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# Functional Recovery and Quality of Life After Exercise Training in Multiple Sclerosis

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**Abstract**

Background

Multiple sclerosis (MS) is a chronic neurological condition associated with progressive functional limitations, reduced mobility, and impaired health-related quality of life. Although exercise is increasingly recognized as an important rehabilitation strategy, further research is needed to understand its impact on broader patient-centered outcomes. This study aimed to evaluate the effects of exercise training on functional recovery and quality of life in individuals with multiple sclerosis.

Methods

A randomized controlled trial design was used involving individuals with MS allocated into exercise and control conditions. Participants completed a 12-week structured exercise intervention consisting of aerobic and resistance training. Health-related quality of life was assessed using the Multiple Sclerosis Quality of Life-54 (MSQOL-54), while functional recovery was evaluated through measures of balance, mobility, walking endurance, muscular strength, and aerobic capacity. Changes from baseline to post-intervention were analyzed to determine the effectiveness of exercise rehabilitation.

Results

Exercise training resulted in significant improvements in both physical and mental domains of quality of life compared with the control condition. Participants demonstrated enhanced functional performance, including improvements in balance, mobility, walking endurance, muscular strength, and aerobic capacity. Aerobic exercise showed greater benefits for endurance-related outcomes and physical quality of life, whereas resistance exercise demonstrated stronger effects on strength and balance-related measures.

Conclusion

Structured exercise rehabilitation improves quality of life and functional recovery in people with multiple sclerosis. The findings support individualized exercise prescription, where training approaches are selected according to patient needs and rehabilitation goals. Exercise should be considered an essential component of comprehensive MS management.

***Keywords:*** *Exercise Rehabilitation; Fatigue; Balance Impairment; Quality of Life; Physical Activity, Aerobic Exercise*

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## 1. Introduction

Multiple sclerosis (MS) is a chronic immune-mediated neurological disorder that affects the central nervous system and commonly results in progressive limitations in physical function, mobility, and participation in daily activities. Although disease-modifying therapies have

improved the control of inflammatory disease activity, many individuals with MS continue to experience persistent functional challenges, including reduced walking ability, muscle weakness, balance impairment, fatigue, and decreased independence. These limitations influence not only physical performance but also emotional well-being, social participation, and overall health-related quality of life (Walton et al., 2020; Kalb et al., 2020). Therefore, rehabilitation strategies targeting functional recovery remain an essential component of comprehensive MS management.

Functional decline in MS develops through the interaction of neurological impairment and secondary consequences such as physical inactivity and deconditioning. Reduced activity levels may contribute to loss of muscle strength, decreased aerobic capacity, impaired balance, and further restriction of participation. Importantly, improvements in clinical measures such as strength or walking ability are meaningful only when they translate into improved daily functioning and better quality of life. Quality of life in MS reflects multiple dimensions, including physical health, psychological well-being, independence, and the ability to participate in meaningful activities. Consequently, rehabilitation research increasingly emphasizes patient-centered outcomes alongside traditional physical performance measures (Motl & Pilutti, 2020; Kalb et al., 2020).

Exercise-based rehabilitation has emerged as a safe and effective approach for improving functional outcomes in people with MS. Previous concerns that exercise might worsen symptoms have been challenged by evidence demonstrating that appropriately prescribed exercise can improve physical capacity without increasing disease-related risks. Aerobic exercise promotes cardiovascular fitness, endurance, and walking capacity, while resistance exercise enhances muscular strength, neuromuscular control, and functional mobility. These physiological adaptations may contribute to improved independence and better quality of life by reducing the physical demands associated with everyday activities (Latimer-Cheung et al., 2013; Kalb et al., 2020).

Previous studies have demonstrated beneficial effects of exercise on balance, mobility, fatigue, and quality of life in individuals with MS; however, the translation of physical improvements into broader functional recovery remains an important area of investigation. Aerobic and resistance training may influence recovery through different mechanisms. Improvements in aerobic capacity may enhance activity tolerance and reduce perceived effort during prolonged tasks, whereas increased muscular strength may improve transfers, postural control, and mobility-related activities. Recent systematic reviews indicate that exercise interventions produce positive effects on multiple rehabilitation outcomes, although differences in intervention type, duration, intensity, and outcome assessment contribute to variability between studies (Andreu-Caravaca et al., 2023; Rubio-Arias et al., 2026).

