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COMPARATIVE STUDY BETWEEN RESISTANCE TRAINING WITH MUSCLE STIMULATOR AND VESTIBULAR REHABILITATION FOR IMPROVING BALANCE IN MULTIPLE SCLEROSIS PATIENTS

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KEYWORDS

Multiple sclerosis, balance, neuromuscular electrical stimulation, resistance training, vestibular rehabilitation, Berg Balance Scale, functional mobility.

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Abstract

Background: Multiple sclerosis (MS) is a chronic immune-mediated demyelinating disorder of the central nervous system characterized by impaired balance, gait dysfunction, muscle weakness, and an increased risk of falls. Physiotherapy interventions such as resistance training and vestibular rehabilitation are commonly employed to improve postural stability and functional mobility. However, evidence directly comparing resistance training combined with muscle stimulation and vestibular rehabilitation remains limited.

Methodology& Results: A randomized controlled trial was conducted on individuals diagnosed with multiple sclerosis who fulfilled the eligibility criteria. Participants were randomly allocated into two intervention groups. Group A received progressive resistance training combined with NMES, while Group B underwent vestibular rehabilitation. Both groups received supervised treatment over the intervention period. Outcome measures included the Berg Balance Scale (BBS), Timed Up and Go Test (TUG), Functional Reach Test (FRT), and Dynamic Gait Index (DGI). Assessments were performed before and after completion of the intervention. Statistical analysis was conducted using appropriate parametric tests, with the level of significance set at $p < 0.05$.

Results: Both interventions resulted in statistically significant improvements in balance and functional mobility. However, the resistance training combined with NMES group demonstrated greater improvements across the primary outcome measures compared with the vestibular rehabilitation group.

Contribution of the Paper

1. This randomized controlled trial directly compares resistance training combined with neuromuscular electrical stimulation (NMES) and vestibular rehabilitation for improving balance in individuals with multiple sclerosis.
2. Both interventions significantly improved balance and functional mobility; resistance training combined with NMES demonstrated greater improvements in balance-related outcomes.
3. The findings provide evidence to help physiotherapists select effective rehabilitation strategies for improving postural stability and functional mobility in ambulatory individuals with multiple sclerosis.

Conclusion: Both rehabilitation strategies were effective in improving balance in individuals with multiple sclerosis. Resistance training combined with NMES produced superior improvements in postural stability and functional mobility, suggesting that it may be considered a preferred intervention for balance rehabilitation in ambulatory individuals with multiple sclerosis.

Introduction

Multiple sclerosis (MS) is a chronic, immune-mediated disorder of the central nervous system characterized by inflammation, demyelination, axonal degeneration, and progressive neurological dysfunction. It is one of the leading causes of non-traumatic neurological disability in young adults and affects more than 2.8 million individuals worldwide. The disease commonly presents between 20 and 50 years of age and disproportionately affects women. The complex pathophysiology of MS results in impairments involving motor, sensory, visual, vestibular, and cognitive systems, leading to significant limitations in functional independence.

Among the numerous clinical manifestations of MS, balance impairment is one of the most disabling. Effective postural control depends on the integration of visual, vestibular, and somatosensory information together with appropriate neuromuscular responses. Demyelinating lesions affecting these pathways disrupt sensory integration, impair postural stability, and increase the risk of falls. As a consequence, individuals with MS frequently experience gait disturbances, decreased mobility, reduced confidence during walking, and diminished participation in daily activities.

Muscle weakness, impaired proprioception, vestibular dysfunction, delayed motor responses, and fatigue collectively contribute to balance deficits in MS. These impairments significantly increase fall risk and negatively affect quality of life. Rehabilitation strategies aimed at improving balance are therefore central to physiotherapy management and have become an important component of multidisciplinary care.

Progressive resistance training has consistently demonstrated improvements in muscle strength, neuromuscular activation, functional mobility, and postural stability. The addition of neuromuscular electrical stimulation (NMES) further enhances motor-unit recruitment and may facilitate neuroplasticity, particularly in individuals with impaired voluntary muscle activation.

Vestibular rehabilitation is another evidence-based intervention that promotes central compensation through gaze stabilization, habituation, balance retraining, and sensory integration exercises. Previous studies have reported improvements in dizziness, balance, gait, and functional independence following vestibular rehabilitation in individuals with MS.

Although both interventions have shown beneficial effects independently, direct comparisons between resistance training combined with NMES and vestibular rehabilitation remain scarce. Determining the relative effectiveness of these approaches is clinically important for optimizing rehabilitation programmes and guiding evidence-based physiotherapy practice.

