

Effect of Combined Training Protocol on Postural Control and Motor Functions of Individuals with Multiple Sclerosis

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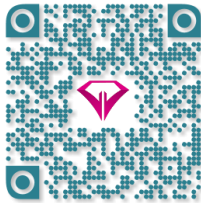
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ABSTRACT

Background & Objective: Multiple Sclerosis (MS) is a common chronic inflammatory disease of the central nervous system. Postural control and motor function disorders are the most common MS related symptoms. Currently, exercise therapy seems to be the most effective non-pharmacological approach in controlling and improving these disorders. Thus, the present study intends to study the effect of combined training protocol on postural control and motor functions of individuals with MS.

Materials & Methods: After selecting 60 women with MS as the study sample, they were randomly assigned to two training intervention and control groups, each comprised of 30 subjects. The training intervention group performed the combined training protocol for eight weeks.

Results: The results of the covariance analysis showed that the combined training protocol had a significant effect on all postural control (postural sway indexes and Berg Balance Scale) and motor function (Timed 25 Feet Walk test and Timed Up and Go test) variables in individuals with MS ($P \leq 0.05$).

Conclusion: The results of this study indicated that the combined training protocol improved postural control and motor functions of individuals with MS. Therefore, these results may be recommended to all individuals who are making an effort to treat and improve individuals with MS.

Keywords: Multiple Sclerosis, Postural Control, Motor Function, Combined Training Protocol



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It should be noted that according to the nature of this research and the necessity of an expert to planning a special training protocol for individuals with MS, two authors were named as the corresponding authors. The second author was as a research fellow, methodologist and statistical consultant and the third author was as a research fellow and training protocol consultant.

Introduction

Multiple Sclerosis (MS) is a common chronic inflammatory disease of the central nervous system, which typically affects young adults aged between 20 and 40 years of age. According to the most recent official studies published in 2014, approximately 2.5 million people suffer from MS all over the world (1). Numerous studies indicate a significant increase in the last two decades in the occurrence and prevalence of MS in Iran (2). Iran accounts for the highest occurrence and prevalence rate of MS in Asia and the Middle East (3). The latest MS census had approximately 70,000 cases in Iran in 2016, and in 2017, with about 148 cases per 100,000 people in Tehran (4). MS results in the demyelination and neural damage of the central nervous system, which results in different manifestations. Among the most commonly seen disorders of MS are postural control and motor function disorders, especially gait disorders, fatigue, muscle weakness, pain, leg

spasticity and visual disorders (5,6). MS, senility and/or musculoskeletal disorders are some of the key factors that negatively affect the efficiency of the postural control system (7). Postural control is a complicated process that depends on the coordination of several sensory, motor, and biomechanical components which are influenced by visual, vestibular, and somatosensory systems with mutual effect on the central nervous system (8).

Results of various studies indicate that about 75 to 85 percent of individuals with MS have postural control disorder and postural instability (9), which has been noted as a risk factor in the increase of falling risk in individuals with MS (10). Motor function disorder, especially gait disorder, is one of the most common disorders and symptoms of individuals with MS, which is seen in approximately 80 percent of MS patients (6).

Nowadays, there are a lot of studies about the positive effects of physical and sport activities on MS patients. Currently, exercise therapy seems to be the most effective non-pharmaceutical method to control symptoms of MS. Studies indicated that appropriate training interventions could be used to improve postural control and the motor function of individuals with MS (9). In a study, Forsberg *et al.* (2016) found a significant difference in balance improvement and gait in individuals with MS after the performance of training intervention (11). Although Normann *et al.* (2016) suggested that core stability exercise was an effective and feasible method for the rehabilitation of individuals with MS (12). Various studies suggested that training interventions (resistance or balance) had numerous benefits for postural control and motor function of the individuals with MS (12-14). In spite of the availability of the various studies, there are few scientific evidences in this regard and various authors recommended further studies on the topic (1). Thus, the present study intends to investigate the effect of combined training protocol on postural control and motor function of the individuals with MS.

