionals, therefore, need to stabilize clients with balance abnormalities while they strengthen their muscles and joints. A focus on simple movements will likely be necessary for this group.[17]

The second factor that contributes to muscle weakness, poor balance, and incoordination is destruction of the myelin sheath and axons. Unfortunately, exercise cannot improve the loss in functional ability associated with demyelination,[17] but it can preserve and improve muscle function in unaffected areas.

Lifestyle Modification Tip: As emphasized throughout this text, sleep is critical for normal functioning. Encourage clients to maintain a regular sleep schedule by going to bed and getting up at the same time each day, developing a relaxing bedtime routine that helps them wind down, avoiding exercise within 3 hours of bedtime, avoiding daytime naps, avoiding alcohol and caffeine within 4 to 6 hours of bedtime, and adjusting the temperature to a comfortable setting. If restless and struggling to get to sleep, they should get out of bed until they feel sleepy. See Chapter 13 for additional tips on improving sleep.

SENSITIVITY TO HEAT

In more than 80% of those with MS, an increased core body temperature exacerbates symptoms. The primary reason for this is that high temperature interferes with impulse propagation along demyelinated axons. Therefore, it is imperative to keep exercise intensity low to avoid overheating. It is also important to exercise in a cool environment, perhaps in the water or in an air-conditioned room.[17]

PAIN

Pain levels vary among those with MS on a daily basis. Additionally, the medications that people with MS use to manage their pain often have numerous side effects. Health professionals need to be aware of these side effects and should modify exercises based on current pain level.

INCONTINENCE

As MS progresses, problems with the urinary system usually develop. This might result in frequent urges to urinate, the inability to completely empty the urinary bladder, varying degrees of incontinence, or frequent urinary tract infections. To decrease the risk of any of these happening, people with MS often restrict water intake. Limiting water intake is especially dangerous to those with MS because overheating can exacerbate symptoms.[1,10]

Overall, people with MS can safely participate in exercise as long as they are aware of special precautions. Since both overexertion and overheating can increase symptom severity or promote relapse, the intensity of the activity and the environment in which the activity occurs are important. Avoid exercising outdoors in the heat, and drink adequate water to keep the internal body temperature within norm. If symptoms develop, decrease intensity or stop the exercise altogether.

HIGHLIGHT Gait Problems with MS

According to the National Multiple Sclerosis Society, people with MS often experience difficulty while walking. Many factors compound this problem, but the major contributor is a sedentary lifestyle, which promotes muscle weakness, joint inflexibility, and loss of balance—factors that can cause "**foot drag**," "**footdrop**," "**vaulting**," "**hip hike**," or "**circumduction**" of the thigh. These adaptive techniques help those with MS compensate for weaknesses on one or both sides of the body. Gait problems are worse for those who experience muscle spasticity who tend to favor the unaffected side of the body. Additionally, many people with MS complain of complete numbness or tingling in the feet—which is the number one cause of footdrop. In some cases, the numbness is so extreme that the person cannot feel any contact with the floor—a factor that further impairs balance. Lastly, generalized fatigue interferes with walking because a sloppy gait often develops when fatigue develops.[1,10] The resulting abnormal gait can then cause misalignments that eventually result in joint problems.

Overall, weakened muscles and joints can cause balance problems that result in ataxia—a swaying movement that resembles drunkenness. Regular strength training and stretching can certainly help improve walking ability by increasing strength, improving flexibility, enhancing balance and coordination, and maintaining proper communication between the nervous and muscular systems. It cannot, however, repair damaged nerves. Since poor walking mechanics during aerobic training can trigger other musculoskeletal problems that might result in huge setbacks for the client, health professionals should evaluate clients for gait deviations. If problems are noted, take time to teach proper walking technique—which consists of a heel first, ball-of-foot second, and toes third movement that propels the client forward. Make sure the client does not drift to one side, and encourage an upright posture. In some cases, those with balance and coordination problems might need to use canes or walkers to prevent falls, but in any case, practice proper walking technique to ultimately improve gait. Working closely with a physical therapist is usually best in these situations.

BARRIERS TO EXERCISE

The fear of worsening symptoms and promoting disease progression are probably the primary barriers to exercise in this population. Sometimes, health care professionals instill this fear in their MS patients when they discourage patients from exerting themselves. At other times, those

Foot drag—a condition where the front of the foot is not lifted completely off the floor when taking a step; consequently, the toes drag along the floor.

Footdrop—occurs during walking when the person's toes contact the floor first, prior to the heel. A healthy walking stride occurs with a heel first, ball-of-foot second, and toes third type of movement.

Vaulting—occurs during walking when the person raises the heel on the stronger leg to enable the weaker leg to swing through.

Hip hike—a compensatory movement that involves raising the stronger hip to allow movement of the weaker side of the body.

Circumduction—swinging one leg out to the side to permit forward progression of the foot during walking.

with MS notice an increase in symptom severity following activity, so they avoid activity to prevent symptoms. What some physicians and MS patients fail to realize is that exercise done at a moderate intensity and in a cool environment can actually minimize symptoms such as fatigue, incoordination, and decreased range of motion.[9]

The unpredictability of relapse is another common barrier. A person with MS who has been exercising and making gains in strength, flexibility, and cardiorespiratory endurance might lose all of these improvements during a relapse. It often takes weeks, and sometimes even months, to work through a relapse at which time many exercise-induced improvements are lost. Following a relapse, clients basically have to start from the beginning. In fact, they often require a totally new exercise protocol.[17]

Additional barriers to exercise for those with disabilities include a general lack of energy, decreased self-confidence, limited disease-specific knowledge of fitness center staff, and fear of falling because of muscle weakness and balance deficits.[19] The next section describes some of the benefits of exercise for this population and presents current scientific evidence to support it.

BENEFITS OF EXERCISE

In the not-so-distant past, physicians unequivocally encouraged people diagnosed with MS to refrain from physical activity because they believed that exertion would worsen fatigue and possibly encourage new symptom development. Over the years, however, researchers have discovered that those with MS not only tolerate exercise well without worsening symptoms but also experience several benefits from it. Some benefits experienced by exercisers with MS include reduced risk for chronic diseases; fewer episodes of debilitating fatigue; improved muscular strength, muscular endurance, flexibility, and balance; and improved mood and confidence level.[9]

QUICK REFERENCE

Research has shown that exercise does not reduce the rate of relapse, nor does it slow the progression of MS. Nevertheless, it reduces the overall loss of functional capacity associated with advancing stages of the disease.

