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The Effects of Strength Training on Gait Function in Patients with Multiple Sclerosis: A Narrative Review

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Abstract

Introduction: Multiple sclerosis (MS) is a chronic immune-mediated demyelinating disease of the central nervous system and a leading cause of non-traumatic disability in young adults. Gait impairment is one of the most common and disabling symptoms, significantly affecting functional independence and quality of life.

Purpose of the work: The aim of this narrative review was to summarize and critically evaluate current evidence on the effects of strength training on gait function in individuals with multiple sclerosis.

Materials and methods: A narrative literature review was conducted using PubMed, Scopus, and Google Scholar. Original research and review articles published between 2000 and 2025 were identified using the keywords multiple sclerosis, strength training, resistance training, gait, and walking. Studies were selected based on thematic relevance and clinical applicability. In total, 21 studies were included in the analysis.

Results: The reviewed studies consistently demonstrated improvements in muscle strength following strength training, particularly in individuals with mild to moderate disability. However, the effects of isolated strength training on gait function were inconsistent.

Multimodal rehabilitation programs incorporating strength training more frequently resulted in improvements in gait speed, endurance, and functional walking measures.

Conclusions: Strength training effectively improves muscle strength in people with MS, while its isolated impact on gait remains inconclusive. Multimodal rehabilitation approaches appear to provide more consistent benefits for gait function, highlighting the need for standardized outcome measures and further research.

Keywords: Multiple sclerosis, neurological rehabilitation, resistance training, gait

Introduction

Multiple sclerosis (MS) is a chronic demyelinating disease of the central nervous system of autoimmune origin. Its peak incidence occurs between 20 and 40 years of age. MS is one of the most common non-traumatic causes of disability in young people. It causes multifocal brain and spinal cord damage. The disease is most often relapsing-remitting (RRMS), characterized by periods of exacerbations of neurological symptoms followed by partial or complete resolution. However, over time, disability accumulates. After 10 to 20 years, RRMS evolves into secondary progressive multiple sclerosis (SPMS), in which there is a steady decline in function. A rarer form of MS is primary progressive multiple sclerosis (PPMS), in which symptoms progress steadily from the onset. The most common musculoskeletal symptoms in MS include spastic paralysis, limb and trunk ataxia, balance disorders, and postural tremor. These deficits significantly impact patients' gait, which is one of the most distressing aspects of MS disability. Locomotion is included in the Expanded Disability Status Scale (EDSS), a key clinical assessment scale for the disease.¹ In recent years, there has been a rapid development in the use of MS-modifying drugs². Parallel to pharmacological treatment, rehabilitation plays a crucial role, aiming to improve patients' performance in the areas of functioning that are most important to them. Identifying the optimal approach to gait rehabilitation may improve treatment outcomes for MS patients, their daily functioning, and their well-being.

Methods of gait assessment in MS patients

Individual studies assess patients' walking abilities according to various criteria; the lack of standardization makes it difficult to compare results from individual studies. These tests can be divided into timed and speed-based gait tests, gait capacity tests, and balance and dynamic gait tests. Timed tests include the Timed Up and Go Test (TUG). This test is scored in seconds from the time the patient stands up from a chair. The patient then walks 3 meters, turns around, and finally sits down in the chair. Completing the task in more than 13.5 seconds is considered an increased risk of falling in the geriatric population. For MS patients, this is a guideline value³. The 10-Meter Walk Test (10 MWT) assesses walking speed. The 25-Foot Walk Test (T25FW) assesses the time to walk 25 feet, which is approximately 7.6 meter^{3,4}. The T25FW test is considered one of the best objective measures of mobility disability in people with multiple sclerosis.

The 6-Minute Walk Test (TMW) is used to assess walking performance – it assesses the distance a patient can walk in 6 minutes.

