Lower Endurance and Strength of Core Muscles in Patients with Multiple Sclerosis

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Background: *Multiple sclerosis (MS) is a chronic inflammatory disorder of the central nervous system associated with a variety of symptoms and functional deficits. Balance impairment is a common concern in patients with MS. Core muscle stabilization is considered a main component of balance. The strength and endurance of core muscles have not been compared between patients with MS and healthy people. The objective of this study was to compare core muscle strength and endurance between ambulatory patients with MS and a healthy group.*

Methods: *Thirty-three patients with MS with Expanded Disability Status Scale scores ranging from 1.0 to 4.5 and 33 matched healthy people participated in this cross-sectional group comparison study. The primary outcome measure was endurance of core muscles assessed by functional endurance tests, and the secondary outcome was isometric strength of core muscles assessed using a dynamometer.*

Results: *Patients with MS had lower performance on endurance tests (P < .001) and strength tests (P < .05) compared with the control group.*

Conclusions: *These results show decreased core muscle strength and endurance in ambulatory individuals with MS compared with a matched control group. Future studies are required to assess how core muscle impairment affects balance and how it would be affected by rehabilitation and exercise programs.* ***Int J MS Care*. 2017;19:100–104.**

Multiple sclerosis (MS) is the most common chronic demyelinating inflammatory disease of the central nervous system, with a high prevalence in young adults aged 20 to 35 years.[1] The mean age at onset of the disease is approximately 30 years.[2] Women are more affected than men, with a ratio of 2:1 to 3:1.[1] More than 2.5 million people around the world live with MS.[1] Motor impairments, muscle weakness, spasticity, balance impairment, and visual disturbances are considered common symptoms of MS.[3-6] Fatigue is the most common symptom and one of the most disabling features in patients with MS,[7] with a prevalence of 53% to 90%.[8] Fatigue can be considered one of the identified risk factors for falls in patients with MS.[9] Balance impairment has a high prevalence (up to 89.7%) in patients with MS, which constrains their daily routine activities and increases the risk of falling.[10-12] Collectively, fatigue and imbalance impose challenges to rehabilitation management and quality of life in patients with MS.[11] One component of balance is the postural stability of the trunk, which is known as core stability.[13] People with MS had reduced trunk stability during arm movements in sitting, implying reduced core stability.[13] Because core stabilization is one of the main components of balance, balance disturbance might be attributed to core stabilization impairment.[14-16] Core is considered a kinetic link that facilitates the transfer of torques and angular momenta between the upper and lower extremities during the execution of body movements.[17] It involves coordinated stabilization of the lumbo-pelvic-hip complex via active (muscles) and passive (inert ligaments and capsules) components.[18]

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Core stability and strength are important components to maximize balance.[19] Ketelhut et al.[20] investigated the characteristics of some core muscles (the lateral flexor group, the external and internal obliques, and the rectus abdominis) during walking. They suggested that patients with MS use compensatory mechanisms during walking to maintain balance and posture. These strategies were likely to result in increased muscle energy cost and early fatigability.[20] A limited number of studies have documented the strength and endurance of core muscles in individuals with MS.[21,22] We hypothesized that these two parameters are decreased in patients with MS compared with healthy individuals; therefore, the objective of this study was to investigate core muscle strength and endurance differences between patients with MS and a matched control group.

Materials and Methods

This cross-sectional group comparison study was conducted in the Rehabilitation School of Shiraz University of Medical Sciences (Shiraz, Iran) between February 1, 2014, and October 31, 2014. The sample size was calculated by conducting a pilot study of 60 individuals with an α level equal to .05 and a power of 80%. Thirty-three patients with MS who were diagnosed by an expert neurologist as having an Expanded Disability Status Scale (EDSS) score ranging from 1.0 to 4.5 were recruited from the neurology center of Imam Reza Hospital (Shiraz, Iran) using a convenience sample. The study was approved by the ethics committee of Shiraz University of Medical Sciences in accordance with the standards of the Helsinki Declaration. All the patients signed an informed consent form before participating in the study. Patients with noncorrected visual or hearing disturbances; self-reported neurologic, musculoskeletal, or psychiatric disorders associated with MS; exacerbations of MS symptoms within the past 3 months; or current or recent participation in an exercise program were excluded from the study.