Therefore, the present randomized controlled trial was undertaken to compare the effectiveness of resistance training combined with NMES and vestibular rehabilitation in improving balance among individuals with multiple sclerosis.

Methodology:

The experimental type of study was conducted in the Department of Neurology, Pacific College of Physiotherapy, Pacific Medical University, Udaipur, Rajasthan in the duration of 12 months. The present study was approved by Institutional Ethical Committee, Pacific Medical University (PMU/IEC/MPT/2025/44). Individuals diagnosed with Multiple Sclerosis by a neurologist were screened for eligibility according to the predefined inclusion and exclusion criteria. Eligible participants were recruited using convenience sampling and randomly allocated into two intervention groups.A total of 48 participants were included in the study. Participants were randomly assigned into:

Group A (n = 15): Resistance Training with Neuromuscular Electrical Stimulation (NMES)

Group B (n = 15): Vestibular Rehabilitation

Randomization was performed using a computer-generated random allocation sequence, ensuring equal allocation to both groups.

Results: A total of 30 participants diagnosed with Multiple Sclerosis completed the study. Participants were randomly allocated into two equal groups: Group A (Resistance Training with Muscle Stimulator; RTMS, n = 15) and Group B (Vestibular Rehabilitation; VR, n = 15). Both groups completed the intervention protocol without major adverse events. Outcome measures included the Berg Balance Scale (BBS), Timed Up and Go

Test (TUG), Functional Reach Test (FRT), and Dynamic Gait Index (DGI). Assessments were performed before and after the intervention

STATISTICS

Table 1: Distribution of Age Group RTMS

Age	Number of Patients	Percentage
20-30	3	20%
30-40	5	33.3%
40-50	7	46.6%
Total	15	100%

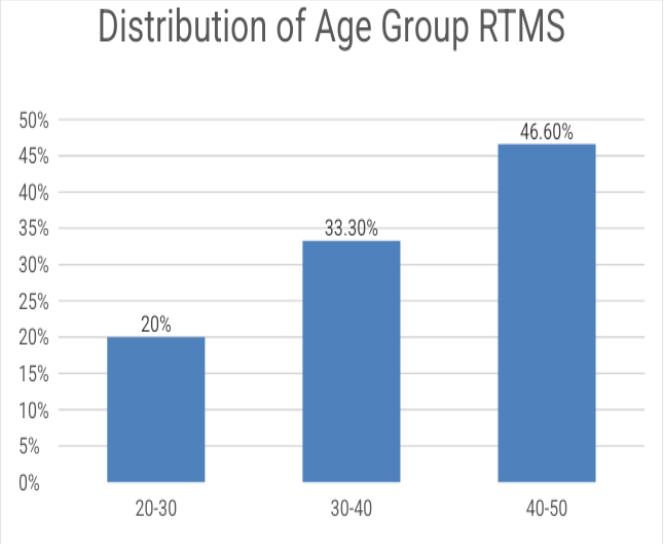

Table 2: Distribution of Gender RTMS

Gender	Number of Patients	Percentage
Male	8	53.3%
Female	7	46.6%
Total	15	100%

The RTMS group comprised **53.3% males (n=8)** and **46.6% females (n=7)**.

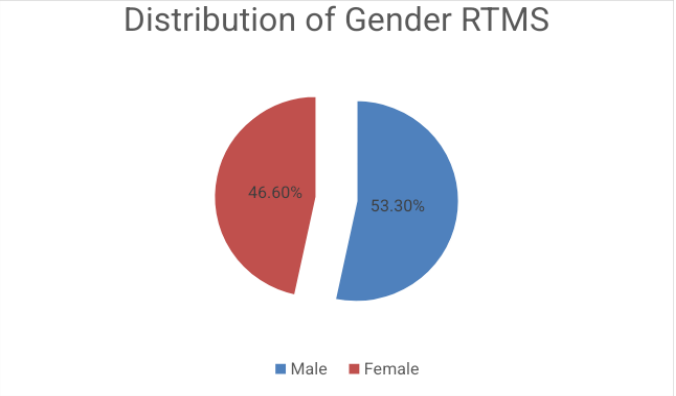

Table 3: Distribution of Occupation RTMS

Occupation	Number of Patients	Percentage
Housewife	3	20%
Businessman	6	40%
Job	2	13.3%
Retd	2	13.3%
Farmer	2	13.3%
Total	15	100%

The majority of participants in the RTMS group were **businessmen (40.0%)**, followed by **housewives (20.0%)**, while **job holders, retired individuals, and farmers each constituted 13.3%** of the sample.

