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Do The Core Stability and Position Sense of Trunk Affect Balance in Patients with Multiple Sclerosis?

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ABSTRACT

Objective: The trunk is known to be the most important key point where sensory inputs are received and motor responses occur, necessary for the maintenance of balance and postural control. The aims of the present study were to investigate the relationship between balance with core stability and position sense of trunk in patients with Multiple Sclerosis (PwMS) and to compare core stability, position sense of trunk and balance in PwMS and healthy controls.

Methods: The study was completed with 45 PwMS and 29 healthy controls with matching age and gender. Balance was assessed with Postural Stability Test (PST) and Modified Sensory Organization Test (MSOT) by using Biodex Balance System®. Core stability was evaluated with core endurance tests according to McGill procedure. Position sense of trunk was evaluated with the lumbosacral (LS) reposition tests by using Dualer IQTM digital inclinometer.

Results: PST, MSOT and LS repositioning tests scores were higher ($p<0.001$) and the trunk flexor, extensor, right and left lateral endurance tests scores were lower ($p<0.001$) in PwMS compared to healthy controls. PST and MSOT were found to be correlated with core endurance tests scores (r_s=-0.406/-0.602, $p<0.05$) and LS reposition test scores (r_s= 0.357/0.510, $p<0.05$) in PwMS.

Conclusion: This study suggested that core stability and position sense of trunk were affected and caused imbalance in PwMS. Therefore, clinicians should consider assessments and interventions directed at decreased core stability and trunk position sense in PwMS.

Keywords: Balance, core stability, multiple sclerosis, position sense of trunk

1. INTRODUCTION

The trunk is one of the most important key points responsible for balance. The trunk plays an important role in the organization of postural reactions (1,2). Optimal postural control of the trunk relies on intact motor, somatosensory, musculoskeletal systems, which are frequently compromised in patients with Multiple Sclerosis (PwMS) (3). Trunk control, affects standing and sitting, and is necessary to maintain body position, to remain stable when the position changes, and for the mobility function (4).

Postural control of the trunk is mainly achieved by the activation of core stability muscles. The core stability, which is formed by the power, strength, and endurance of the core muscles, is shown as the most important factor that ensures the balance of the individual in different conditions and environments during functional activities (1,5,6). Hodges and Richardson (5) reported that core muscles are activated as anticipatory before the movement begins, in order to maintain balance. Impaired core muscle activation, decreased postural control, less effective anticipatory postural adjustments, and increased reliance on compensatory postural adjustments have been indicated in PwMS (7,8).

In recent years, it has been seen that core stability trainings in patients with MS have begun to be included in physiotherapy programs, based on the knowledge that core stability is important in the development of postural control and balance. (9-12). However, there is only one study examining the relationship between core stability and balance in PwMS (13). In this study, core stability was evaluated with core endurance tests, one of its sub-parameters, and it was stated that there is a relationship between core endurance and postural control, but additional studies are needed.

Although core stability is an important motor component of balance, it is not the only factor in maintaining balance. Sensation, which is the first step in the formation of motor responses and in the formation of corrective orders by controlling the responses for the continuation of balance, is often overlooked. Perceiving sensations from the body and

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the environment and creating balanced responses suitable for the task is possible with sufficient sensory input from the somatosensory, vestibular and visual systems (14,15). In particular, the importance of the proprioceptive sense in maintaining balance is known (14,16). Like core stability, position sense of trunk, a sub parameter of proprioception, is also a significant component of trunk stability. Trunk musculature provides some core stability; however, the trunk cannot be stable without adequate position sense. Finally, we can say that trunk stability requires appropriate neural control and muscle strength as well as adequate sense of position to provide a stable foundation for movement (17-19). Additionally, we thought that the loss of sensation in the core region might affect the activity levels of the core muscles. Therefore, we also wonder about the relationship between balance and position sense of trunk. Previous studies examined the relationship between balance and position sense of trunk in patients with stroke, elderly persons, patients with ataxia, and patients with low back pain (20-23). These researches are important in terms of showing the relationship between balance disorders with the loss of position sense of trunk. However, there are no studies showing the relationship between balance and position sense of trunk in PwMS.

Therefore, the primary purpose of the study was to investigate the relationship between balance with core stability and position sense of trunk in PwMS. The secondary purpose was to compare core stability, position sense of trunk, and balance in PwMS and healthy controls.

