The effect of resistance training on quality of life in people with multiple sclerosis: A systematic review, meta-analysis, and meta-regression

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Running head: Resistance training in multiple sclerosis

Clinical significance:

- Resistance training improved overall quality of life in people with multiple sclerosis.
- Resistance training improved physical health related quality of life in people with multiple sclerosis.
- As a result of the above, integrated care programmes for people with multiple sclerosis should incorporate resistance training.

Abstract

Background: Multiple sclerosis is a chronic autoimmune condition that impairs quality of life. While disease-modifying therapies are the primary treatment, resistance training has emerged as a non-pharmacological intervention to enhance both physical and mental health aspects of quality of life.

Objective: This systematic review and meta-analysis evaluated effects of resistance training on physical and mental health components of quality of life, as well as overall quality of life, in people with multiple sclerosis.

Methods: A comprehensive literature search was conducted across Scopus, Medline, and SPORTDiscus to identify randomized and non-randomized trials assessing the impact of resistance training on quality of life in people with multiple sclerosis. Data from 13 studies were synthesized with random-effects meta-analyses.

Results: Resistance training improved overall quality of life (standardized mean difference = 1.25; 95% confidence interval: 0.03 to 2.47, p=0.045), physical health (standardized mean difference = 0.29; 95% confidence interval: 0.05 to 0.53, p=0.017), and mental health (standardized mean difference = 0.23; 95% confidence interval: −0.11 to 0.56, p=0.184). No association was found between study duration and effect size in the meta-regression.

Conclusions: Resistance training shows potential to improve quality of life in individuals with multiple sclerosis, particularly in physical and mental health domains. However, the effects were inconsistent and not statistically significant for mental health. Further high-quality, standardized, and adequately powered trials are needed to confirm these findings and inform clinical practice.

1.0: Introduction:

Multiple sclerosis is an autoimmune disease where brain and spinal cord myelin becomes damaged[1]. It can result in a wide range of neurological symptoms including fatigue, motor dysfunction, cognitive impairment, and neuropathic pain[2]. This chronic, progressive neurological disorder can have a significant impact on quality of life, including their physical, social, and psychological wellbeing[3]. Often pharmacological interventions such as disease modifying therapies are prescribed to multiple sclerosis patients[4]. These often aim to reduce the frequency and severity of relapses; however, they do not always address symptoms such as fatigue or mobility which can be critical determinants of quality of life[5].

Using the 36-Item Short Form Health Survey (SF-36), multiple sclerosis patients have scored lowest in domains such as vitality and physical functioning, with scores strongly associated with social and emotional wellbeing[5]. As the disease is progressive in about 2/3 of cases, and chronic, it is essential to consider interventions which enhance quality of life, as part of the management of multiple sclerosis. Whilst disease modifying therapies and pharmacological interventions remain the standard of care[4], there has been increasing attention towards non-pharmaceutical interventions, such as resistance training[3,6–9], which may improve patient outcomes in ways pharmacological treatments do not.

Resistance training has repeatedly shown to improve muscle health, balance, mobility, mood, and fatigue in people with and without multiple sclerosis[7,10,11]. All these domains are crucial for enhancing quality of life in people with multiple sclerosis[6,9]. However, Macdonald and colleagues[12] noted in their meta-analysis that people with multiple sclerosis engage in less physical activity than healthy controls when measured using accelerometers during free-living conditions.

Despite the ostensibly effectiveness of resistance training in people multiple sclerosis[6,9,13], evidence is scant. Additionally, many trials vary in terms of duration, intensity, and outcome measures.

Moreover, most studies prioritize physical or performance-based outcomes, often relegating quality of life to a secondary outcome. As such, there is a need for a comprehensive synthesis of available literature to evaluate the effect of resistance training on quality of life in people with multiple sclerosis. Several tools exist to quantify quality of life, of which some are specific to multiple sclerosis and some are applied to the general population. Specific tools include the Hamburg Quality of Life Questionnaire in Multiple Sclerosis (HAQUAMS)[14], the Multiple Sclerosis International Quality of Life (MusiQoL) tool[15], the Multiple Sclerosis Quality of Life-54 (MSQOL-54) tool[16], and the French version of the MSQOL-54 tool (SEP-59)[17]. It is possible that these capture quality of life in people with multiple sclerosis more validly than generic instruments.

This systematic review and meta-analysis aimed to evaluate the effect of resistance training on quality of life in people with multiple sclerosis.

2.0: Methods:

2.1: Eligibility criteria

Studies that were included in this review met the following criteria: 1. Published as full text, 2. Used human participants with multiple sclerosis; 3. Included a resistance training protocol; 4. Had a comparator of no intervention or an alternative intervention; 5. Measured quality of life. The protocol of the review, outlining the objectives was registered with PROSPERO before searches were made (Study ID: CRD420251144651. Available at: https://www.crd.york.ac.uk/PROSPERO/view/CRD420251144651. Procedures followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines[18].