Materials and Methods

The present study has been approved by the National Biomedical Research Ethics Committee (IR.UT.SPORT.REC.1397.001) and by the Iranian Registry of Clinical Trials (IRCT20170115031954N1.). This study is an applied quasi-experimental research including a pretest and posttest of the experimental and control group investigating the effect of combined training protocol on postural control and motor function of individuals with MS. The statistical population of the present study includes individuals with MS who had files in the MS Society of Zanjan by the year 2017. From amongst this population, 60 women with MS were purposively selected as the sample under supervision of a specialist considering the inclusion criteria, and randomly assigned to two training intervention and control groups, each comprised of 30 subjects. The inclusion criteria included: relapsing-remitting MS diagnosed by a neurologist (15,16), expanded disability status between 1 and 4/5 as diagnosed by a neurologist (MS fellowship), aged between 30 and 45 years, and a history of an MS diagnosis of more than one year. The exclusion criteria included: a history of other neurological diseases and disorders such as stroke, vestibular disorder (13,15,16), disease relapse within the last three months (15-17), a history of cardiovascular and pulmonary diseases (15,16), comorbid musculoskeletal disorders and abnormalities in the spine and lower extremities (15,16), using aids for gait and other daily activities, lack of normal vision or vision correction by glasses (15,16), pregnancy at the time of study (13,16), explicit and severe cognitive disorders (17), regular training program within the last three months (13), participation in other exercise therapy interventions, physical therapy and/or massage at the time of study (15), relapse of disease at the time of study, and irregular participation and

excessive absence from training sessions. In this study, Zebris Force Distribution Measuring System (FDM-s), Zebris, Germany, and Berg Balance Scale (BBS) were used to measure postural control. Zebris Force Distribution Measuring System measures postural control based on the postural sway indexes (sway area of body's center of pressure in square millimeter and sway path length of body's center of pressure in millimeter). Three tests were taken for each task, with a twenty seconds test duration and a one-minute rest period between the two tests. Tasks were randomly tested in two open-eye and closed-eye positions.

The Berg Balance Scale was used to quantitatively and functionally assess the postural control of the subjects (18). In order to measure motor function, timed 25 Feet Walk (T25FW) and Timed Up and Go (TUG) were used. In Timed 25 Feet Walk Test, the subject was asked to safely walk the specified distance at the maximum speed with regular and normal steps with the recorded time as the subject's score (17). In the Timed Up and Go Test, the subject was seated on a normal armchair, leaning on the back of the chair, with a seat height of 45 cm. As soon as the examiner would say "Go", the subject was asked to stand up and complete the test (14).

After pretest, the training intervention group performed the combined training protocol for eight weeks according to the specified instructions specified of the study design. It is necessary to note that after the completion of eight-weeks of study training protocol and posttest, two subjects from the intervention and control groups were excluded from the study process due to various reasons such as the relapse of disease, excessive absence, etc.

Training Protocol: The training protocol of this study is a set of applied, performable, effective, accessible, and safe exercises which include functional daily activities effective in the improvement of the study variables. The training protocol of this study focused on the improvement of postural control and motor function disorders in individuals with MS. The training intervention exercises of this study included different sensory positions, levels, and multiple motor patterns. The first part of the training intervention included stability exercises for the body's score muscles. The second part included exercises specific to postural control. These exercises tried to challenge and strengthen postural control in the form of functional activities by making changes to somatosensory, visual, and vestibular inputs. All exercises of the training protocol were purposively designed based on scientific findings. Progress in the training protocol was regulated in graduation and in consideration of the overload principle. In addition, unlike most studies, this study's training protocol was designed in compliance to the FITT (Frequency, Intensity, Time and Type) Principle (11,12,17). The training protocol of this study included three weekly sessions for 8 consecutive weeks, with each session lasting approximately 60 to 80 minutes. Each training session of the training protocol had three

sections. The initial warmup was approximately 10 minutes, which included simple static stretching exercises and aerobic exercises with a sixty-percent maximal heartbeat. The special exercise performances of this study's training protocol consisted of approximately 45 to 60 minutes. The cool down exercises lasted for approximately 5 minutes. Exercises of this protocol were designed in three initial, improvement and maintenance phases (Table 3).