2. METHODS

2.1. Participants

Ethical approval of the study was obtained from Gazi University Clinical Research Ethics Committee (Approval Date: 25.04.2016/Decision number: 228). Fifty PwMS with a clinically definitive diagnosis of MS by a neurologist were referred from the University Hospital, Neurology Department to Physiotherapy and Rehabilitation Department. The inclusion criteria for PwMS were being 18 to 65 years of age, 1-4 points on the Expanded Disability Status Scale (EDSS) (24), walking independently, and being a volunteer to participate in research. The exclusion criteria for PwMS were history of a MS attack in the previous 3 months, having circulatory system problems which causes muscle weakness or decrease of sense, orthopedic problems, visual impairment, pain in the ankle, knee, hip or spine, and having a score of 24 points from the Standardized Mini Mental Test (25). Additionally, 30 healthy controls were recruited from a local community center as control group through poster advertising. The inclusion criteria for healthy controls were being a volunteer to participate in research and being 18 to 65 years of age. The exclusion criterion for healthy controls was having neurological, orthopedic, circulatory, or visual problems, which may cause balance disorder, pain and biomechanical limitations in spine, hip, knee, and ankle. The study protocol was registered at ClinicalTrials.gov (NCT03566251). The study was conducted according to the Helsinki Declaration.

2.2. Procedure

The level of disability was assessed by a neurologist using the EDSS. Mental status was evaluated by the same neurologist using the MMSE. Characteristics of participants and duration of the disease were recorded. Between the measurements, 2-minute rest periods were given.

2.3. Outcome Measures

Measurements were performed with the following sequence.

2.3.1. Balance

Balance was assessed using Biodex Balance System® (Biodex®, Inc., Shirley, NY, USA), which is a reliable measure for assessing balance, by Postural Stability Test (PST) and Modified Sensory Organization Test (MSOT) (26).

2.3.1.1. PST: With this test, the static balance of the patient while standing is evaluated by the ability to keep the gravity center on the support surface. The test was performed on the right and left one foot, on a firm surface and with the eyes open. During the test, the patients are asked to keep the black dot they see on the screen in the middle of the target throughout the test. The tests were applied for 10 seconds, and a rest period of 10 seconds was given. As a result of the tests, the overall postural stability index score was obtained. Low scores indicated better performance.

2.3.1.2. MSOT: MSOT evaluates the effects of vestibular, visual, and somatosensory senses on balance during the standing position. It assesses the sensory component of balance on two different support surfaces and in two different visual conditions; condition 1: firm surface-eyes open, condition 2: firm surface-eyes closed, condition 3: foam surface-eyes open, and condition 4: foam surface-eyes closed. During all tests, patients were asked to stand as still as possible. All conditions were performed two times for 30 seconds and 30-second rest period was given between tests. At the end of the tests, sway index scores were obtained for each condition. Low scores indicated better performance (27,28).

2.3.2. Core stability

Core stability was evaluated with core endurance tests according to McGill procedure. The core endurance tests evaluated are trunk flexor test, trunk extensor test, and the left and right trunk lateral endurance tests. The purpose of core endurance tests is to maintain a static position for as long as possible. A stopwatch was used during the assessments, and the scores were recorded in seconds. One practice trial was performed, then each test was performed twice, and the best measurement score was recorded.

In order to avoid the effects of fatigue, the practical trial test was applied for a maximum of 5 seconds (29,30) (Figure 1).

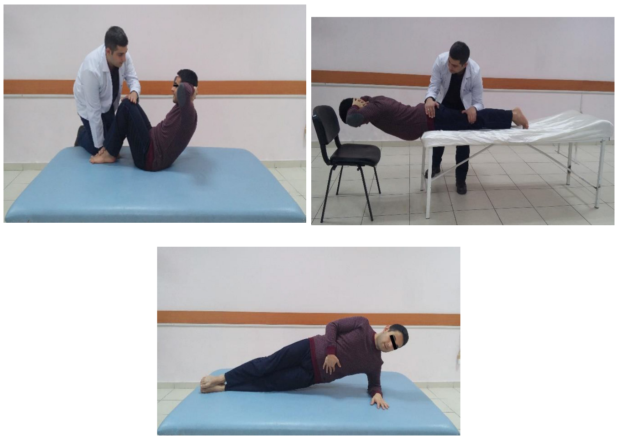

Figure 1. *The core stability tests.*

2.3.2.1. Trunk flexor test: The hips and knees were at 90º flexion position, the trunk was at 60º flexion, the feet were fixed, and the arms were bended across the chest with the hands placed on the opposite shoulder. The trunk support was removed, and the participants were asked to maintain their positions for as long as possible. The test was terminated as soon as the patients could not maintain their positions.