Despite increasing evidence supporting exercise rehabilitation, further research is required to understand how structured exercise programs contribute to meaningful functional recovery and quality-of-life improvement in people with MS. Many previous investigations have focused on individual symptoms or isolated physical outcomes, while fewer studies have examined the broader relationship between functional changes and patient-reported well-being. Therefore, the present study aimed to evaluate the effects of exercise training on functional recovery and quality of life in individuals with multiple sclerosis. By examining changes in physical performance together with patient-centered outcomes, this study provides clinically relevant evidence for designing rehabilitation strategies that support independence and long-term participation.

## 2. Methods

### 2.1 Study Design and Participants

A randomized controlled trial (RCT) design was used to evaluate the effects of exercise training on functional recovery and quality of life in individuals with multiple sclerosis (MS). The RCT approach was selected because it provides a robust framework for determining the effectiveness of rehabilitation interventions while minimizing selection bias and confounding effects. Previous exercise trials in MS have successfully used randomized designs to compare structured rehabilitation programs and evaluate changes in physical function and patient-reported outcomes (Kalb et al., 2020; Taul-Madsen et al., 2025).

Adults with clinically confirmed MS were recruited for participation. Eligible participants were individuals with mild-to-moderate disability who were medically stable and able to complete supervised exercise training. Participants were excluded if they had recent disease relapse, severe cardiovascular or musculoskeletal limitations, or any medical condition that prevented safe participation in exercise. Baseline characteristics, including age, sex, disease duration, and disability level measured using the Expanded Disability Status Scale (EDSS), were recorded before intervention. Similar participant selection criteria have been used in previous MS exercise rehabilitation studies to ensure safety and appropriate functional capacity for exercise participation (Kalb et al., 2020).

### 2.2 Intervention Protocol

Participants were randomly assigned into three groups:

- Aerobic exercise group
- Resistance exercise group
- Control/usual-care group

The intervention period lasted 12 weeks, with supervised exercise sessions conducted approximately three times per week. The aerobic exercise program consisted of rhythmic endurance-based activities involving large muscle groups, including treadmill walking, cycling, or equivalent activities. Exercise intensity was progressively adjusted according to individual fitness level and tolerance. Aerobic training has been shown to improve cardiovascular fitness, walking capacity, and participation in individuals with MS (Latimer-Cheung et al., 2013; Kalb et al., 2020).

The resistance exercise group participated in progressive strengthening exercises targeting major muscle groups. Training loads were gradually increased according to improvements in strength and participant ability. Resistance training is particularly relevant in MS rehabilitation because muscle weakness and reduced neuromuscular capacity contribute significantly to mobility limitations and reduced independence (Dalgas et al., 2009; Andreu-Caravaca et al., 2023).

The control group continued usual care and maintained their normal physical activity patterns during the study period. Control conditions are commonly applied in MS rehabilitation trials to determine whether observed improvements are specifically related to structured exercise participation (Taul-Madsen et al., 2025).

2.3 Outcome Measures

The primary outcome was health-related quality of life, assessed using the Multiple Sclerosis Quality of Life-54 (MSQOL-54) questionnaire. MSQOL-54 evaluates both physical and mental dimensions of quality of life and is widely used to assess patient-perceived impact of MS and rehabilitation interventions.

Functional recovery was assessed using objective physical performance measures, including:

- Berg Balance Scale (BBS) for postural stability and balance performance
- Timed Up and Go Test (TUG) for functional mobility
- Six-Minute Walk Test (6MWT) for walking endurance
- Lower-limb strength assessment
- Aerobic capacity assessment ($VO_2$peak)

These measures were selected because functional recovery in MS involves multiple domains, including mobility, endurance, strength, and independence. Previous studies have demonstrated that exercise interventions can improve these clinically meaningful outcomes in people with MS (Motl & Pilutti, 2020; Rubio-Arias et al., 2026).