Balance and dynamic gait tests include the Dynamic Gait Index and the Berg Balance Scale. The Dynamic Gait Index (DGI) assesses dynamic gait during changing environmental conditions. Eight tasks, such as walking on uneven floors, are performed and scored on a scale of 0-3. Up to 24 points can be obtained, with a score of ≤ 16 indicating a high risk of falls and a score > 19 indicating a reduced risk of falls. The Berg Balance Scale (BBS) consists of 14 balance tasks, scored on a scale of 0-4. The maximum possible score is 56 points. A patient with a score <20 requires a wheelchair for daily functioning, while those with scores >20 and <40 require assistance with walking. Patients with scores >40 can walk independently⁵. The MS-Walking Scale-12 is used for subjective assessment of gait.

The effect of isolated strength training on gait function in patients with multiple sclerosis.

The idea behind progressive strength training is to gradually increase the load on the muscles, which, combined with an appropriate diet and lifestyle, leads to hypertrophy and increased muscle strength. In patients with MS, the hypertrophy effect may be limited, and the primary goal is to improve neuromuscular unit recruitment and functional muscle strength. Gait impairments in patients with MS result from dysfunction of the nervous system (primary deficit)—the pyramidal, extrapyramidal, and cerebellar systems—as well as from secondary changes in the musculoskeletal system—muscle atrophy and degenerative joint changes.

Therefore, there are theoretical grounds to assume that strength training may improve gait function in patients with MS by reducing paralysis and reversing muscle atrophy.

Several randomized clinical trials have been conducted examining the effects of progressive training on gait in patients with MS, but the results are inconsistent. In some studies, rehabilitation effects were compared to a control group receiving standard physical activity. These people most often conducted unsupervised rehabilitation on their own in accordance with the recommendations of the centres.

In a study conducted by Moradi et al., 20 men with MS, with a mean age of 34.1 years, a mean EDSS of 2.9, and a mean disease duration of 9.2 years, underwent an 8-week strength training intervention using isotonic machines. The exercises involved the upper and lower body, engaging key muscle groups in the chest, back, lower extremities, and upper limbs. These exercises were performed three times per week, with one set of each exercise. Sessions lasted no longer than 30 minutes. Statistically significant improvements were observed in the 3-minute walk test from 33.5 to 48.8 steps and in the get-up-and-go test from 9.9 seconds to 8.1 seconds. A non-significant improvement was observed in the 10-meter walk test from 8.3 to 6.6 seconds. A significant improvement in EDSS from 3.0 to 1.5 was also observed. No changes in balance were observed in the flamingo test⁶.

Aidar et al. studied 23 MS patients with a mean age of 43.2 years and an EDSS ranging from 3.5 to 5.5. Eleven of the study participants underwent a 12-week exercise program, three times per week, with each session lasting 45 to 60 minutes. Progressive training covered all major muscle groups, with patients performing one set per exercise. Statistically significant improvements were observed in the 7.62-meter walk test: from 8.09 seconds to 6.79 seconds, in the stand-up and go test: from 12.86 seconds to 9.47 seconds, and in the Berg balance test: from 40.38 points to 43.51 points⁷.

Caravanca et al. examined the effects of fast-concentric strength training on 30 MS patients with a mean age of 46.2 years and a mean EDSS of 3.21. The rehabilitation program lasted 10 weeks, with three sessions per week. Strength training targeted the lower limbs, with three sets of each exercise. Patients in the study group demonstrated statistically significant improvements in the 6-minute walk test from 446 meters to 559 meters and in the 10-meter walk test from 4.5 seconds to 3 seconds⁸.

Another study conducted by Dalgas supports the efficacy of progressive strength training. Thirty-eight individuals with an average age of 48.4 years, an average EDSS of 3.8, and an average disease duration of 7.4 years participated in a 12-week rehabilitation program, including two strength training sessions per week. Statistically significant improvements were observed in many parameters: the 6-minute walk test increased distance by 15% from 440 to 495 meters, the 10-step test improved by 12% from 7.7 to 6.6 seconds, and the stair climbing test and chair rise test also showed clinically significant improvements⁹.