REDUCED RISK FOR CERTAIN CHRONIC DISEASES

When they begin exercising, those with MS experience the same reduced risk for heart disease, cancer, stroke, and diabetes as do members of the general population. As mentioned in several other chapters, consistent exercise lowers blood pressure, enhances oxygen delivery to body cells, and improves blood lipid levels, all of which benefit the heart and blood vessels.[11,12,14,20] Exercise also helps maintain a healthy weight, which not only improves heart health but also decreases the risk of developing type II diabetes (see Chapter 9 for further information). The combination of a healthy weight and a healthy blood lipid profile further protects against colon and breast cancer. Additionally, all weight-bearing exercises promote healthy bone tissue and inhibit bone loss.

EXERCISE AND THE PERCEPTION OF FATIGUE

Numerous studies have investigated the effects of exercise on fatigue level, but the results are conflicting. Some researchers have found that exercise actually decreases the perception of fatigue, but most have discovered that exercise resulted in no change in fatigue levels at all—in

the short or long term. Even if physical activity does not reduce fatigue, it is important to note that it does not exacerbate fatigue either. This is encouraging given that many physicians discourage activity fearing that increased exertion intensifies fatigue.[14,15,17,18,20–22]

IMPROVED MUSCULAR STRENGTH, MUSCULAR ENDURANCE, FLEXIBILITY, AND BALANCE

No one would dispute that exercise improves strength, endurance, flexibility, and balance in the general population, so it should be no surprise that people with MS can experience these same benefits when they become active.[1,17,20] Some would argue that activity is even more important for someone with MS since MS patients, who are much more likely to be sedentary than is the average person, typically experience a major decline in functional capacity after diagnosis. Consider the cycle of events that are set into motion when someone with MS avoids activity: without stimulation, muscle mass diminishes; as muscle mass diminishes, joint stability decreases; as joints weaken, surrounding ligaments, tendons, and muscles stiffen; and as supportive structures stiffen and muscles weaken, balance and coordination problems result. Furthermore, since the nervous and muscular systems work together to move body parts, they need to regularly communicate with one another to preserve normal functioning. Regular physical activity encourages this interaction and promotes more efficient communication.[23,24]

IMPROVED MOOD AND CONFIDENCE

A diagnosis of MS is shocking and difficult for many people. It often destroys confidence and impairs mood. It might even lead to depression. In fact, many (but certainly not all) people diagnosed with MS seek out therapy or take medication for depression. In some cases, exercise is a worthy prescription for low self-esteem and a poor mood. It not only promotes the release of powerful chemicals that elevate mood but also encourages social interaction and provides a sense of accomplishment for participants, both of which enhance mood. MS clients diagnosed with depression might still need medical or therapeutic interventions, but physical activity can certainly help. It gives them some sense of control over their bodies, something those with MS often feel that they lack.[14,17,18,20,25]

According to the National Multiple Sclerosis Society, physical activity helps manage MS symptoms. In fact, a study in 1996 at the University of Utah was the first to demonstrate that MS patients who participated in aerobic exercise improved muscular strength, cardiorespiratory functioning, urinary bladder and bowel functioning, and perceived level of fatigue and depression. Furthermore, participants had a more positive attitude about life in general.[1,26] Since then, several studies have confirmed these findings by demonstrating that exercise can be a healthy adjunct to traditional treatment methods for MS.[16]

Health professionals working with this special population need to be flexible on a daily basis. MS symptoms fluctuate frequently, so be prepared to make adjustments, or possibly even postpone workouts based on client capabilities and limitations *each day*. Pushing through excessive fatigue is not advised, for this can prompt a relapse.

QUICK REFERENCE

The goal of exercise is to make participants as fit as they can be!

RECOMMENDATIONS FOR EXERCISE

Because the symptoms of MS vary so much, it is difficult to make general exercise recommendations that consider the degrees of limitation of all people affected by it. Some people with MS maintain normal functioning and experience infrequent relapse, while others are severely disabled and have frequent relapse. Health professionals need to accommodate changing capabilities, which often fluctuate on a daily basis. Additionally, physicians, physical therapists, and other rehabilitation specialists should work as a team to create exercise prescriptions for clients with MS. Furthermore, health or fitness professionals who plan to work with this group should consider pursuing postrehabilitative specialty training since MS requires extensive knowledge about disease progression and variability.

QUICK REFERENCE

People with MS should always consult a physician before beginning an exercise program. In fact, a physician and physical therapist should be involved with exercise testing and prescription.

Organizations such as the National Multiple Sclerosis Society, the National Center on Physical Activity and Disability, and the American College of Sports Medicine have established some general guidelines for exercise testing and prescription for this special population. Another excellent resource is Brad Hamler's book, *Exercise for Multiple Sclerosis: A Safe and Effective Program to Fight Fatigue, Build Strength, and Improve Balance*.[10] The following exercise suggestions are a compilation of recommendations from these sources.

EXERCISE TESTING

As with other populations, exercise testing can help determine the fitness level and response to exercise for those with MS. The following suggestions are primarily based on guidelines from ACSM.[45]

- Fitness professionals and their MS clients should always check with a physician and/or physical therapist for clearance prior to exercise.
- Complete a thorough health history to determine the client's medical history, symptoms, medications, and activity limitations prior to exercise.
- ACSM suggests that health professionals consider using the 6-minute walk test to assess functional endurance, 5× sit-to-stand to assess strength, Timed Up and Go (TUG) to assess gait speed, Berg Balance Scale to assess balance, and the Dynamic Gait Index to assess dynamic balance.
- A cycle ergometer is suggested for testing aerobic fitness; however, a recumbent stepping ergometer or dual action stationary cycle is also appropriate.
- Monitor the client for symptom exacerbation and stop or avoid exercise when symptoms are present.
- Exercise in a low humidity, cool environment (72°F to 74°F).
- Muscular strength can typically be tested as with the general population.
- Joint range of motion should be assessed with a goniometer since this population is prone to spasticity and subsequent joint contractures.