Finally, data was analyzed in two descriptive and inferential statistics sections in SPSS 20 (SPSS, Inc. Chicago, Illinois, USA). In order to confirm the normal distribution of data, Kolmogorov-Smirnov (K-S) Test was used ($P \geq 0.05$). Independent t-test was used for determining homogeneity of the groups by age, height, and weight indexes. The Mann-Whitney U Test was used for the expanded disability status. Furthermore, the Analysis of Covariance Test (ANCOVA) was used in order to investigate the effect of combined training protocol on postural control and motor function

variables and compare the obtained results of the study groups. It is necessary to note that the significance level was considered at 95%, with $\alpha \leq 0.05$ throughout the study.

Results

The information related to the study samples and the statistical analysis results are provided in Tables 1 and 2, respectively. It is necessary to mention that results in Table 1 show no significant difference between the two groups and both groups are homogenous with respect to these variables ($P \geq 0.05$).

As provided in Table 2, the results of the Analysis of Covariance Test indicate that the combined training protocol has a significant effect on all postural control (postural sway indexes and Berg Balance Scale) and motor function (Timed 25 Feet Walk Test and Timed Up and Go Test) variables in the individuals with MS ($P \leq 0.05$).

Table 1. Demographics of Study Samples by Group (Mean \pm Standard Deviation)

	Training Intervention Group (28 Subjects)	Control Group (28 Subjects)	P-value
Age (year)	38.39 \pm 4.59	36.36 \pm 3.54	0.069
Height (cm)	159.85 \pm 3.31	157.92 \pm 4.27	0.065
Weight (kg)	66.63 \pm 9.56	61.26 \pm 11.36	0.061
Expanded Disability Severity Scale	2.51 \pm 1.22	2.44 \pm 0.77	0.746

Table 2. Descriptive Statistics and Results of Analysis of Covariance of Means of Two Training Intervention and Control Groups

Variable	Training Intervention Group		Control Group		Degree of Freedom	Mean Squared	F	Significance Level		
	Pretest	Posttest	Pretest	Posttest						
Postural Control	Postural sway indexes in standing position with open eyes	Sway Area of body's center of pressure	85.58 \pm 56.40	70.21 \pm 45.88	60.06 \pm 37.25	84.19 \pm 53.61	1	17716.68	26.66	0.001
		Sway path length of body's center of pressure	224.24 \pm 65.55	205.45 \pm 65.97	201.99 \pm 56.76	211.59 \pm 54.92	1	8640.25	9.34	0.004
	Postural sway indexes in standing position with closed eyes	Sway Area of body's center of pressure	120.29 \pm 85.19	98.53 \pm 68.37	91.71 \pm 61.09	121.25 \pm 77.75	1	29378.75	19.29	0.001
		Sway path length of body's center of pressure	306.24 \pm 134.01	265.56 \pm 88.72	283.24 \pm 135.36	282.96 \pm 112.83	1	11085.66	4.51	0.021
	Berg Balance Scale	41.10 \pm 8.31	45.03 \pm 6.43	43.96 \pm 6.51	41.64 \pm 6.53	1	425.07	49.54	0.001	
Motor Function	Timed 25 Feet Walk Test	5.48 \pm 1.26	4.42 \pm 1.30	5.36 \pm 1.22	5.03 \pm 1.07	1	6.78	10.51	0.002	
	Timed Up and Go Test	8.45 \pm 2.31	6.64 \pm 1.92	7.54 \pm 1.51	7.77 \pm 1.76	1	46.46	50.91	0.001	