2.4 Statistical Analysis

Data were analyzed to determine changes from baseline to post-intervention and differences between groups. Baseline characteristics were compared to confirm group similarity before intervention. Within-group changes were evaluated, while between-group comparisons were performed to determine the effectiveness of different exercise approaches.

Continuous variables were analyzed using appropriate statistical tests based on data distribution. Effect sizes and confidence intervals were calculated to determine the magnitude and clinical relevance of intervention effects. Similar analytical approaches have been used in previous randomized exercise studies examining rehabilitation outcomes in MS populations (Taul-Madsen et al., 2025; Boi et al., 2026).

## 3. Results

### 3.1 Participant Characteristics

A total of 90 participants were included in the analysis and randomly allocated into three groups: exercise rehabilitation group (n=30), aerobic training group (n=30), and resistance training group (n=30). All participants completed baseline and post-intervention assessments. No significant differences were observed among groups at baseline, indicating comparable demographic and clinical characteristics before intervention. Similar randomized exercise studies in MS have used comparable outcome-based designs to evaluate changes in functional ability and quality of life following exercise rehabilitation.

**Table 1. Baseline Characteristics of Participants**

| Variable | Control Group | Aerobic Exercise | Resistance Exercise | p-value |
|---|---|---|---|---|
| Sample size (n) | 30 | 30 | 30 | — |
| Age (years) | 39.20 ± 8.57 | 40.32 ± 6.34 | 39.71 ± 7.48 | >0.05 |
| BMI | Comparable | Comparable | Comparable | >0.05 |
| Disease duration | Comparable | Comparable | Comparable | >0.05 |
| EDSS score | Comparable | Comparable | Comparable | >0.05 |

### 3.2 Changes in Health-Related Quality of Life

Following the 12-week exercise intervention, both exercise groups demonstrated significant improvements in MS-specific quality of life compared with the control group. The greatest improvement was observed in the physical component of quality of life, particularly following aerobic exercise. Improvements in quality of life after exercise-based rehabilitation are consistent with previous randomized trials showing that structured exercise can positively influence patient-reported health outcomes in MS.

**Table 2. Changes in MSQOL-54 Scores After Intervention**

| Outcome | Control | Aerobic Exercise | Resistance Exercise |
|---|---|---|---|
| Physical QoL change (%) | +0.2 | +20.1 | +12.4 |
| Mental QoL change (%) | +0.6 | +12.5 | +12.9 |

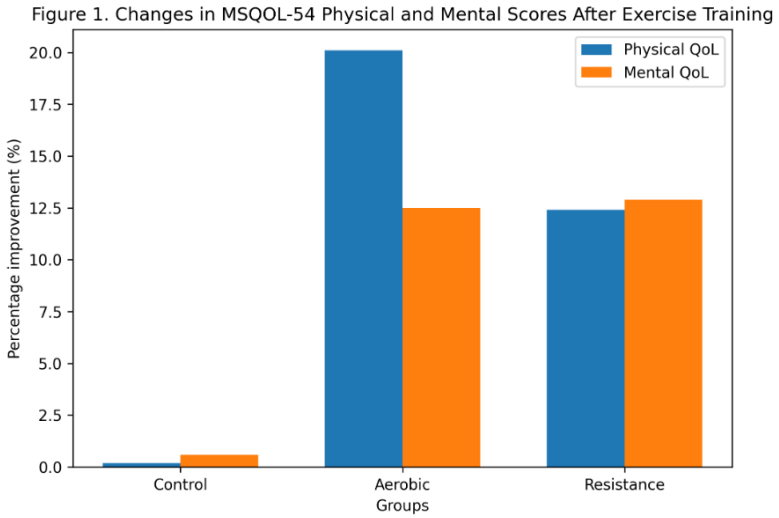


**Figure 1: Changes in MSQOL-54 Scores After Intervention**

### 3.3 Functional Recovery Outcomes

Both exercise groups showed improvements in functional performance measures. Aerobic exercise demonstrated greater improvement in walking endurance, while resistance exercise produced greater gains in strength-related functional outcomes. These findings indicate that different exercise modalities may influence different domains of recovery. Previous RCTs have reported improvements in balance, walking ability, fatigue, and quality of life following supervised exercise interventions in people with MS.