- Six-minute walk test—an easy-to-use test that measures the distance a person can walk in 6 minutes on a flat, hard surface.
- Five times sit-to-stand—measures functional lower limb strength. Client sits in a standard chair with arms folded across chest. Ask the client to stand up and sit down five times as quickly as possible. Inability to complete 5 repetitions or without use of the upper extremities indicates failure.
- TUG test—a simple test that measures mobility; requires both static and dynamic balance. The test measures the time required for a person to rise from a chair, walk three meters, turn around, walk back to the chair, and sit down.
- Berg Balance Scale—a 14-item test that assesses static and dynamic balance; considered the gold standard for determining balance. See Rehabilitation Measures Database for specific details on the test.
- Dynamic Gait Index—developed to assess gait, balance, and fall risk. Evaluates steady-state walking and walking during challenging tasks. See www.physio-pedia.com/Dynamic_Gait_Index for more details.
- Contracture—a condition where muscles shorten and stiffen thereby limiting range of motion at a joint.

EXERCISE PRESCRIPTION

- For those clients with minimal disability, follow the guidelines for the general population.
- Choose activities that the client enjoys and is capable of executing with proper body alignment. More functional clients can participate in jogging, cycling, or rowing activities, while less functional clients might need to limit activity to walking.
- A 5- to 10-minute low-intensity warm-up with very gradual progression is essential prior to exercise to prepare potentially weakened or spastic muscles and tight joints for activity. Focus on limbering movements. Avoid stretching early in the warm-up since stretching unprepared muscles can lead to muscle spasms or injury in some MS clients.[10] The treadmill or stationary cycle provide-good warm-ups.
- Those with MS should participate in aerobic exercise on 2 to 5 days per week at an intensity of 40% to 70% HRR or VO_2R (or 5 to 6 on the 0 to 10 RPE scale). Initially, exercise duration should progress to 10 continuous minutes. Over time, it should reach 30 to 60 minutes as tolerated. Include activities such as walking, cycling, and swimming.
- Resistance exercise should be performed two times per week at 60% to 80% of 1RM. Initially do one set of 10 to 15 repetitions. Progress to two sets as tolerated. Machines, free weights, resistance bands, and body weight are appropriate. When focusing on muscle endurance or when using body weight for resistance, consider increasing the number of repetitions to 20 to 30.
- Intensity should remain low throughout the workout since overexertion can exacerbate MS symptoms in some MS clients. As Brad Hamler states in his book, "MS patients are recommended not to push too hard…."[10] This is true for both aerobic and resistance training. Overexertion can promote excessive heat production. Excessive heat production raises core temperature. An elevated core temperature can cause extreme fatigue and joint or muscle injuries. Since those with MS have a diminished sweating response to begin with, excessive heat production can be dangerous.[27] Consider using fans to cool the exercise room.
- Flexibility exercises should be done on 5 to 7 days per week, one to two times per day. Hold stretches for 30 to 60 seconds and repeat for 2 to 4 repetitions. If contracture is present, duration might need to be increased.

- Ensure proper body alignment during all exercises. This means maintaining a neutral spine and a full range of motion (if possible) throughout all movements.
- Encourage clients to drink plenty of cool water before, during, and after exercise. This helps moderate core body temperature and prevents overheating. Clients with MS sometimes avoid drinking adequate amounts of water, especially if they have problems with their urinary systems. They might feel embarrassed about taking frequent bathroom breaks, so fitness professionals need to routinely emphasize the importance of water intake while offering periodic bathroom breaks during the workout.
- Make sure the exercise environment is cool so that the risk for overheating is limited. Avoid physical activities outside during the hottest times of the day or the hottest months of the year.
- Consider water aerobics or swimming for cardiovascular training. The water cools the body and reduces the risk of overheating. The water is also excellent for resistance training, especially with the use of special water devices that increase resistance.
- In addition to exercise in the water, tai chi and yoga provide remarkable benefits for the MS client. Both involve deliberate movements that promote flexibility, balance, and strength.
- Encourage frequent rest periods during the workout. During resistance training, allow a 30- to 90-second rest period in between each set. If clients feel particularly fatigued, offer longer rest periods. Elastic bands, light dumbbells, exercise equipment, and the client's body weight provide safe and effective resistance for this group of clients. A stability ball is also indispensable for improving core strength and balance. Be careful with free weights since many MS patients experience unpredictable muscle spasms that might cause them to drop the weights. Instead, use elastic bands or weight equipment for any overhead resistance exercises.
- Avoid slippery floor surfaces and clear the exercise area of floor hazards since balance is often a problem in this special population. Consider using a body bar or the client's cane to help with balance, and assess balance frequently so that modifications can be made to meet client needs. Clients might need to perform an exercise in the seated position rather than in the standing position. They might have to hold onto a wall or a piece of equipment while performing an exercise to increase stability.
- Ensure adequate lighting since many MS sufferers have eyesight problems. Mark equipment clearly.
- Always consider medication side effects and make modifications as necessary.
- Try to explain to clients the difference between fatigue associated with MS and the fatigue associated with exercise.

QUICK REFERENCE

According to Brad Hamler, author of *Exercise for Multiple Sclerosis*,[10] those with MS cannot afford to waste energy. Instead, they need to exercise at maximum efficiency and avoid thinking that "more is better."

QUICK REFERENCE

If clients with MS notice any new symptoms developing during exertion, they should stop the activity immediately. Only continue if doing so does not elicit the same symptoms again.