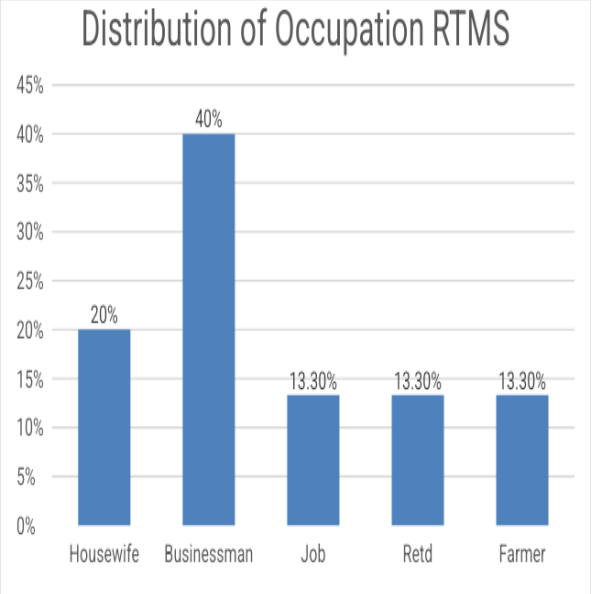

Table 4: Distribution of BBS RTMS

BBS	Mean ± SD (n=15)	Range	Maximum	Minimum
Pre BBS	44.8±1.4	5	47	42
Post BBS	50.8±1.4	5	53	48

The mean **BBS score** in the RTMS group increased from **44.8 ± 1.4** before treatment to **50.8 ± 1.4** after treatment.

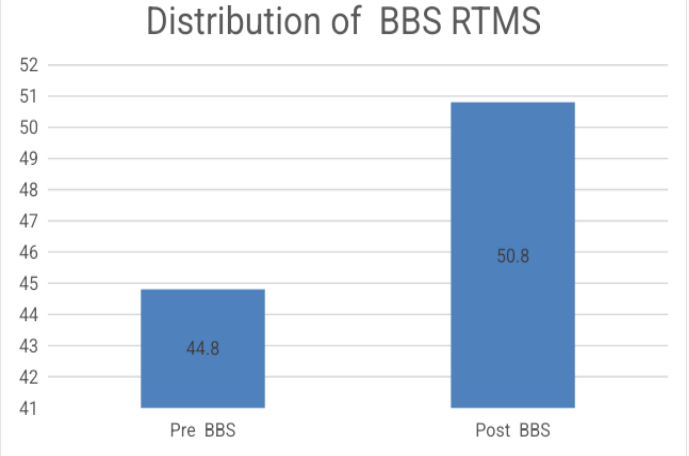

Table 5: Distribution of TUG RTMS

TUG	Mean ± SD (n=15)	Range	Maximum	Minimum
Pre TUG	15.3±0.5	1.7	16.2	14.5
Post TUG	11.7±0.5	1.8	12.6	10.8

The mean **TUG score** in the RTMS group decreased from **15.3 ± 0.5 seconds** before treatment to **11.7 ± 0.5 seconds** after treatment.

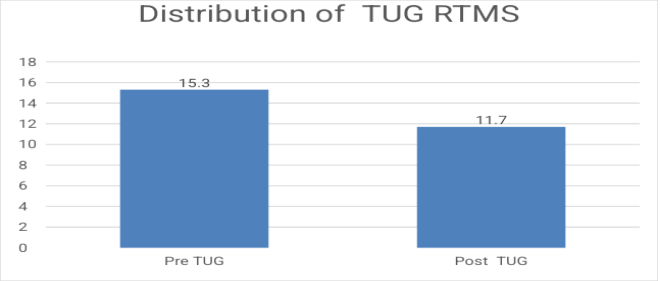

Table 6: Distribution of FRT RTMS

FRT	Mean ± SD (n=15)	Range	Maximum	Minimum
Pre FRT	22.8±0.7	2.4	24.1	21.7
Post FRT	28.8±0.7	2.4	30.1	27.7

The mean **FRT score** in the RTMS group increased from **22.8 ± 0.7** before treatment to **28.8 ± 0.7** after treatment.