Table 3. Training Protocol

PHASE	WEEK	EXERCISES									
		EXERCISE NO. 1 (FULL PLANK)	EXERCISE NO. 2 (SIDE PLANK)	EXERCISE NO. 3 (ABDOMINAL BRIDGE)	EXERCISE NO. 4 (BIRD DOG)	EXERCISE NO. 5 (DIAGONAL CRUNCH)					
INITIAL	1	3×10 FIGURE 1-1	3×10 FIGURE 2-1	3×12 FIGURE 3-1	3×12 FIGURE 4-1	3×10 FIGURE 5-1					
	2	4×10 FIGURE 1-1	4×10 FIGURE 2-1	4×12 FIGURE 3-1	4×12 FIGURE 4-1	4×10 FIGURE 5-1					
	3	4×10 FIGURE 1-1	4×10 FIGURE 2-1	4×12 FIGURE 3-1	4×12 FIGURE 4-1	4×10 FIGURE 5-1					
IMPROVEMENT	4	4×10 FIGURE 1-2	4×10 FIGURE 2-2	4×12 FIGURE 3-2	4×12 FIGURE 4-2	4×10 FIGURE 5-2					
	5	4×10 FIGURE 1-2	4×10 FIGURE 2-2	4×12 FIGURE 3-2	4×12 FIGURE 4-2	4×10 FIGURE 5-2					
	6	4×12 FIGURE 1-3	4×12 FIGURE 2-3	4×15 FIGURE 3-3	4×15 FIGURE 4-3	4×12 FIGURE 5-3					
MAINTENANCE	7	4×12 FIGURE 1-3	4×12 FIGURE 2-3	4×15 FIGURE 3-3	4×15 FIGURE 4-3	4×12 FIGURE 5-3					
	8	4×12 FIGURE 1-3	4×12 FIGURE 2-3	4×15 FIGURE 3-3	4×15 FIGURE 4-3	4×12 FIGURE 5-3					
Exercises											
Phase	Week	Exercise No. 6 (Walk) Figure 6-1	Exercise No. 6 (Walk) Figure 6-2	Exercise No. 6 (Walk) Figure 6-3	Exercise No. 6 (Walk) Figure 6-4	Exercise No. 7 (Tandem) Figure 7-1	Exercise No. 7 (Tandem) Figure 7-2	Exercise No. 7 (Tandem) Figure 7-3	Exercise No. 8 (Standing) Figure 8-1	Exercise No. 8 (Standing) Figure 8-2	Exercise No. 8 (Standing) Figure 8-3
Initial	1	3×20 Open	3×15 Open	3×15 Open	---	3×15 Open	---	---	---	---	---
	2	4×20 Open	4×15 Open	4×15 Open	---	4×15 Open	---	---	---	---	---
	3	4×20 Open	4×15 Open	4×15 Open	3×15 Open	4×15 Open	3×15 Open	---	---	---	---
Improvement	4	3×20 Open, Closed	3×15 Open, Closed	3×15 Open, Closed	3×15 Open	3×15 Open, Closed	3×15 Open	---	---	---	---
	5	3×20 Open, Closed	3×15 Open, Closed	3×15 Open, Closed	3×15 Closed	3×15 Open, Closed	4×15 Open	3×15 Open	3×15 Open	---	---
	6	4×20 Open, Closed	4×15 Open, Closed	4×15 Open, Closed	3×15 Open, Closed	4×15 Open, Closed	4×15 Open	3×15 Open	3×15 Open	3×15 Open	3×15 Open
Maintenance	7	---	---	---	---	---	---	3×15 Open, Closed	3×15 Open, Closed	4×15 Open	3×10 Open, Closed
	8	---	---	---	---	---	---	3×15 Open, Closed	3×15 Open, Closed	4×15 Open	3×10 Open, Closed

* It is necessary to note that the ratio for rest between repetitions is 1 to 1.
 * It is necessary to note that in the table above, 3×10 means three sets of the concerned exercise for a 10 seconds repetition.
 * It is necessary to note that the rest between repetitions is proportionate to the duration of exercises.
 * It is necessary to note that in the table above, 3×10 open, closed means three sets of the concerned exercise for a 10 seconds repetition with eyes open and closed.

Discussion

The present study investigated the effect of combined training protocol on postural control and motor function of individuals with MS. The results of the present study showed that the combined training protocol had a significant effect on postural control (postural sway indexes and Berg Balance Scale) and motor function (Timed 25 Feet Walk Test and Timed

Up and Go Test) in individuals with MS and led to the improvement of these variables. The results of these changes are completely provided in [Table 2](#).