SAMPLE RESISTANCE TRAINING PROGRAM FOR THOSE WITH MS

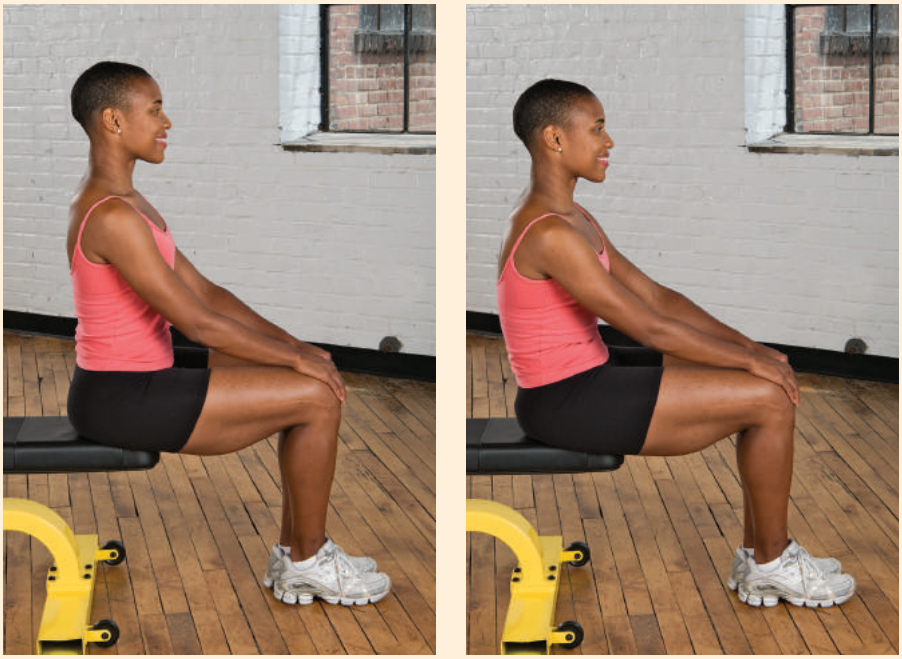
People with MS can benefit from resistance training that uses free weights, weight machines, elastic bands, their own body weight, and several other tools designed for the general population. The key is to vary the mode and to design a program that meets an individual client's capabilities.

Warm-Up

- Before resistance training, do a 5- to 10-minute warm-up on the treadmill or stationary cycle to increase blood flow to muscles before challenging them with resistance.
- Keep in mind that the warm-up should be gradual and of low intensity to avoid overheating.

Core Training

A strong core improves posture and balance and can improve the functioning of all muscles in the body. Depending on the client's level of fitness, choose one or two of the following exercises per exercise session. Have beginners initially perform 10 to 15 repetitions with excellent form. Progress to 20 to 30 repetitions as tolerated.



■ **Seated Abdominal Squeezes (Fig. 12-5)**

Sit in a chair with back straight, feet flat on the ground, and arms to the side or on the knees. Squeeze the abdominals and release while breathing. This is an effective exercise for beginners.


■ Basic Crunch with a Stability Ball (Fig. 12-6)

Lie on back with legs propped up on stability ball. Hips and knees should be bent at 90 degrees. Cross the arms to front of the chest. Slightly raise the shoulder blades, head, and neck up from the floor by contracting the abdominals. Maintain a neutral spine. Slowly lower the shoulder blades, head, and neck while maintaining tension in the abdominals. Do not touch the shoulder blades to the floor in between repetitions.


■ Crunch/Reverse Crunch Combination (Fig. 12-7)

Lie on the back with hips and knees bent at 90 degrees. Legs should be parallel to the ground, and arms should lie flat on each side. While performing a basic crunch as described in the previous figure, roll the hips toward the chest while contracting the abdominals. A more advanced version of this exercise is to interlock the hands behind the head while performing the crunch (as pictured).

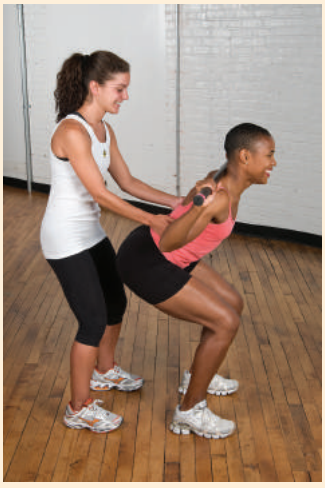

■ Oblique Crunches with a Stability Ball (Fig. 12-8)

Lie on the back with legs propped up on stability ball. Hips and knees should be bent at 90 degrees. Cross the right leg over the left knee. Place the left hand behind the head and stretch the right arm out to the right. Slightly raise the left shoulder blade, head, and neck up from the floor by contracting the abdominals and rotate to the right. Maintain a neutral spine. Slowly lower the left shoulder blade, head, and neck while maintaining tension in the abdominals. Do not touch the shoulder blade to the floor in between repetitions. Repeat designated number of times. Perform the same exercise using the right shoulder blade. To make the exercise more difficult, place both hands behind the head as pictured.

Lower-Body Training

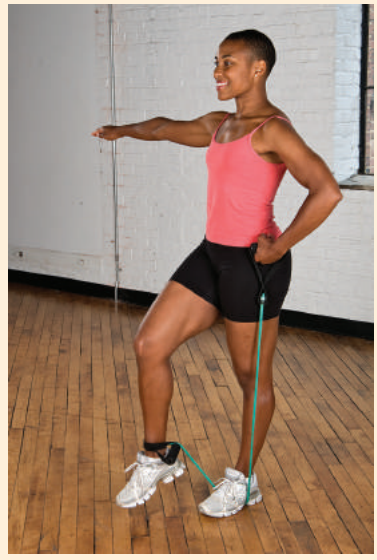
A strong lower body helps enhance posture, maintain balance, and improve gait. Choose one exercise per muscle group and perform a designated number of repetitions of each.

Quadriceps Training

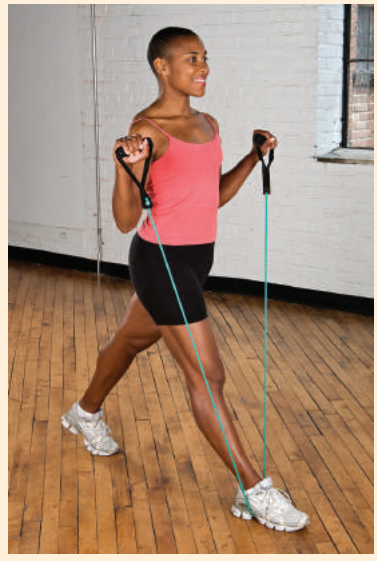
■ Standing Squat (Fig. 12-9)

Stand with feet slightly wider than shoulder width apart. Point toes forward. Beginners should clasp hands and flex shoulders at 90 degrees to the front. Keeping the spine neutral, slowly lower the buttocks while keeping the knees over the ankles. Stop when the thighs are parallel to the ground (with knees and hips bent at 90-degree angles). Do not lean forward. Pictured above is a more advanced version using a body bar. Note: The spotter should be closer to the exerciser than shown in this picture. Additionally, she should squat along with the exerciser to ensure she can provide proper assistance to the exerciser and to protect her own back.