The control group included 33 healthy people recruited using a convenience sample and matched with patients with MS on sex, age, and body mass index. Individuals were excluded if they participated in any regular exercise program or had a neuromuscular or musculoskeletal disease.

The primary outcome measure of the study was the endurance of core muscles, and the secondary outcome was the strength of core muscles.

Static endurance of trunk muscles is an important factor for mechanical support.[23] There is not a precise definition of endurance. Muscle endurance is defined as the ability of a muscle or group to repeatedly move against submaximal resistance.[24] The participants randomly performed endurance and strength tests, with a 10-minute rest between the two trials. Endurance was evaluated using three tests: the Sorenson test, the flexor endurance test, and the side bridge endurance test (Plunk test).

For the Sorenson test, the participant would lie prone on a plinth. The trunk was off the plinth from the anterior superior iliac spine. The lower extremities were fixed at the hip, thigh, and knee on the plinth via straps. The hands were crossed over the chest. Before starting the test, the trunk was allowed to rest on a chair in front of the participant. The participant was asked to extend the trunk and come up to the level of the plinth as the examiner told them and to maintain this position for as long as they could. To ensure maintenance of the suitable position, a round sticky pad with a radius of 2.5 cm was attached to the midaxillary line at the xiphoid level. A laser pen was fixed on an adjustable bar 30 cm from the participant, and the visible light of the laser was focused at the center of the pad. As the participant came up, the laser was lighted. When the light of the laser was out of the circle, the stopwatch (Q & Q HS 43, Courier Services, Citizen Watch Co. Ltd., Malaysia) was stopped and the achieved time was recorded. There is not a predetermined mean endurance time limitation for the Iranian population.[25,26] To prevent a sudden fall, the participants were advised to rest on the chair in front of them when they were unable to continue the test.

For the flexor endurance test, the participant was in the hook-lying position on an adjustable plinth. The upper part of the trunk was maintained in 60° of flexion using a wedge. The hands were crossed over the chest. The feet were fixed on the plinth via a strap. The participant was asked to maintain the position as the wedge was removed from the back. When the participant was unable to maintain the position, the test was stopped and the achieved time was recorded.[27]

For the side bridge endurance test (Plunk test), the participant was in a side-lying position with the legs extended, resting on the lower forearm with the elbow flexed to 90°. The upper arm was crossed over the chest. The examiner stood in front of the participant and asked him or her to lift the hip off the plinth, holding the elevated position in a straight line while resting on the flexed elbow. When the participant lost the position, the test was stopped and the achieved time was recorded.

Loss of the position was confirmed by observing the participant. Each test was repeated three times, and the average time was recorded.[28,29] The test was performed separately for the right and left sides. The endurance tests were performed in a random manner. There was a 10-minute rest between trials.

To investigate the isometric strength of core muscles, the participant sat on an adjustable chair while the hip and knee joints were at 90° of flexion and the soles were in contact with the ground. The thighs were fixed to the chair via straps. The strength of the trunk flexors, extensors, and lateral flexors was measured using a dynamometer (MIE Medical Research Ltd, Leeds, UK). The dynamometer was calibrated initially. To evaluate the trunk flexors, the padded sling of the dynamometer was fixed 1 inch below the xiphoid process. The lateral flexors were evaluated while the padded sling was fixed on the midclavicular line at the xiphoid level. For the extension test, the padded sling was fixed on the ninth thoracic vertebra. Each isometric contraction was maintained for 5 seconds. Each trial was randomly repeated three times, with a 1-minute rest between trials. The maximum exhibited number was recorded in each trial, as was the average of the three trials.