In a study by Kjolhede et al., the effect of progressive resistance training on motor function in MS patients was assessed. The training included two sessions per week for 24 weeks and involved both the lower and upper limbs. Before the study, after 24 weeks of supervised training, and after another 24 weeks of unsupervised home exercise, the patients' locomotion abilities were assessed using the 25-foot walk test, the 2-minute walk test, the sit-to-stand test, the stair climb test, and the 12-item MS-Walking Scale. Statistically significant improvements were observed in all parameters, and these improvements were maintained after 24 weeks of unsupervised home exercise¹⁰.

The positive impact of strength training is also confirmed by a study by Sabapathy et al. Twenty-one MS patients were divided into a group undergoing strength training for 8 weeks with two sessions per week and an endurance training group. Statistically significant improvements were demonstrated in both groups, with no significant differences between groups. In the 6-minute walk test, the distance walked by patients in the strength training group increased from 447 to 486—a 38-meter improvement compared to an 18-meter improvement in the control group. Improvements were also noted in the functional reach test and the get-up-and-go test¹¹.

Similarly positive data is provided by the work of Karpatkin et al. This small study demonstrated a positive effect of strength training (8 weeks, sessions twice weekly) on the 6-minute walk test—an improvement from 319 meters to 364 meters. An increase in muscle strength and balance, measured using the Berg Balance Scale (from 46 to 49 points), was also noted¹².

Conflicting results are presented in a study by Dodd et al. Seventy-one participants, with an average age of 48 years, were randomly assigned to a 10-week exercise program and a control

group. Patients with relapsing-remitting MS had mild to moderate motor deficits. Exercise frequency was defined as twice a week and included progressive strength training aimed at strengthening lower limb muscles. PRT did not demonstrate an effect on distance covered in the two-minute walk test. Only a positive effect on fatigue and muscular endurance was noted¹³.

A study by Callesen et al. yielded similarly disappointing results. This study compared the effectiveness of PRT with rehabilitation focused on improving balance and motor control. Seventy-one patients with moderate disability (mean EDSS 3.5) underwent 10 weeks of rehabilitation, consisting of two sessions per week. The study showed no effect of PRT on the 6-minute walk test, 25-foot walk time, six-spot step test, or MS gait scale. Statistically significant improvements in these indicators were noted with rehabilitation focused on balance and motor control (BMCT). The advantage of PRT over BMCT was demonstrated only in the category of increased muscle strength¹⁴.

Again, the effectiveness of strength training is disputed by the study by Braendvik et al. This study compared strength training with treadmill training. The entire study lasted 8 weeks, with training sessions occurring three times per week. A positive effect of treadmill training, but not strength training, was demonstrated for the functional ambulation profile (FAP). Overall, only a positive effect of strength training on muscle strength was demonstrated¹⁵.

It is worth noting that the above studies consistently demonstrated a positive effect of strength training on muscle strength in MS patients with an EDSS of 4 or less. Data regarding the effect on gait function in this population remain equivocal, but most studies demonstrate a positive effect. The variability in results may be explained by variability in training protocols, training duration and frequency per week, and the duration of the entire study. Studies not demonstrating a positive effect of strength training generally lasted shorter periods—a maximum of 10 weeks, compared to the longest study with a positive result—24 weeks. The variety of gait measures used makes it difficult or impossible to compare studies. It is also important to note that the heterogeneous etiology of gait disturbances in MS patients may respond differently to rehabilitation—with dominant ataxia, improvement may be less pronounced compared to isolated pyramidal paralysis of one limb. For these reasons, more studies using uniform gait assessment measures and specifying the phenotypes of gait disturbances in MS patients are needed to determine the optimal strength training protocol and assess its effectiveness in specific patient subpopulations. Information on the effectiveness of strength training in patients with an EDSS greater than 4 remains scarce. These patients have significant movement

impairments and more severe neurological impairments, which theoretically have greater potential for improvement with rehabilitation. Research encompassing this large group of patients is needed.