■ Single-Leg Extension with Elastic Tubing (Fig. 12-10)

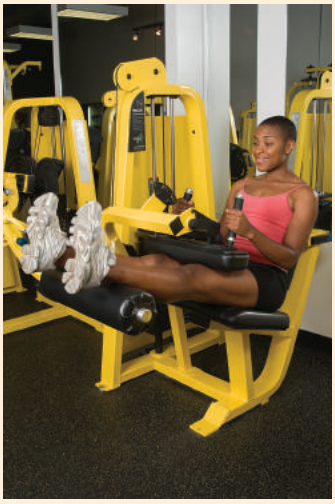
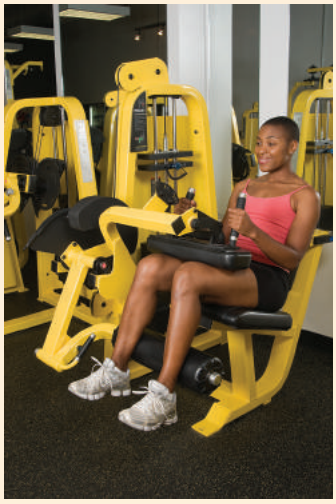
Loop elastic tubing and place securely around right ankle. Hold other handle in left hand; keep left arm extended at side. Step on tubing with left foot. Extend right leg. Pause. Return to start. Perform 10 to 15 times on right. Switch and repeat with left leg.




■ Single-Leg Lunges Using Elastic Tubing (Fig. 12-11)

Hold one handle in each hand. Place tubing under right foot. Step back with left foot; elevate left heel. Place hands on waist or on shoulders. Contract abdominals and maintain neutral spine. Keep right knee over right ankle. Drop left knee down toward floor, but do not let knee touch floor. Pause. Return to start. To increase difficulty, lift left leg back after lunging (hyperextend left thigh). Complete 10 to 15 repetitions. Switch sides and repeat.

Hamstrings Training

■ Leg Curl Using Weight Machine (Fig. 12-12)

Sit in a leg curl machine with back pressed against pad and hands holding grips. Maintain neutral spinal alignment during entire exercise and contract abdominal muscles to protect lower back. Bend knees to 90 degrees. Pause. Return to starting position. Complete 10 to 15 repetitions.

Lower-Leg Training


■ Calf Raises on a Platform (Fig. 12-13)

Stand on a step with heels unsupported, and maintain balance with a body bar, cane, or nearby wall if necessary. Slowly lift both heels while contracting calf muscles. Lower and repeat designated number of times. For variation, do one calf at a time. If balance is a problem, sit in a chair with back straight and knees bent at 90 degrees. Lift heels and lower. Place light weights on thighs for added challenge.

■ **Toe Lifts for Tibialis Anterior (Fig. 12-14)**

Stand on platform with toes unsupported. Use wall, body bar, or personal trainer for balance if necessary. Begin with toes pointing down. Lift toes toward ceiling and release. Repeat designated number of times.

Upper-Body Training

Exercises that focus on the upper body improve posture and preserve functional strength. Choose one exercise for each muscle group and perform 10 to 15 repetitions for each.

Chest Training

■ **Push-Ups on Knees (Fig. 12-15)**

Start in push-up position with hands slightly wider than shoulder width apart and knees in contact with the floor. Maintain a neutral spine and contract abdominals throughout movements. Lower the torso until elbows are at a 90-degree angle. Then extend from the elbows to push back into starting position. Complete 10 to 15 repetitions. Make this exercise more difficult by extending knees and doing a regular push-up.

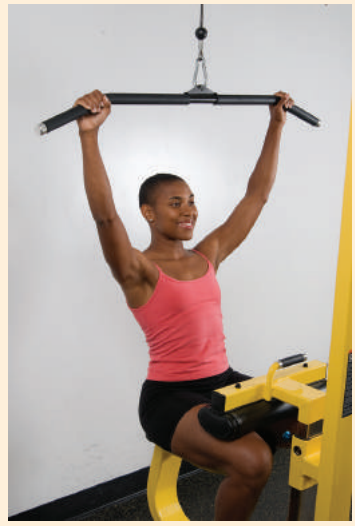

■ Chest Press Using a Body Bar (Fig. 12-16)

Lie on a flat bench with feet flat on floor (this position allows for more balance than does the feet-up-on-bench position; however, shorter individuals might want to put their feet on a raised support, such as a step bench placed at the end of the weight bench). Grasp a body bar with hands slightly wider than shoulder width apart. Extend elbows while pushing bar up at a slight angle and contracting chest muscles. Lower the bar back toward chest without touching bar to chest. Complete 10 to 15 repetitions. Modify this exercise by using an incline bench. Note: The spotter in this image is using an underhand grip which is safe for lighter weights. NSCA recommends an underhand grip with one hand and an overhand grip with the other.


■ Chest Fly with an Elastic Band (Fig. 12-17)

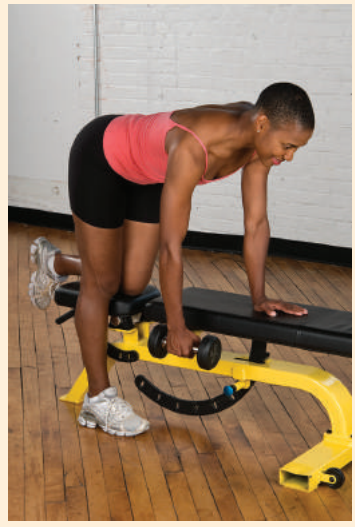
Stand with feet slightly wider than shoulder width apart. Contract the abdominals and maintain neutral spinal alignment throughout exercise. Place band around back just below shoulder level. Grasp each end of band with one hand and turn palms to the front. Begin with shoulders abducted and arms parallel to ground. Keeping the elbows slightly bent, bring arms to the front of the body while contracting the chest muscles. Slowly return to starting position. Repeat designated number of times.