Data were analyzed using SPSS for Windows version 16.0 (SPSS Inc, Chicago, IL). Descriptive statistics were used for reporting means and standard deviations (SDs) of the variables. The normal distribution of data was confirmed using the Kolmogorov-Smirnov test. The endurance and strength of the core muscles were compared between the groups using the independent-samples t test. The Pearson correlation coefficient was calculated to evaluate the correlation between strength and endurance variables and EDSS scores. Statistical significance was set at $P < .05$.

Results

Thirty-three patients diagnosed as having MS and 33 healthy people as a control group participated in the study. Two participants in the control group were reluctant to perform the tests, so the data from 31 control participants were analyzed. The mean ± SD time from the diagnosis of MS was 90 ± 5 months (range, 12–216 months). Demographic data for the participants are summarized in Table 1. There were no statistically significant differences between the groups at baseline.

The endurance of core muscles was determined using the Sorenson test, the flexor endurance test, and the lateral bridge endurance test. There was a statistically significant difference between the groups in all the applied tests; patients with MS had a lower time average on all the tests (Table 2).

The mean strength of the flexors, extensors, and lateral trunk flexors is summarized in Table 3. The strength of all the evaluated muscle groups was significantly lower in the MS group compared with the control group.

To evaluate the correlation between EDSS scores and strength and endurance variables, the Pearson correlation coefficient was calculated (Table 4). None of the

Table 1. Demographic data comparing the MS and control groups (N = 64)

Characteristic	MS group (n = 33)	Control group (n = 31)	*P* value
Age, mean ± SD, y	36.30 ± 8.11	35.54 ± 9.85	.73
BMI, mean ± SD	22.5 ± 1.36	22.41 ± 1.62	.80
EDSS score, mean ± SD	1.09 ± 0.23	—	—
Sex, F/M, No.	28/5	26/5	.66

Abbreviations: BMI, body mass index; EDSS, Expanded Disability Status Scale; MS, multiple sclerosis; SD, standard deviation.

Table 2. Endurance test results comparing the MS and control groups

Endurance test	Group	Test result, mean ± SD, s	95% CI of difference	*P* value
Sorenson	MS	51.57 ± 61.74	−99.12 to −33.59	.001
	Control	117.93 ± 69.32		
Flexor endurance	MS	59.42 ± 70.54	−324.65 to −86.17	.001
	Control	264.84 ± 318.97		
Left lateral bridge	MS	10.18 ± 10.27	−61.15 to −18.61	.001
	Control	50.06 ± 57.25		
Right lateral bridge	MS	6.78 ± 6.49	−91.90 to −26.13	.001
	Control	65.80 ± 89.49		

Abbreviations: CI, confidence interval; MS, multiple sclerosis; SD, standard deviation.

Table 3. Core muscle strength comparing the MS and control groups

Strength test	Group	Strength value, mean ± SD	95% CI of difference	*P* value
Extensor muscles, N	MS	214.05 ± 89.72	−101.35 to −2.27	.04[a]
	Control	265.87 ± 108.10		
Flexor muscles, N	MS	180.60 ± 50.34	−85.76 to −14.47	.007[a]
	Control	230.70 ± 85.79		
Left lateral flexor muscles, s	MS	161.68 ± 49.77	−70.88 to −13.63	.005[a]
	Control	203.94 ± 64.27		
Right lateral flexor muscles, s	MS	170.92 ± 59.33	−70.66 to −1.54	.04[a]
	Control	207.03 ± 78.20		

Abbreviations: CI, confidence interval; MS, multiple sclerosis; SD, standard deviation.
[a]Statistically significant.

***Table 4.* Pearson correlation coefficients between EDSS scores and strength and endurance variables**

Variable	Test	EDSS score	*P* value
Strength, N	Flexor	−0.12	.48
	Extensor	0.04	.80
	Left lat flx	−0.13	.44
	Right lat flx	−0.23	.18
Endurance, s	Sorenson	−0.21	.22
	Left Plunk	−0.13	.45
	Right Plunk	−0.25	.15
	Flx	−0.26	.13

Abbreviations: EDSS, Expanded Disability Status Scale; Flx, flexion; Lat flx, lateral flexor.

strength and endurance variables had a meaningful correlation with EDSS scores.