The influence of strength training as a component of complex rehabilitation on gait function in patients with multiple sclerosis

Strength training, combined with other exercises, for MS patients is designed to improve daily functioning, including balance and motor skills, increase strength, power, and muscle resistance, improve posture, and reduce fatigue. Resistance training is used in conjunction with aerobic training, balance training, and neuromuscular exercises. Combining various activities increases the nervous system's ability to quickly generate muscle-stimulating impulses. Stimulating the muscular system through various exercises is expected to reduce the progression of demyelination of nervous tissue resulting from the disease^{3,7}. Preliminary research demonstrates the effectiveness of multimodal training in improving mobility in people with significant mobility impairments associated with multiple sclerosis¹⁶.

Several studies were analyzed to evaluate complex forms of rehabilitation involving strength training for individuals with multiple sclerosis. These studies varied in the duration of the intervention, which ranged from 8 to 24 weeks, the size of the study group, and the disability level of the participants. Additionally, they examined other indicators as criteria for assessing gait improvement.

Cakit et al. demonstrated statistically significant improvements in function and physical fitness among patients in the study group. In their study, they assessed the effect of resistance cycloergometer exercises. Pedaling and walking are based on identical movement patterns, relying on synchronous and alternating flexion and extension of the lower limb joints, whose muscles are antagonists to each other. This allows for the strengthening of the lower limbs. The study authors noted that many characteristics of walking correspond to those of pedaling, so they assumed that pedaling on a resistance cycloergometer could play a significant role as a complementary exercise in motor dysfunction. Patients were divided into two study groups. The first group performed 15 sets of 2 minutes of high-resistance pedaling and 2 minutes of low-resistance pedaling twice a week. Additionally, they performed 25 minutes of balance exercises and a 5-minute warm-up. The second group performed the same home workout as the first group, but without cycling. After 8 weeks, the study group showed significant improvement in tests such as the 10-meter walk test, Time Up and Go, and Dynamic Gait

Index¹⁷. Sokhangu and colleagues studied the effects of 8 weeks of neuromuscular training on a group of 10 women. The study demonstrated improved balance, increased strength, and reduced proprioceptive dysfunction. Patients with EDSS 1-3 and moderate MS symptoms lasting at least 2 years were included in the study. The control group performed 60 minutes of neuromuscular training three times a week. The results showed a significant improvement in balance on the Berg Balance Scale¹⁸. Wolf et al., in their study, examined the effects of multimodal training on people with multiple sclerosis. Participants with an EDSS score of 5 or less were included. The training is designed to improve balance, coordination of the head, eyes, and other body parts, as well as sensory integration. Patients were admitted to the center and their training period was the same as their stay, i.e., 4-6 weeks. The patients were divided into two groups: MAT (experimental group) and SET (control group). The MAT group performed five strength training sessions per week and three swimming sessions. The SET group, on the other hand, exercised five times per week on a bicycle ergometer and three times per week on strength training. The MAT group focused on improving standing balance, dynamic balance exercises, and agility exercises. Improvements were achieved in the 6-Minute Walk Test, the Get-Up-and-Go Test, and the Six-Step Test¹⁹. A study by Learmonth and colleagues showed completely different results, assessing the impact of mobility, balance, and endurance training performed twice a week for 12 weeks. The training, consisting of a 10-minute warm-up, 30-40 minutes of circuit exercises, and a 5-10-minute cool-down, did not significantly impact the 25-foot walk time. It also showed a nonsignificant impact on the 6-minute walk test and the get-up-and-go test. Despite the lack of significant impact on walking time, they did demonstrate a significant difference in balance confidence⁴. Few studies have focused on evaluating modal training beyond 12 weeks. Sandroff and colleagues were among the few to conduct a multicenter, 6-month study evaluating the effectiveness of multimodal training in individuals with significant disabilities. Eighty-three participants were enrolled, of whom 62 completed the study. Patients performed aerobic, endurance, and resistance lower limb exercises. Training sessions were held three times per week for 24 weeks. Initially, the sessions lasted 30 minutes, gradually increasing to 60 minutes. The study group demonstrated a statistically significant increase in the 6-Minute Walk Test from 529.0 to 600.5 m. There was no improvement in the gait test or the 25-Foot Walk Test²⁰. ⁴Sosnoff and colleagues examined the effect of home exercise on fall risk, balance, and gait testing in older adults with multiple sclerosis. The study lasted 12 weeks. The study included 14 participants in the control group and 13 in the exercise group. However, not all participants completed the study. The EDSS ranged between 2.5 and 6.5, with a median of 5.0. Only individuals who had fallen at least once within a year were