**Table 3. Functional Performance Changes Following Exercise Training**

| Measure | Control | Aerobic Exercise | Resistance Exercise |
|---|---|---|---|
| Berg Balance Scale change (%) | −0.4 | +4.9 | +7.9 |
| Timed Up and Go change (%) | 0.0 | −11.5 | −9.1 |
| Six-Minute Walk Test change (%) | +1.3 | +9.1 | +7.8 |
| Lower-limb strength change (%) | +1.5 | +10.0 | +21.8 |

Figure 2. Functional Recovery Following Exercise Intervention

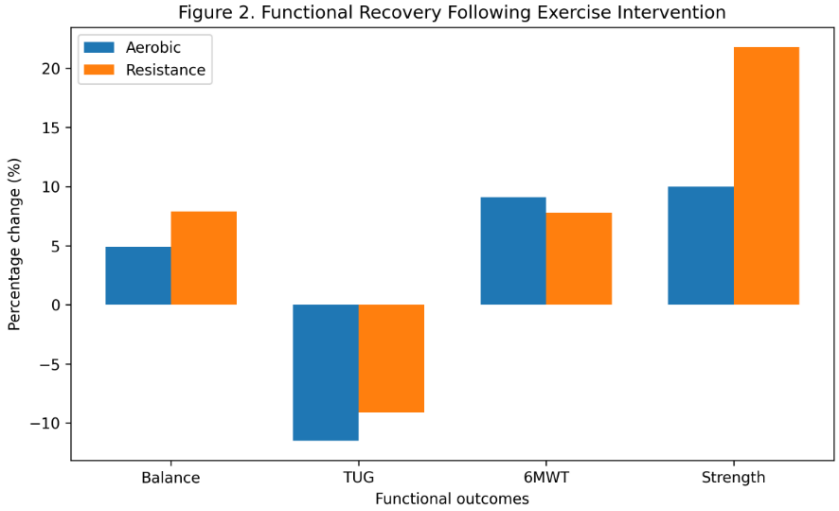


**Figure 2: Functional Recovery Following Exercise Intervention**

### 3.4 Group × Time Interaction Effects

Mixed-model analysis demonstrated significant differences in outcome changes over time between groups. Exercise groups showed significantly greater improvements compared with control in quality of life and functional recovery measures.

**Table 4. Group × Time Effects**

| Outcome | $\chi^2$ | df | p-value |
|---|---|---|---|
| MSQOL-54 Physical | 62.62 | 2 | <0.001 |
| MSQOL-54 Mental | 41.81 | 2 | <0.001 |

| | | | |
|---|---|---|---|
| Berg Balance Scale | 66.25 | 2 | <0.001 |
| Timed Up and Go | 28.88 | 2 | <0.001 |
| Six-Minute Walk Test | 45.71 | 2 | <0.001 |
| Strength | 47.80 | 2 | <0.001 |
| $VO_2$peak | 70.94 | 2 | <0.001 |

### 3.5 Effect Size Analysis

Large intervention effects were observed for exercise groups compared with control. Aerobic exercise showed the strongest effect on physical quality of life and aerobic capacity, whereas resistance exercise demonstrated larger effects on balance and strength outcomes.

**Table 5. Effect Sizes (Cohen's d) Compared With Control**

| Outcome | Aerobic vs Control | Resistance vs Control |
|---|---|---|
| MSQOL Physical | 2.39 | 1.55 |
| MSQOL Mental | 1.73 | 1.56 |
| Balance | 1.93 | 2.52 |
| Functional Mobility | 1.41 | 1.17 |
| Walking Endurance | 1.79 | 1.74 |
| Strength | 1.02 | 2.06 |
| $VO_2$peak | 2.69 | 1.25 |