Back Training




■ Latissimus Dorsi Pulldown Using Weight Machine (Fig. 12-18)

Sit on a lat pulldown machine with pad on thighs. Hold the bar with hands placed slightly wider than shoulder width apart. Keep back in neutral alignment while contracting abdominal muscles. Pull the bar down toward the chest while depressing scapulae. Do not pull the bar behind the neck since this can put excessive pressure on the cervical spine and shoulders. Do not try to touch the bar to the chest since this puts excessive pressure on shoulder; simply bring the bar to chin level (or slightly below chin level). Pause. Return to starting position and repeat designated number of times.




■ Single-Arm, Bent-Over Row on a Bench (Fig. 12-19)

Hold a dumbbell in the right hand. Contract abdominals and maintain neutral spine throughout movement. Place left knee and left hand on bench while bending at hip. Extend right hand with weight toward floor. Pull weight up while flexing right elbow. Pause. Slowly lower weight while extending elbow. Repeat. Then switch sides.

Shoulder Training

■ Shoulder Press with Dumbbells (Fig. 12-20)

Sit on a bench with knees bent, feet on floor, and back in neutral alignment. Grasp one dumbbell in each hand and hold them at about ear height with arms parallel to floor. Extend elbows while pushing weights up toward ceiling. Pause. Return to starting position. Repeat designated number of times. Note: There are two different thoughts on how to spot this particular exercise. Some suggest spotting at the elbows as shown, while others suggest spotting at the wrists. The National Strength and Conditioning Association (NSCA) suggests the latter. Choose the method that suits your particular client.

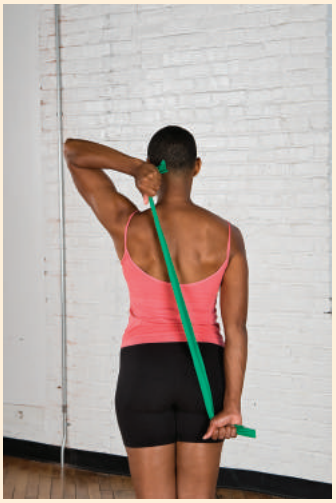
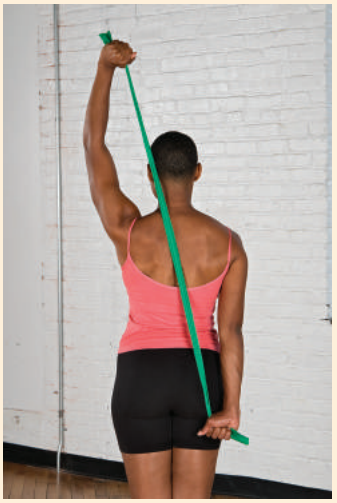
■ Lateral Shoulder Raises with Dumbbells (Fig. 12-21)

Stand with feet shoulder width apart, spine in neutral alignment, and abdominals contracted. Hold one dumbbell in each hand, palms facing each other. Slowly abduct arms to about 70 degrees while keeping elbows slightly bent. Pause. Lower to starting position. Repeat designated number of times.

Biceps Training


■ Biceps Curl Using a Body Bar (Fig. 12-22).
Stand with feet slightly wider than shoulder width apart, spine in neutral alignment, and abdominals contracted. Hold body bar in front with both hands, elbows extended. Slowly flex elbows while contracting biceps until bar is at shoulder level. Pause. Return to starting position. Repeat designated number of times. For variation, perform this exercise using elastic bands or dumbbells

Triceps Training

■ Triceps Extension Using an Elastic Band (Fig. 12-23)
Stand with feet shoulder width apart, neutral spine, and abdominals contracted. The elastic band will be behind the back during this exercise. Hold one end of the elastic band with the right hand and fully extend right arm. Hold the other end of the elastic band with the left hand while left elbow is bent. During this exercise, extend left elbow so that hand moves toward ceiling until left arm is straight (without locking elbow) and perpendicular to floor. Pause. Return to starting position. Repeat designated number of times. Switch hands and repeat on right arm. For variation, use dumbbells to perform this exercise. Alternatively, use a body bar to work both triceps at the same time.

Stretching

Stretch all muscles worked during this routine. Either stretch each muscle group following the exercise that focused on that particular muscle group or stretch all muscles following the entire routine.

Lifestyle Modification Tip: Encourage clients to explore alternative therapies such as massage, acupuncture, dry needling, meditation, deep breathing, myofascial release, or other stress reduction techniques. See highlights in chapter 13 for more details on dry needling and myofascial release therapy.

NUTRITIONAL CONSIDERATIONS

Some MS-related organizations suggest that specific diets can treat MS, but there is currently a relative lack of research into the relationship between nutrition and MS. Based on what *is* known about this disease, however, diet does not appear to cause, prevent, or slow development. Still, some groups suggest that certain nutrients, including dietary fats, antioxidants, vitamin B_{12}, and vitamin D, might improve MS symptoms.[10,28]

Researchers began looking at the relationship between dietary fat intake and MS progression because fat is the major component of the myelin sheath, the part of the neuron attacked by the immune system in MS. Some studies suggest that a higher intake of essential omega-3 or omega-6 fatty acids can actually improve MS symptoms, while others show no improvements.[1,29,30] Currently, experts suggest that those with MS follow the same guidelines for fat intake as the general population: decrease the intake of saturated fat and increase the intake of omega-3 fatty acids. Unless deficient in omega-3 fatty acids, people with MS do not seem to benefit from supplements.[31]

Antioxidants are chemicals in the body that fight free radicals (see Chapter 2 for further information). Since some evidence suggests that free radicals are partly responsible for the damage that occurs in MS, various experts recommend increasing antioxidant intake.[10,28,30,32,33] This, however, is controversial because high levels of antioxidants enhance immunity, and since overactive immune cells destroy myelin sheath, excessive antioxidant intake could worsen MS damage. Overall, further research is necessary before specific recommendations can be made.[28,34]