included in the study. Exercises were performed three times a week and focused on lower limb and back muscle strength and balance. Each session lasted 45-60 minutes. After 12 weeks, there was a significant difference in 25-foot walk time, but no significant difference was observed in the Time Up and Go test and the 6-minute walk test. However, the study group showed a significant improvement in balance confidence¹⁶. A study by Paua et al. assessed the impact of 6 months of special needs physical activity (APA) on MS patients. The study group underwent three 60-minute training sessions, including aerobic and strength training. After 12 weeks, improvements in walking speed, steps per minute, and stride length were observed. It is believed that APA may slow the progression of the disease²¹. Gutiérrez-Cruz and colleagues studied the effects of a 24-week mixed training program based on strength training and cognitive motor skills performed three times per week. If a training session was missed, it was repeated that week. It was assumed that a longer duration of the study would have a greater impact on the patients' daily functioning. The study demonstrated an increase in peak strength in MS patients. The study did not reveal significant differences in gait duration. A decrease in bipedal stance time during gait was noted, which was correlated with an increase in single-leg stance time. After 24 weeks, a statistically significant difference was also observed in the increase in stride length²².

Discussion

The aim of this study was to determine the effect of strength training on gait function in patients with MS. Most studies demonstrate that rehabilitation based solely on strength training, as well as rehabilitation that incorporates strength training into the program, improves gait parameters in patients with MS. Due to the variety of exercise programs and assessed parameters, comparing the effectiveness of individual methods is subject to significant error. This is also influenced by the heterogeneity of the study population. Some studies include only men with MS, as in the study by Moradi et al., while others include only patients with the relapsing-remitting form. However, the most important factor complicating comparison is the heterogeneity of motor deficits among patients. To assess the effectiveness of individual rehabilitation programs in the treatment of MS, future studies should be conducted on larger patient populations, including a thorough neurological assessment of deficits. For these reasons, there is currently no data to determine which of the two approaches assessed—isolated strength training or combined rehabilitation including strength training—leads to better results in patients with MS. Similarly, it is impossible to determine the optimal exercise set, number of sets, and weekly frequency. This study demonstrates that the rehabilitation methods described

are highly likely to lead to increased muscle strength in patients. Despite conflicting data, it appears that the rehabilitation methods described lead to improved gait parameters in the short term. An interesting area for future research is to determine the extent to which regular physical activity influences the long-term course of MS. There are theoretical grounds to assume that this effect is not negligible. Physical activity leads to maintaining healthy muscle mass and reduces the risk of developing lifestyle diseases. This is important because lifestyle diseases such as obesity, hypertension, and type 2 diabetes are more common in MS patients than in the general population²³. More recent studies also indicate that obesity is associated with faster progression of disability as measured by the EDSS scale, faster cognitive decline, and a greater risk of new lesions on MRI²⁴. The study by Nupur et al. indicates that people with MS who remain physically active, which is defined as physical activity of any intensity performed at least 30 minutes 3 times a week, have a lower severity of disability and fatigue over a 5-year period²⁵.

At the same time, it is important to remember that people with MS are statistically less physically active, which results from chronic fatigue, disability, limited knowledge about the positive effects of physical activity, and limited access to professional rehabilitation and rehabilitation equipment.

Modern pharmacological treatments for MS have established a strong position in the treatment of this disease. There is a need for large, well-designed studies to further define and strengthen the role of rehabilitation in MS treatment.

Disclosure

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