Results of the present study are consistent with those of the study conducted by Forsberg *et al.* (11), Normann *et al.* (12) and Carling *et al.* (17). Upon the

study of 73 subjects in two groups with 7-weeks of training intervention, Forsberg *et al.* found a significant difference in balance and gait of the training intervention group (11). Normann *et al.* also studied the effect of balance and core stability exercises on gait in 12 individuals with MS. After performing the exercises for 5 weeks, they reported a significant improvement in sitting balance, twenty-five-foot-walk duration, and two-minute and six-minute walks, and self-assessment scales (12). In addition, the results of the present study are inconsistent with Tomruk *et al.* (15), which can probably be attributed to the different training protocol of their study, the different age range and sex of the subjects, and the different measurement methods. In regard to our study and its possible reasons for the effectiveness of training intervention in the stability exercises of core muscles, it can be stated that human movement originates from the trunk which is an area of utmost importance for stability. This is because the trunk forms the largest part of the body, and due to its anatomical position, it acts as the body's center of gravity. Different studies have also mentioned the core muscle activities of the body previous to the movement of the lower extremity and assumed that the role of these muscles are necessary in the securing of stability and the creation of stable support in order to perform movements in the lower extremity (19). Results of different studies indicate that the activity of the body's core stabilizing muscles can be considered as an important and fundamental factor in effective postural control and motor function. With that said, in order to improve postural control and body stability and motor function of individuals with MS, it seems necessary to include strengthening exercises of these muscles in training interventions (20). Furthermore, muscle weakness is a dominant characteristic of the disorders resulting from MS. Many studies associated muscle weakness in the lower extremity with postural control disorder, postural instability, motor function disorder, and increased disability in MS patients. These studies suggested a direct relationship between strength and postural instability in such individuals (21). Performing resistance exercises leads to neural stimulation, improved muscle strength, increased muscle tone, and improved muscle oxidative capacity (22). Due to demyelination, MS patients experience disturbed signal conduction of efferent neurons and neuromuscular adaptations, which occur as a result of resistance training, can increase the signal conduction of efferent neuron, leading to improved muscle coordination, which helps the stabilization of the body's standing position (23). Additionally, increased muscle strength is associated with an improvement in

one's motor function (21). Also, due to training interventions, improved gait parameters may result from increased muscle strength and decreased spasticity of the lower extremity. This can increase control in the muscles, joints, and coordination, which leads to an improved static and dynamic stability (24). Yahia *et al.* (2011) found a significant relationship between postural control and motor function disorders and muscle weakness in quadriceps and hamstring muscles in MS patients, and suggested the inclusion of hamstring and quadriceps strengthening in their training interventions (25). Regarding the effectiveness of the exercises specific to postural control, it can be stated, in accordance to other studies, individuals with MS have a delay in postural responses, which is correlatively related to a delay in the conduction of stimulated sensorimotor potentials. A possible reason for MS is the demyelination of the posterior spinal cord, which consequently results in delayed postural responses, leading to postural control disorder (26). The effect of balance exercise interventions is at least partially related to the role of sensorimotor inputs in postural control. In fact, motion sense, especially proprioception, is very important for the effectiveness of both postural feedback and feedforward controls and gait (27). Feedback mechanisms from afferent data—originating from the skin, muscles, and special senses (visual and vestibular)—dynamically form gait patterns in relation to environmental conditions. In order to cope with these environmental conditions, the central nervous system uses compensatory postural adjustments (feedback mechanisms) and/or predictive postural adjustments (feedforward mechanisms). These exercises seem to play a role in strengthening neural signals, which leads to improved postural control (27). Training interventions, with a manipulation at the visual level for further challenging postural control, may improve sensorimotor processing integration in dynamic patterns (28). Brichetto *et al.* (2015) suggested that performing balance training could result in the reorganization of neural networks, the improvement of the central sensory integration, and the improvement of postural control in individuals with MS (29). By changing vestibular system inputs, the performance of balance training interventions seems to provide a sufficient stimulation proportionate to the movement patterns of neural reorganization, the development of central sensory integration, and the consequently improved postural control (30). Additionally, with the change of visual system inputs, balance training interventions play a key role in neuromuscular reorganization. Since visual inputs play a key role in the performance of coordinated

movements, these exercises seem to be effective in the postural control improvement of MS patients (30).

Conclusion

The present study aimed to study the effect of combined training protocol on postural control and motor function of individuals with MS. The results showed that the combined training protocol had a significant effect on postural control and motor function in MS patients and improved upon these variables. Therefore, considering the obtained results, such findings may be recommended to sport professionals and coaches, physicians, physical therapists, and all individuals who are attempting to treat and improve MS patients. However, in order to thoroughly improve postural control and motor function disorders in such individuals, further research is needed.

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Conflict of Interest

The authors declared no conflicts of interest.

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