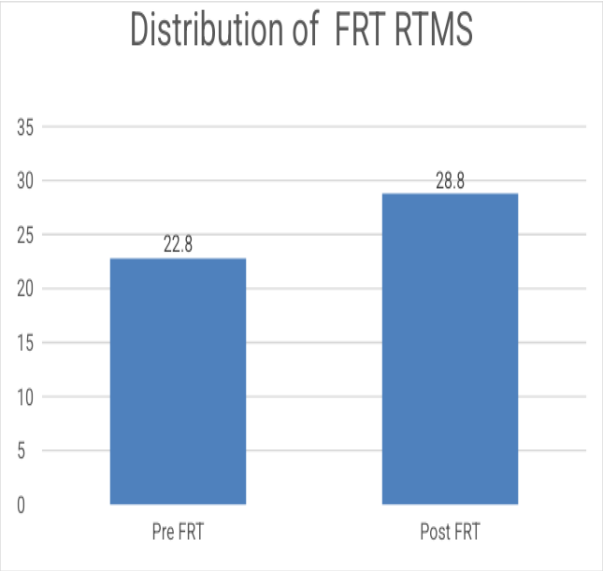

Table 7: Distribution of DGI RTMS

DGI	Mean ± SD (n=15)	Range	Maximum	Minimum
Pre DGI	18.2±1.2	4	20	16
Post DGI	21.2±1.2	4	23	19

The mean **DGI score** in the RTMS group increased from **18.2 ± 1.2** before treatment to **21.2 ± 1.2** after treatment.

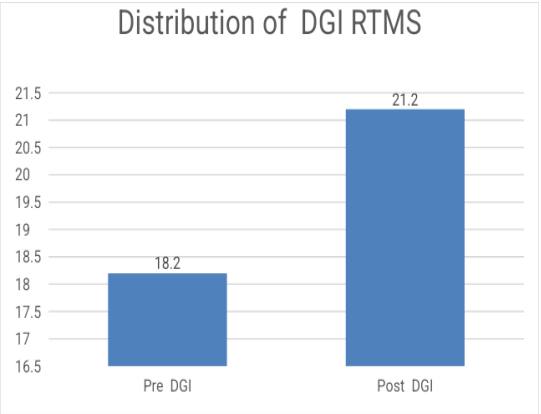

Table 8: Comparison of Pre and Post BBS RTMS

BBS	Mean ± SD (n=15)	Statistical T value	P Value
Pre BBS	44.8±1.4	Nil	NIL
Post BBS	50.8±1.4		

The difference between every pair is the same. Can't compute test. The mean **BBS score** increased from **44.8 ± 1.4** at pre-test to **50.8 ± 1.4** at post-test, indicating improved balance after RTMS intervention.

Table 9: Comparison of Pre and Post TUG RTMS

TUG	Mean ± SD (n=15)	Statistical T value	P Value
Pre TUG	15.3±0.5	21.2	0.0001(S)
Post TUG	11.7±0.5		

The mean **TUG score** significantly decreased from **15.3 ± 0.5 seconds** before treatment to **11.7 ± 0.5 seconds** after treatment.The difference was **statistically highly significant** (**t = 21.2, p = 0.0001**)

Table 10: Comparison of Pre and Post FRT RTMS

FRT	Mean ± SD (n=15)	Statistical T value	P Value
Pre FRT	22.8±0.7	Nil	Nil
Post FRT	28.8±0.7		

The correlation and t cannot be computed because the standard error of the difference is 0.[a] The mean **FRT score** increased from **22.8 ± 0.7** before treatment to **28.8 ± 0.7** after treatment, indicating improved functional reach after RTMS intervention.

Table 11: Comparison of Pre and Post DGI RTMS

DGI	Mean ± SD (n=15)	Statistical T value	P Value
Pre DGI	18.2±1.2	Nil	Nil
Post DGI	21.2±1.2		

The correlation and t cannot be computed because the standard error of the difference is 0.[a] The mean **DGI score** increased from **18.2 ± 1.2** before treatment to **21.2 ± 1.2** after

RESULTS

The present study was conducted to compare the effectiveness of Resistance Training with Muscle Stimulator (RTMS) and Vestibular Rehabilitation (VR) in improving balance among patients with Multiple Sclerosis. A total of 30 participants who satisfied the inclusion and exclusion criteria were included in the study. They were randomly divided into two equal groups. Group A consisted of 15 participants who received Resistance Training with Muscle Stimulator, while Group B consisted of 15 participants who underwent Vestibular Rehabilitation. The effectiveness of both interventions was assessed using the Berg Balance Scale (BBS), Timed Up and Go Test (TUG), Functional Reach Test (FRT), and Dynamic Gait Index (DGI). Assessments were carried out before and after the intervention period.