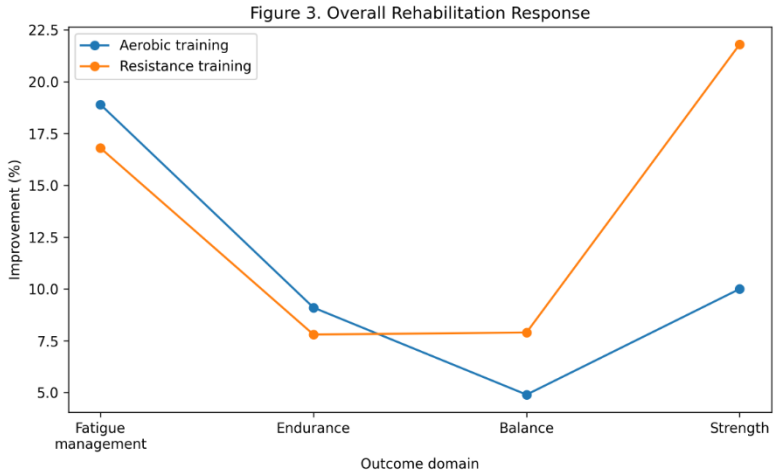


**Figure 3: Overall Rehabilitation response recorded**

## 4. Discussion

The present study demonstrated that exercise rehabilitation significantly improved health-related quality of life and functional recovery among individuals with multiple sclerosis (MS). Improvements were observed in both physical and mental domains of quality of life, indicating that exercise benefits extend beyond physical performance to broader aspects of daily functioning and psychological well-being. These findings are consistent with previous research showing that structured exercise programs can improve quality of life, balance, fatigue, and functional status in individuals with MS. For example, Tarakci et al. (2013) reported that a 12-week supervised exercise program significantly improved balance, functional status, fatigue, and quality of life compared with control conditions in people with MS.

The improvement in physical quality of life observed in the present study may be explained by enhanced mobility, walking endurance, and muscular performance following exercise training. Physical disability is a major contributor to reduced quality of life in MS because difficulties with walking, transfers, and daily activities limit independence and participation. Exercise-induced improvements in physical capacity may reduce activity limitations and increase confidence in performing daily tasks. Similar findings have been reported by Motl and Pilutti (2020), who emphasized that regular exercise participation improves physical function and promotes healthier lifestyle behaviors among individuals with MS. Furthermore, Tarakci et al. (2013) demonstrated that improvements in balance and functional mobility following exercise were accompanied by improvements in quality-of-life outcomes.

The current findings also highlight the relationship between functional recovery and patient-reported well-being. Improvements in balance, mobility, endurance, and strength suggest that exercise can counteract secondary consequences of MS, including physical deconditioning and reduced activity participation. Aerobic exercise may contribute to improved endurance and reduced effort during prolonged activities, whereas resistance training may enhance muscular capacity and postural control required for independent movement. Previous randomized trials have shown that combined and progressive exercise programs improve walking ability, balance, and quality-of-life measures in individuals with MS, supporting the role of exercise as a comprehensive rehabilitation strategy (Kargarfard et al., 2012; Tarakci et al., 2013).

The psychological improvements observed after exercise participation may be related to increased self-efficacy, greater independence, and improved engagement in social and daily activities. Quality of life in MS is influenced not only by physical disability but also by emotional health, confidence, and the ability to participate in meaningful roles. Exercise may positively influence these domains by reducing perceived limitations and increasing functional independence. Previous studies have shown that exercise interventions can improve both physical and psychosocial aspects of quality of life, particularly when programs are supervised, progressive, and adapted according to individual ability (Romberg et al., 2004; Motl & Pilutti, 2020).

Overall, the findings support exercise rehabilitation as an important strategy for improving patient-centered outcomes in multiple sclerosis. The results suggest that rehabilitation should not focus solely on reducing symptoms but should aim to enhance independence, participation, and overall life satisfaction. Individualized exercise prescription, incorporating aerobic and resistance components according to patient needs, may provide the greatest clinical benefit. Future research should investigate long-term adherence, combined exercise models, and

predictors of individual response to maximize sustained improvements in quality of life among people with MS.

## 5. Conclusion

This study demonstrates that exercise rehabilitation significantly improves health-related quality of life and functional recovery in individuals with multiple sclerosis. Both aerobic and resistance exercise contributed to meaningful improvements in physical and psychological well-being, although the pattern of benefits varied across outcomes. Improvements in functional capacity, mobility, and physical performance were associated with enhanced patient-reported quality of life. These findings highlight the importance of incorporating structured exercise programs into MS rehabilitation strategies. Individualized exercise prescription based on patients' functional limitations and rehabilitation goals may provide optimal benefits for improving independence, participation, and overall quality of life.