Vitamin B_{12}, found only in animal-based products, is also needed by the body to make myelin sheath. Interestingly, the neurological symptoms of a vitamin B_{12} deficiency resemble the symptoms associated with MS. If the B_{12} deficiency is caught early, the symptoms are reversible; if caught too late, they become permanent. Because of its role in nervous system functioning, vitamin B_{12} has been the focus of recent research. Some experts believe that vitamin B_{12} supplements should be used to treat MS, but more research is needed before recommendations can be made. The fact that most MS sufferers have adequate B_{12} levels implies that B_{12} supplements will do nothing to improve the symptoms or progression of MS.[28,35,36]

Because MS is more common in geographical areas with limited exposure to sunlight and because people with MS tend to have low blood levels of vitamin D, some experts have suggested a link between vitamin D deficiency and MS.[28,37–40] They believe that vitamin D supplements might actually slow disease progression in those with or without deficiencies. A recent study has shown small decreases in circulating T-cell levels in MS patients who take supplemental vitamin D, an indicator that would support supplementation since an overactive immune system is the culprit in autoimmune diseases.[39] Unfortunately, however, there is currently insufficient research to advise intakes in excess of current recommendations for the treatment of MS.[28]

A few organizations suggest that dietary restrictions of gluten, sugar, pectin, and processed foods slow the progression of MS, but supporting data are inconclusive.[41,42,46] In general, research suggests that these particular food components play absolutely no role in MS development.[28] However, a relatively recent study showed that glucose intolerance was 5.5 to 11 times higher among MS patients than the control group.[43] Further research is necessary before recommending that those with MS avoid gluten products unless specifically diagnosed with gluten sensitivity.

People with MS benefit from a well-balanced diet just like members of the general population. They usually report that they feel better when they eat healthy foods that comply with basic dietary guidelines. As long as their diets are varied and provide adequate energy, those with MS do not normally require any special supplements.

SUMMARY

The type and amount of exercise considered safe and effective for MS clients depend solely on how advanced the MS is. Those with mild to moderate MS can usually participate in various exercises and subsequently benefit from increased physical activity. Those with severe MS, however, might be unable to participate in traditional aerobic or resistance exercises because of severe muscle spasticity, muscle weakness, ataxia, or fatigue. This does not mean that they should avoid exercise altogether. Instead, it means that exercise prescriptions need to be carefully structured to work around client capabilities.[17]

The good news is that people with MS do not have to avoid physical activity for fear of worsening their symptoms. Studies show that mild- to moderate-intensity exercise as described in this chapter is well tolerated by MS clients and provides benefits similar to those experienced by the general population. By following safety guidelines and by listening carefully to their bodies, those with MS can develop muscular strength, improve bone density, and enhance cardiorespiratory fitness to avoid the secondary complications associated with a sedentary lifestyle.

CASE STUDY 1

Greg, a 28-year-old man recently diagnosed with relapsing–remitting MS, is referred to you for training. He was a running back in college but has not been very active since he graduated. Greg's major symptoms are general fatigue and muscle weakness in his right leg that causes him to have a slight limp, but his physician classifies him as highly functional. Despite the fact that he has not been very active over the past 6 years, Greg still looks rather muscular, and he would like to stay that way.

- Design an exercise program for Greg and discuss what he can realistically expect. Be sure to discuss the type, frequency, duration, and intensity of the program.
- Would you offer any nutritional advice? If so, what?

CASE STUDY 2

Deborah is a 43-year-old woman who was diagnosed with relapsing–remitting MS 10 years ago. Since then, she has progressively gained weight and is now 25 pounds overweight. Her physician has encouraged her to exercise to help manage her weight, but because she has struggled with fatigue since before her diagnosis, she has never really felt physically capable of exercising. Her biggest concern is that physical activity will completely exhaust her.

- Is Deborah's concern legitimate? How would you address it? Would you encourage her to exercise now or not? Explain.
- Describe an exercise program you think would benefit Deborah.

THINKING CRITICALLY

1. Describe some of the symptoms of MS. Do these symptoms suggest any other conditions or diseases?
2. What is an autoimmune disorder? Why is MS classified as one?
3. What is the function of the myelin sheath? Define demyelination and remyelination.
4. List and briefly describe the four different categories of MS. Which is the most common? Which is the least common?
5. List four symptoms of MS that might interfere with exercise ability (these are listed as precautions in this chapter). How does each of these symptoms interfere with the ability to exercise?
6. Why do many people with MS develop gait problems? How does this affect their ability to exercise?
7. What are the major barriers to exercise for this particular population? Explain.
8. Describe four benefits of exercise in this population.
9. Describe the available treatments for MS.
10. Identify three nutrients that are being investigated for their potential in slowing MS development and progression. Explain why some experts believe these nutrients might have therapeutic effects.