DISCUSSION:

The present study was conducted to compare the effectiveness of Resistance Training with Muscle Stimulator (RTMS) and Vestibular Rehabilitation (VR) in improving balance among individuals with Multiple Sclerosis. Multiple Sclerosis is a chronic, progressive neurological disorder that commonly affects balance, coordination, muscle strength, and gait. These impairments often interfere with mobility, increase the risk of falls, and reduce an individual's ability to perform daily activities independently. Physiotherapy therefore plays a significant role in improving functional performance and enhancing the quality of life of individuals living with Multiple Sclerosis. In the present study, the effectiveness of two rehabilitation approaches was evaluated using the Berg Balance Scale (BBS), Timed Up and Go Test (TUG), Functional Reach Test (FRT), and Dynamic Gait Index (DGI).

The demographic findings revealed that the majority of participants belonged to the 40–50 years age group. This observation is consistent with the clinical progression of Multiple Sclerosis, as balance impairment and functional disability generally become more evident during middle adulthood. The study also included an almost equal number of male and female participants, which ensured a balanced distribution between the two groups and minimized the possibility of gender-related bias influencing the study findings.

Participants who received Resistance Training with Muscle Stimulator demonstrated noticeable improvement in all outcome measures following the intervention. The Berg Balance Scale scores increased, indicating better postural stability and functional balance. Timed Up and Go Test scores decreased, reflecting improved mobility and greater efficiency while performing functional tasks. Similarly, improvements in the Functional Reach Test and Dynamic Gait Index indicated

better dynamic balance, gait performance, and postural control.

The findings observed in the present study are consistent with those reported by Dalgas et al. (2012), who demonstrated that progressive resistance training significantly improved muscle strength, balance, walking ability, and functional capacity in individuals with Multiple Sclerosis. The authors suggested that strengthening the lower limb muscles improves neuromuscular efficiency, enabling individuals to perform functional activities with greater confidence and stability.

Comparable findings were also reported by Kjølhede et al. (2015), who observed significant improvements in muscle strength, walking performance, and physical function following progressive resistance training in patients with Multiple Sclerosis. They concluded that improved muscle strength contributes directly to better postural control and functional mobility.

Similarly, Motl and Pilutti (2012), in their review of exercise interventions for Multiple Sclerosis, reported that strengthening exercises are effective in improving mobility, reducing fatigue, enhancing balance, and improving quality of life. Their findings further support the improvements observed in the Resistance Training with Muscle Stimulator group in the present study.

The positive changes seen in the RTMS group may be explained by the combined effect of resistance exercises and electrical muscle stimulation. Resistance exercises improve muscle strength and endurance, while muscle stimulation enhances motor unit recruitment and neuromuscular activation. Improved muscle activation may have enabled participants to achieve better postural stability, increased walking efficiency, and improved overall functional performance.

Participants who underwent Vestibular Rehabilitation also demonstrated improvement in all outcome measures after the intervention. There was an increase in Berg Balance Scale scores together with improvements in Functional Reach Test and Dynamic Gait Index scores, whereas Timed Up and Go Test scores decreased following treatment. These findings indicate improvements in balance, gait stability, dynamic postural control, and functional mobility.

The present findings are in agreement with the study conducted by Hebert et al. (2011), who investigated the effects of Vestibular Rehabilitation in individuals with Multiple Sclerosis and reported significant improvements in balance confidence, postural stability, and walking performance. They explained that vestibular exercises improve the integration of visual, vestibular, and somatosensory information, thereby enhancing postural control during movement.

The results are also comparable with those of Cattaneo et al. (2007), who demonstrated that balance-specific rehabilitation significantly improved postural stability and reduced fall risk in patients with Multiple Sclerosis. They emphasized that repetitive balance training promotes motor learning and helps individuals develop more effective postural strategies during functional activities.

Prosperini et al. (2013) similarly reported that vestibular and balance rehabilitation improved gait stability and reduced fall risk among individuals with Multiple Sclerosis. Their findings support the improvements observed in the Functional Reach Test and Dynamic Gait Index in the present study.

When the outcomes of both intervention groups were compared, improvements were observed in all four outcome measures. The Vestibular Rehabilitation group demonstrated a slightly greater improvement in Timed Up and Go Test scores, whereas the Resistance Training with Muscle Stimulator group showed marginally higher post-treatment scores on the Berg Balance Scale and Dynamic Gait Index. However, the overall improvements between the two groups were comparable, suggesting that both interventions were effective in improving balance and mobility.