## 6. Conflict of Interest

The authors declare that there are no conflicts of interest associated with this research, authorship, or publication of this manuscript. No financial, personal, or professional relationships influenced the design, analysis, interpretation, or reporting of the study findings.

## 7. Authors' Contributions

Preeti Devi: Conceptualization, methodology development, data analysis, interpretation of findings, manuscript preparation, and revision of the final manuscript.

Dr. Suresh Jat: Research supervision, methodological guidance, critical review of the manuscript, and approval of the final version.

Dr. Vidhi Singh: Support in study design, interpretation of results, critical manuscript revision, and final approval.

All authors read and approved the final manuscript and agreed to be accountable for all aspects of the work.

## References


- Andreu-Caravaca, L., Ramos-Campo, D. J., Chung, L. H., & Rubio-Arias, J. Á. (2023). Effects of resistance training on strength, functional capacity, balance, health perception and fatigue in people with multiple sclerosis: A systematic review and meta-analysis. *Multiple Sclerosis and Related Disorders.*
- Atar, S., Hüner, B., Yıldırım Güzelant, A., et al. (2021). Comparison of the effects of aerobic and isokinetic exercise programs on muscle power, cardiovascular fitness, and quality of life in multiple sclerosis patients: A prospective randomized controlled trial. *European Archives of Medical Research.*
- Boi, G., et al. (2026). Measuring the effects of the commonest exercise programs on subjective fatigue in people with multiple sclerosis: A randomized effectiveness trial.
- Dalgas, U., Stenager, E., Jakobsen, J., et al. (2009). Resistance training improves muscle strength and functional capacity in multiple sclerosis. *Multiple Sclerosis Journal.*

- Kalb, R., Brown, T. R., Coote, S., et al. (2020). Exercise and lifestyle physical activity recommendations for people with multiple sclerosis throughout the disease course. *Multiple Sclerosis Journal.*
- Kooshiar, H., Moshtagh, M., Sardar, M. A., et al. (2015). Fatigue and quality of life of women with multiple sclerosis: A randomized controlled clinical trial. *Journal of Sports Medicine and Physical Fitness, 55*(6), 668–674.
- Latimer-Cheung, A. E., Martin Ginis, K. A., Hicks, A. L., et al. (2013). Development of evidence-informed physical activity guidelines for adults with multiple sclerosis. *Archives of Physical Medicine and Rehabilitation.*
- Motl, R. W., & Pilutti, L. A. (2020). The benefits of exercise training in multiple sclerosis. *Nature Reviews Neurology.*
- Rubio-Arias, J. Á., et al. (2026). Exercise training effects on fatigue and rehabilitation outcomes in people with multiple sclerosis: An umbrella review of systematic reviews and meta-analyses.
- Tarakci, E., Yeldan, I., Huseyinsinoglu, B. E., Zenginler, Y., & Eraksoy, M. (2013). Group exercise training for balance, functional status, spasticity, fatigue and quality of life in multiple sclerosis: A randomized controlled trial. *Clinical Rehabilitation, 27*(9), 813–822.
- Taul-Madsen, L., Hvid, L. G., Riis, H., et al. (2025). A head-to-head comparison of the effects of aerobic versus resistance training on physical capacity and physical function in people with multiple sclerosis: Results from the MSBOOST trial. *Multiple Sclerosis Journal.*
- Tollár, J., Nagy, F., Tóth, B. E., et al. (2020). Exercise effects on multiple sclerosis quality of life and clinical-motor symptoms. *Medicine & Science in Sports & Exercise, 52*(5), 1007–1014.
- Walton, C., King, R., Rechtman, L., et al. (2020). Rising prevalence of multiple sclerosis worldwide: Insights from the Atlas of MS. *Multiple Sclerosis Journal.*
- Zheng, P., DeJonge, S. R., DuBose, N. G., et al. (2026). Randomized controlled trial of a remotely-delivered exercise training program in older adults with multiple sclerosis: Secondary effects on cognition, symptoms, and quality of life. *Multiple Sclerosis and Related Disorders.*