2.2: Information sources

Three electronic databases were searched to find research articles, these were: Scopus, Medline and SPORTdiscus. Searches were performed until 16th September 2025 with no start date.

2.3 Search strategy

The search strategy used various terms relating to multiple sclerosis and resistance training, which were developed through an examination of published literature. Search terms used were: "multiple sclerosis” OR “multiple sclerosis” OR “multiple-sclerosis”; “resistance training” OR “strength training” OR “weight training” OR “resistance protocol” OR “strength protocol”; “quality of life” OR “QoL”.

2.4: Study selection

Once each database had been searched, articles were downloaded into a single reference list using Proquest Refworks. All duplicates were removed by using the deduplication tool, which was manually checked. Titles and abstracts were assessed for eligibility by HA with the use of Rayyan[19]. Eligible paper full texts were then sourced and assessed further for eligibility. A second assessor (LH) screened 100 titles at the titles and abstract stage, and all articles at the full text stage. Agreement between assessors yielded a Cohen’s kappa of 1.00. Data were extracted with as much detail as provided. Study quality was assessed using the risk of bias (RoB-2) tool[20] for randomized control trials and the risk of bias in non-randomized studies of intervention (ROBINS-I)[21] for all other trials. The certainty of evidence for each outcome was assessed using the GRADE (Grading of Recommendations Assessment, Development and Evaluation)[22] approach.

2.5: Data collection

Author name, study design, means and standard deviation, sample size, control group descriptions, aims, and summary of results were extracted from each study and tabulated using guidance from the Template for Intervention Description and Replication (TIDieR)[23] (table 1).

2.6: Data analysis

Standardized mean difference is given as the outcome measure. Random-effects models were fitted to the data. Heterogeneity (i.e., τ_2), was estimated using the restricted maximum-likelihood estimator[24]. In addition to the estimate of τ^2, the Q-test for heterogeneity[25] and the I^2 statistic[26] are reported. Meta-regressions were conducted to test whether study duration in weeks influenced effect sizes. Due to a sample size lower than 10, funnel plots were visually inspected only. No missing data were evident. No sensitivity analysis was conducted. The analysis was carried out using R (version 4.5.0)[27] and the metafor package (version 4.8.0)[28].

3.0: Results

This systematic review and meta-analysis included 13 studies which examined resistance training on quality of life in people with multiple sclerosis. Quality of life was measured with a variety of scoring systems and either reported as a full composite score or divided into a physical health composite and a mental health composite. Tools included multiple sclerosis tools; the MSQOL-54 (including French translation [SEP-59]), the HAQUAMS, and the MusiQoL, and general population quality of life assessment tools; the World Health Organization Quality-of-Life Scale (WHOQoL-Bref), the Medical Outcomes Study 36-item (SF-36), and 12-item (SF-12) short-form health survey.

INSERT TABLE 1

3.1: Study Selection

After the initial database search, 2,301 records were identified (Figure 1). Once duplicates were removed, 1,836 titles and abstracts were screened for inclusion resulting in 47 studies being sought for retrieval as full text and assessed for eligibility. One paper was unretrievable. Of those retrieved, 13 papers were eligible to be included. Nine were RCTs[7,29–36], and four were uncontrolled trials[37–40].

The most common ways of reporting results were as a physical health composite (physical health component) score and a mental health composite (mental health component) score or as a full quality of life composite score.

INSERT FIGURE 1

3.2: The effect of resistance training on quality of life composite score

The standardized mean difference was a large positive effect ($\hat{\mu}$=1.25, 95% CI: 0.026 to 2.472, p=0.045, z=2.00) where resistance training improved quality of life. A meta-regression was also performed to assess the effect of duration, and there was no significant relationship between resistance training duration (in weeks) and quality of life (p=0.141). According to the Q-test, heterogeneity was evident ($Q(4)$=96.57, p<0.001, τ^2=0.2072, I^2=96%; Figure 3).

INSERT FIGURE 2 AND 3

3.3: Effect of resistance training on physical health composite scores

The standardized mean difference was a small positive effect ($\hat{\mu}$=0.290, 95% CI: 0.052 to 0.572, p=0.017, z=2.39; Figure 4) where resistance training improved physical health. A meta-regression was also performed to assess the effect of resistance training duration, and there was no statistically significant association between resistance training duration (in weeks) and physical health (p=0.268). According to the Q-test, heterogeneity was absent ($Q(7)$=8.728, p=0.366, τ^2=0.0159, I^2=12%; Figure 5).