Discussion

The present results revealed that patients with MS had significantly lower performance in endurance and strength tests of core muscles compared with a matched control group. To our knowledge, this was the first study comparing the endurance and strength of core muscles in patients with MS and a healthy group.

Patients with MS had a lower ability to maintain all the endurance test positions. Reduced endurance in patients with MS can be attributed to conversion of type I (slow) muscle fibers to type II (fast) fibers.[30,31] Slow fibers have less fatigability compared with fast fibers.[30] Biomechanical investigations have revealed no change in passive mechanical properties of muscles in patients with MS[32]; therefore, observed changes might be attributed to contractile elements of muscle tissue. Kent-Braun and colleagues[33] attributed the lower function of patients with MS to deconditioning of muscle fibers, which has an important role in intramuscular functions. They suggested that the characteristics of individual muscle fibers and skeletal muscles had changed in patients with MS.[33]

Core muscles were weaker in patients with MS compared with a matched control group. Reduced performance in both endurance and strength tests might be attributed to fiber-type shifts similar to what happens in reduced activity.[34] The percentage of type I muscle fibers decreased from 76% to 65%.[34] The altered peripheral function in patients with MS may be due to not only long-term changes in central drive but also chronically decreased muscle activity.[35]

Biopsy of the tibialis anterior muscle confirmed a decline in the number and size of type I muscle fibers in patients with MS compared with a healthy group, which accounted for smaller muscle size and anaerobic consumption of energy.[33] Garner and Widrick[36] attributed reduced generated muscle force in patients with MS to physiologic alterations in type I and IIa muscle fibers. They claimed that the number of cross-bridge cycles decreased during muscle contraction in patients with MS, which may account for muscle weakness and fatigability.[36] Ng and coworkers[35] compared voluntary and electrically stimulated isometric contractions from the ankle dorsiflexor muscles between a group of patients with MS and a control group. Considering similar muscle fat-free cross-sectional area and electrically stimulated force, maximal voluntary contraction was 27% lower in patients with MS. They recommended that the lower electrical-induced contraction in patients with MS might be due to central nervous system impairments rather than peripheral dysfunction.[35]

Reduced strength and endurance of core muscles in patients with MS may be related to fatigue.[37,38] Individuals with MS were weaker than matched controls, which suggested that there was a reduced ability to activate muscle mass in MS or that the muscle mass of patients with MS had lower quality (ie, reduced force per unit of muscle mass) than that of controls.[38]

In this study, we did not find any correlation between EDSS scores and core muscle strength and endurance. Because EDSS scores showed little variability in the present study, we cannot make claims about the lack of correlation between EDSS scores and core strength and endurance. Future studies considering variable EDSS scores are warranted to precisely evaluate the correlation between these variables.

The main clinical point of this study was that it was the first to show that core muscles were significantly weaker in a group of ambulatory patients with MS compared with a healthy group. The fact that core muscle impairment was observed in patients with MS with low neurologic disability suggests that this problem may

PracticePoints

- Core muscle strength and stability are important for balance, yet these parameters have not been precisely studied in patients with MS.
- Patients with MS and a mean ± SD Expanded Disability Status Scale score of 1.09 ± 0.23 exhibited lower performance on tests of endurance and strength of core muscles compared with a matched group of healthy individuals.

occur early in the course of the disease. This study had some limitations. First, it can be expanded to a limited group of patients with MS with EDSS scores of approximately 1. The relevance of the findings of this study needs to be further confirmed using other EDSS scores. The second limitation was the lack of consideration of some variables that might have contaminated the results, eg, the cognitive status of the participants. We were not sure whether all the participants tried their best during maximal isometric voluntary contraction. This study paved the way for future studies to evaluate the effects of core stabilization exercises or other rehabilitation techniques on balance improvements in patients with MS.

In conclusion, ambulatory patients with MS with low EDSS scores had appreciably lower performance on endurance and strength tests of core muscles compared with a matched control group. □

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