REFERENCES

1. National Multiple Sclerosis Society. www.nationalmssociety.org
2. Khan F, Pallant J. Use of the international classification of functioning, disability and health to identify preliminary comprehensive and brief core sets for multiple sclerosis. Disabil Rehabil 2007;29(3):205–213.
3. National Institute of Neurological Disorders and Stroke. www.ninds.nih.gov/disorders/multiple_sclerosis/multiple_sclerosis.htm
4. Compston A, Coles A. Multiple sclerosis. Lancet 2008;372(9684):1502.
5. White L, Castellano V. Exercise and brain health—implications for multiple sclerosis. Part I. Sports Med 2008;38(2):91–100.
6. Dendrou CA, Fugger L, Friese MA. Nat Rev Immunol 2015;15(9):545–558.
7. Antel J. Stem cells: understanding their role in treating MS. MS in Focus 2008;11:4–6.
8. Franklin R. Remyelination, the next treatment for MS? MS in Focus 2008;11:18–20.
9. Dalgas U, Stenager E. Exercise and disease progression in multiple sclerosis: can exercise slow down the progression of multiple sclerosis? Ther Adv Neurol Disord 2012;5(2):81–95.
10. Hamler B. Exercise for Multiple Sclerosis. A Safe and Effective Program to Fight Fatigue, Build Strength, and Improve Balance. New York: Hatherleigh Press, 2006.
11. Olenik L. Moving well with multiple sclerosis: PACE model part 1. Palaestra 2005;21(3):26–30.
12. Olenik L. Responding to multiple sclerosis: PACE model part 3—movement and the stress response. Palaestra 2006;22(3):20–25.
13. Mayo Clinic. www.mayoclinic.org
14. Smith C, Hale L. The effects of non-pharmacological interventions on fatigue in four chronic illness conditions: a critical review. Phys Ther Rev 2007;12:324–334.
15. McCullagh R, Fitzgerald P, Murphey R, et al. Long-term benefits on quality of life and fatigue in multiple sclerosis patients with mild disability: a pilot study. Clin Rehabil 2008;22:206–214.
16. Pilutti LA, Greenlee TA, Motl RW, Nickrent MS, Petruzzello SJ. Effects of exercise training on fatigue in MS: a meta-analysis. Psychosom Med 2013;75(6):575–580.
17. Karpatkin H. Multiple sclerosis and exercise: a review of the evidence. Int J MS Care 2005;7:36–41.
18. Dodd K, Taylor N, Denisenko S, et al. A qualitative analysis of a progressive resistance exercise programme for people with multiple sclerosis. Disabil Rehabil 2006;28(18):1127–1134.
19. Elsworth C, Dawes H, Sackley C, et al. A study of perceived facilitators to physical activity in neurological conditions. Int J Ther Rehabil 2009;16(1):17–42.
20. Costello E, Raivel K, Wilson R. The effects of a twelve-week home walking program on cardiovascular parameters and fatigue perception of individuals with multiple sclerosis: a pilot study. Cardiopulm Phys Ther J 2009;20(1):5–12.
21. Smith C, Hale L, Oslon K, et al. How does the experience of fatigue in people with multiple sclerosis change during an eight week exercise programme? J Physiother 2008;36(2):92–93.
22. Fragoso Y, Santana D, Pinto R, et al. The positive effects of a physical activity program for multiple sclerosis patients with fatigue. NeuroRehabilitation 2008;23:153–157.

23. Taylor N, Dodd K, Prasad D, et al. Progressive resistance exercise for people with multiple sclerosis. Disabil Rehabil 2006;28(18):1119–1126.
24. Snook E, Motl R, Gliottoni R, et al. The effects of walking mobility on the measurement of physical activity using accelerometry in multiple sclerosis. Clin Rehabil 2009;23:248–258.
25. Rietberg MB, Brooks D, Uitdehaag BMJ, Kwakkel G. Exercise therapy for multiple sclerosis. Cochrane Database Syst Rev 2004;3:Art. No.: CD003980. doi: 10.1002/14651858.CD003980.pub2.
26. Petajan J, Gappmaier E, White AT, et al. Impact of aerobic training on fitness and quality of life in multiple sclerosis patients. Ann Neurol 1996;39:432–441.
27. National Center on Physical Activity and Disability. www.ncpad.org
28. Multiple Sclerosis Society. www.mssociety.org
29. Harbige L, Sharief M. Polyunsaturated fatty acids in the pathogenesis and treatment of multiple sclerosis. Br J Nutr 2007;7:S46–S53.
30. Van Meeteren M, Teunissen C, Dijkstra C, et al. Antioxidants and polyunsaturated fatty acids in multiple sclerosis. Eur J Clin Nutr 2005;59:1347–1361.
31. Today's Dietitian. www.todaysdietitian.com
32. Anonymous. Multiple sclerosis therapy. Pain and central nervous system weekly. Atlanta February 9, 2009;358.
33. Kaur C, Ling E. Antioxidants and neuroprotection in the adult and developing central nervous system. Curr Med Chem 2008;15(29):3068.
34. Besler H. Serum levels of antioxidant vitamins and lipid peroxidation in multiple sclerosis. Nutr Neurosci 2002;5(3):215–220.
35. Reynolds E. Vitamin B_{12}, folic acid, and the nervous system. Lancet 2006;5(11):949–960.
36. Najafi MR, Shaygannajad V, Mirpourian M, Gholamrezaei A. Vitamin B_{12} deficiency and multiple sclerosis: is there any association? Int J Prev Med 2012;3(4):286–289.
37. Cantorna M. Vitamin D and multiple sclerosis: an update. Nutr Rev 2008;66:S135.
38. Kimball S, Ursell M, O'Connor P, et al. Safety of vitamin D_3 in adults with multiple sclerosis. Am J Clin Nutr 2007;86(3):645.
39. Sotirchos ES, Bhargave P, Eckstein C, van Haren K, Baynes M, Ntranos A, et al. Safety and immunologic effects of high-vs-low-dose cholecalciferol in multiple sclerosis. Neurology 2015;(42):51–54.
40. Alharbi FM. Update in vitamin D and multiple sclerosis. NeuroSciences 2015;20(4):329–335.
41. Haghighi A, Ansari N, Mokhtari M, et al. Multiple sclerosis and gluten sensitivity. Clin Neurol Neurosurg 2007. doi:10.1016/j.clineuro.2007.04.011
42. Tengah C, Lock R, Unsworth D, et al. Multiple sclerosis and occult gluten sensitivity. Neurology 2004;62:2326–2327.
43. Shor DB, Barzilai O, Ram M, et al. Gluten sensitivity in multiple sclerosis: experimental myth or clinical truth? Annals N Y Acad Sci 2009;1173:343–349.
44. White L, Castellano V. Exercise and brain health—implications for multiple sclerosis. Part II. Sports Med 2008;38(3):179–186.
45. American College of Sports Medicine. ACSM's Guidelines for Exercise Testing and Prescription. 10th Ed. Philadelphia, PA: Wolters Kluwer, 2018:298, 339–344.
46. Bhargava P, Mowry EM. Gut microbiome and multiple sclerosis. Curr Neurol Neurosci Rep 2014;14:492–495.
47. Marcus JF, Waubant EL. Updates on clinically isolated syndrome and diagnostic criteria for multiple sclerosis. Neurohospitalist 2013;3(2):65-80.

SUGGESTED READING

Hamler B. Exercises for Multiple Sclerosis: A Safe and Effective Program to Fight Fatigue, Build Strength, and Improve Balance. New York: Hatherleigh Press, 2006.