INSERT FIGURE 4 AND 5

3.4: The effect of resistance training on mental health composite scores

The standardized mean difference was a small positive effect that did not reach statistical significance ($\hat{\mu}$=0.232, 95% CI: −0.110 to 0.575, p=0.184, z=1.33; Figure 6). A meta-regression was also performed to assess the effect of duration, and similarly there was no significant association between resistance training duration (in weeks) and mental health (p=0.911). According to the Q-test, the true outcomes were heterogeneous ($Q(7)$=16.872, p=0.031, τ^2=0.1435, I^2=56%; Figure 7).

INSERT FIGURE 6 AND 7

3.5: Risk of bias analysis

Risk of bias was assessed using the RoB-2 tool for RCTs and the ROBINS-I tool for non-randomized studies. Among the nine RCTs, many studies demonstrated some concerns (Figure 8), particularly related to the randomization process and deviations from intended interventions. Full blinding of participants and personnel was rarely feasible due to the nature of the intervention. This introduced potential performance bias; however, most studies blinded data analysis personnel or the assignment of group. Outcome data were generally complete, and measurement tools were validated, reducing the risk of detection and attrition bias.

INSERT FIGURE 8

The four non-randomized studies were generally rated as having moderate risk of bias (Figure 9). All studies showed concerns regarding measurement of outcome, and two studies had moderate bias around participant selection and three studies has moderate bias around reporting of results.

INSERT FIGURE 9

3.5: Certainty of evidence assessment

The certainty of evidence for each outcome was assessed using the GRADE framework. For the quality of life composite outcome, the certainty was rated as low due to very high heterogeneity

(I^2=96%), substantial imprecision reflected in a wide confidence interval, and some concerns regarding risk of bias across included studies. The physical health composite outcome was rated as moderate certainty, with downgrading applied for risk of bias concerns but no concerns related to inconsistency, indirectness, imprecision, or publication bias. The mental health composite outcome was rated as low certainty owing to moderate heterogeneity, imprecision with confidence intervals spanning benefit and no effect, and some risk of bias concerns among contributing studies. Overall, while resistance training appears to offer benefits for domains of quality of life, the strength of evidence varies across outcomes.

4.0: Discussion

This systematic review and meta-analysis examined the impact of resistance training on quality of life in people with multiple sclerosis. Most studies showed improved physical quality of life following resistance exercise, primary concerning the composite score (i.e. overall mental health), though heterogeneity was high. Prior research has linked exercise to improvements in fatigue, mobility, and strength in multiple sclerosis[8,41], and this review synthesizes evidence that resistance training may enhance both physical and mental health outcomes.

4.1: Quality of life composite score

The quality of life composite score reflects overall wellbeing, including physical and emotional aspects[42]. This review found moderate to large positive effects of resistance training compared to controls, with consistent improvements across all six included studies. Duration did not significantly influence outcomes, suggesting benefits regardless of program length. However, our meta-regression analyzing the effects of duration on effect size is limited to the 12-26 week range.

Therefore, it is unknown if durations shorter than 12 weeks or longer than 26 weeks would amplify or dampen the effect of resistance training on quality of life in people with multiple sclerosis.

One study[31] showed particularly strong effects in a randomized control trial of 10 weeks. This study incorporated group exercise, which could suggest that group exercise classes are more effective than individual training programmes. It would have been interesting to perform subgroup analysis on group vs. individual one-to-one vs. remote exercise programmes, but there was an insufficient number of studies to conduct this analysis.

4.2: Physical health composite score

The physical health composite score, as reported in multiple studies, encompasses domains from validated instruments such as the MSQoL-54[16] and SF-36[43] that assess physical functioning, fatigue, and bodily pain. Given the high prevalence of motor impairment and fatigue in individuals with multiple sclerosis, this measure is particularly relevant to daily functioning. The present meta-analysis identified a small effect of resistance training on physical health component scores, indicating that such interventions may significantly enhance the physical dimension of quality of life in this population.

Among the nine studies included, all demonstrated improvements in physical health scores favoring the resistance training intervention. Notably, Dalgas et al.[8] reported the largest standardized mean difference. Participants in this study exhibited relatively high levels of disability (as determined by the Expanded Disability Status Scale [EDSS] 3–5), suggesting that individuals with greater impairment may derive more pronounced physical benefits from resistance training. As with the influence of group vs. individual exercise, it would have been interesting to perform a meta-regression on the mean Expanded Disability Status Scale of participants and the effect size. However, due to variation in reporting this was impossible. For example, some studies report an

Expanded Disability Status Scale of less than a threshold, more than a threshold, a mean, or a range, so a measure of central tendency was impossible to extract from the studies. However, this supposition is supported by findings from Correale et al.[30] and Zaenker et al.[38], whose cohorts had lower Expanded Disability Status Scale scores and reported smaller improvements. Similarly, Royer et al.[37], who studied participants with minimal disability, found no significant between-group differences in physical health scores, despite improvements in secondary outcomes such as muscular strength. In contrast, Romberg et al.[29] observed moderate improvements in participants with moderate disability, further supporting the hypothesis that the magnitude of benefit may correlate with baseline disability severity.