These findings are comparable with those reported by Latimer-Cheung et al. (2013), who concluded that different forms of therapeutic exercise, including strengthening and balance training, improve balance, mobility, and physical function in individuals with Multiple Sclerosis. Their review suggested that although exercise programs differ in their approach, most interventions produce meaningful functional improvements without one

method consistently outperforming another.

The improvements observed in the Berg Balance Scale indicate better static and dynamic balance during functional activities. Higher scores suggest that participants were able to maintain postural stability more effectively while performing everyday tasks. Likewise, the reduction in Timed Up and Go Test scores reflects improved functional mobility, enabling participants to perform activities such as standing up, walking, turning, and sitting with greater confidence and efficiency.

Similarly, the increase in Functional Reach Test scores indicates improved limits of stability and dynamic balance. The ability to reach further without losing balance reflects better postural control and reduced risk of falls. Improvement in Dynamic Gait Index scores further demonstrates enhanced gait adaptability, improved walking stability, and better performance while negotiating different walking environments and functional challenges.

The comparable improvements observed in both groups may be explained by the different mechanisms through which the interventions act. Resistance Training with Muscle Stimulator primarily enhances muscle strength, motor unit recruitment, and neuromuscular coordination, whereas Vestibular Rehabilitation focuses on improving sensory integration, postural control, and balance strategies. Since balance depends on the coordinated function of the muscular, vestibular, visual, and somatosensory systems, improvements in either system can positively influence functional performance. This may explain why both intervention groups demonstrated clinically meaningful improvements despite following different rehabilitation approaches.

The overall findings of the present study suggest that both interventions successfully addressed the major balance impairments commonly seen in individuals with Multiple Sclerosis. Improvement across all outcome measures indicates better postural stability, enhanced gait performance, increased functional mobility, and greater confidence while performing daily activities. These findings reinforce the importance of incorporating structured rehabilitation programs into the physiotherapy management of individuals with Multiple Sclerosis.

Although the present study demonstrated encouraging findings, certain limitations should be considered while interpreting the results. The sample size was relatively small, which may limit the generalizability of the findings. The duration of the intervention was also limited, and no follow-up assessment was carried out to determine whether the improvements were maintained over time. Future studies involving larger sample sizes, multicentre participation, longer intervention periods, and long-term follow-up are recommended to provide stronger evidence regarding the effectiveness of Resistance Training with Muscle Stimulator and Vestibular Rehabilitation in individuals with Multiple Sclerosis.

Conclusion:

The present study was conducted to compare the effectiveness of Resistance Training with Muscle Stimulator (RTMS) and Vestibular Rehabilitation (VR) in improving balance among individuals with Multiple Sclerosis. Based on the findings of the study, it can be concluded that both intervention protocols were effective in improving balance, gait performance, functional mobility, and dynamic postural stability.

Participants in both groups demonstrated improvements in all outcome measures, including the Berg Balance Scale (BBS), Timed Up and Go Test (TUG), Functional Reach Test (FRT), and Dynamic Gait Index (DGI), following the intervention period. These improvements indicate that both rehabilitation approaches contributed positively to enhancing functional performance and reducing balance impairments associated with Multiple Sclerosis.

Although the Vestibular Rehabilitation group demonstrated a slightly greater improvement in the Timed Up and Go Test, the Resistance Training with Muscle Stimulator group achieved marginally higher post-treatment scores in the Berg Balance Scale and Dynamic Gait Index. However, the differences between the two interventions were minimal, suggesting that both treatment approaches produced comparable clinical outcomes.

Resistance Training with Muscle Stimulator

appears to be beneficial in improving muscle activation, strength, neuromuscular coordination, and functional balance, whereas Vestibular Rehabilitation primarily enhances postural control, sensory integration, gait stability, and dynamic balance. Since both interventions target different components of balance control, they may be considered valuable rehabilitation strategies in the physiotherapy management of individuals with Multiple Sclerosis.

Overall, the findings of the present study support the use of both Resistance Training with Muscle Stimulator and Vestibular Rehabilitation as effective physiotherapy interventions for improving balance and functional mobility in patients with Multiple Sclerosis. The results also highlight the importance of incorporating structured exercise-based rehabilitation into routine clinical practice to enhance independence, improve mobility, and promote better functional outcomes in this population.

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