4.3: Mental health composite score

The mental health component of quality of life encompasses psychological domains such as emotional wellbeing, vitality, role functioning, and social engagement[44]. This meta-analysis identified a small positive effect of resistance training on mental health, suggesting potential benefits for psychological wellbeing in individuals with multiple sclerosis. However, substantial heterogeneity was observed across studies.

Although a small effect was evident, the wide confidence interval crossing zero suggests considerable variability. These discrepancies may reflect differences in baseline psychological status, intervention intensity, and the inclusion of behavioral support. The study reporting the largest effect[7] also reported the largest effect for physical health quality of life, suggesting this intervention design was the most effective. The overall trend across studies was neutral to positive, aligning with broader literature in chronic disease populations, where resistance training has been associated with reductions in depressive symptoms and anxiety[45,46].

4.4: Practical implications

These findings suggest that resistance training may improve quality of life in people with multiple sclerosis, particularly overall quality of life. While the mental health composite pooled effect was small and did not reach $p<0.05$, the physical health composite pooled effect was marginally greater and statistically 'significant'. Thus, resistance training should be recommended to people with multiple sclerosis if there are no contraindications to exercise.

4.5: Limitations

We observed substantial heterogeneity, especially within the mental health composite scores, where a small number of studies showed very large or negative effects. Confidence intervals were wide and sometimes crossed zero, reducing statistical certainty. Additionally, methodological inconsistencies between studies such as variation in program length, reported intensity, and participant characteristics limit the precision and reliability of the pooled estimates. The other limitation was that most studies were limited to 12 weeks, and very few studies included a follow-up. Therefore, it was not possible to determine the long-term benefits of resistance training. We have already discussed the inability to perform meta-regression or subgroup analyses so we will not repeat ourselves. However, another meta-regression which would have been of interest would have been the effect of exercise intensity on quality of life improvement. This was impossible due to ambiguity in reporting of training variables.

5.0: Conclusion

This systematic review and meta-analysis provides evidence that resistance training can benefit quality of life in multiple sclerosis patients, particularly in domains related to physical health. While trends also indicate mental health benefits, effects were less consistent, likely due to heterogeneity in study design, intervention characteristics, and participant profiles.

Authorship contributions according to the CRediT taxonomy

Conceptualization, HA, LDH; methodology, HA, AMC, LDH; software, LDH; validation, HA, NEMS-H, NFS, PWH, CJG, AMC, LDH; formal analysis, HA, LDH; investigation, N/A; resources, LDH; data curation, HA, AMC, LDH; writing—original draft preparation, HA, LDH; writing—review and editing, HA, NEMS-H, NFS, PWH, CJG, AMC, LDH; visualization, HA, LDH; supervision, LDH; project administration, HA, LDH. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest statement

The submitted work was not carried out in the presence of any personal, professional, or financial relationships that could potentially be construed as a conflict of interest.

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Table and figure legends

Table 1. Study characteristics of included articles.

Figure 1. PRISMA flow diagram outlining exclusions of potential studies and final number of studies.

Figure 2: Forest plot showing k=6 studies reporting effect of resistance training on quality of life compositive score. Note the size of each square indicates the study weighting in the model, and error bars depict 95% confidence intervals. The diamond represents the overall standardized mean difference.

Figure 3: Funnel plot of studies reporting effect of resistance training on quality of life compositive score.

Figure 4: Forest plot showing k=9 studies reporting effect of resistance training on quality of life physical health compositive score. Note the size of each square indicates the study weighting in the model, and error bars depict 95% confidence intervals. The diamond represents the overall standardized mean difference.

Figure 5: Funnel plot of studies reporting effect of resistance training on quality of life physical health compositive score.

Figure 6: Forest plot showing k=9 studies reporting effect of resistance training on quality of life mental health compositive score. Note the size of each square indicates the study weighting in the model, and error bars depict 95% confidence intervals. The diamond represents the overall effect size.

Figure 7: Funnel plot of studies reporting effect of resistance training on quality of life mental health compositive score.

Figure 8: Risk of bias tool (RoB-2) visualization.

Figure 9: Risk of bias in non-randomized studies – of interventions (ROBINS-I) visualization.