2.3.2.2. Trunk extensor test: The participants were positioned on the treatment table in the prone position with the hips, pelvis, and knees fixed. The upper extremities and trunk were supported by a chair at the same height as the treatment table. The chair support removed, and the patients maintained the horizontal body position as much as possible by crossing the arms behind the neck. The test was terminated as soon as the patients could not maintain their horizontal positions.

2.3.2.3. Trunk lateral endurance test: The participants were positioned in the side-lying position to make the elbow at 90º flexion position, forearm on treatment table, the lower arm in vertical position on the ground, the top arm bended across the chest with the hand placed on the opposite shoulder, the top foot in front of the lower foot and lower extremities in extension on the treatment table. The test was terminated as soon as the patients could not maintain their positions, or when the pelvis and hips returned to the mat. The test was evaluated both on the left and right sides. The test was terminated as soon as the patients could not maintain side-lying position.

2.3.3. Position sense of trunk

Position sense of trunk was assessed with the lumbosacral (LS) reposition tests by using Dualer IQ™ digital inclinometer (JTECH Medical Salt Lake City, UT, USA) (31). The tests were performed under three different visual-surface conditions while standing: 1; eyes open-firm surface, 2; eyes closed-firm surface, 3; eyes open-foam surface. The density of the foam surface was 44.85 kg/m^3. Participants placed the trunk in a 30° flexion position in the sagittal plane and held the position for 3 seconds (position 1) (Figure 2). The three seconds given for patients to describe the position are long enough, but not long enough to cause fatigue during testing and trial (32). After returning to the starting position, the patients were asked to repeat the previously attained angle. The patients verbally expressed when they felt that they had reached the angle and maintained their position (position 2) (Figure 2). The angular degree difference between the position 1 and position 2 was defined as the degree of trunk repositioning error (TRE). TRE is a reliable and valid method for measuring sense of trunk position. All conditions were performed five times. The lowest and highest scores were discarded for each condition, and the average of the remaining three scores was recorded as the TRE score. (22,31,33).

Figure 2. *The lumbosacral reposition test.*

2.4. Statistical Analysis

G*Power software package (G*Power, Version 3.0.10, Franz Faul, Universität Kiel, German) was used to calculate the sample size required for the study. According to the flexor endurance test scores of the study, it was calculated that 38 patients with MS were needed to obtain 90% power with α = 0.05 type I error, and β = 0.10 type II error (34). For statistical analyses, SPSS 15.0 (SPSS Inc., Chicago, USA) was used. Data normality was tested using the Kolmogorov–Smirnov test. Data were expressed as means (±SD) and medians (IQR 25-75). Demographic data of patients with MS and healthy participants were compared using an Independent Sample T Test. A Mann Whitney U Test and an Independent Sample T Test and were used to compare the assessment results of the patients with MS and healthy controls. A Spearman and Pearson correlation analyses were used to determine the relationship between the variables in PwMS. Statistical significance was set at alpha <0.05.

3. RESULTS

Fifty PwMS were screened for the study; 5 cases were excluded, 2 of whom did not want to participate in the study and 3 of whom did not meet the inclusion criteria. Thirty healthy volunteers were screened for the study; 1 of whom did not meet the inclusion criteria.

Demographic and disease characteristics of persons were given Table 1. There was no difference between groups regarding demographic characteristics including age, gender, and BMI (p>0.05, Table 1).

Postural sway was found to be increased according to PST and MSOT when PwMS were compared with healthy controls (p<0.001, Table 2). The trunk flexor, extensor, right and left trunk lateral endurance test scores were lower in PwMS compared to healthy controls (p<0.001, Table 2). In addition, the LS repositioning test error degree was higher in PwMS compared to healthy controls (p<0.001, Table 2).

Core endurance test scores were found to be correlated with PST-right, PST-left, MSOT-Condition 1, MSOT-Condition 2, MSOT-Condition 3, and MSOT-Condition 4 in PwMS (p<0.05) (Table 3). Similarly, LS reposition test scores were shown to correlate with PST-right, PST-left, MSOT-Condition 1, MSOT-Condition 2, MSOT-Condition 3, and MSOT-Condition 4 in PwMS (p<0.05) (Table 4).

Table 1. *Demographic and clinical characteristics of the multiple sclerosis patients and healthy controls.*

Characteristics	MS Group	Control group	p
Age, years (X ± SD)	36.71 ± 9.16	35.66 ± 9.60	0.556
Gender, female/male n (%)	34 (75.6)/11 (24.4)	21 (72.4)/8 (27.6)	0.763
BMI, kg/m^2 (X ± SD)	24.82 ± 4.03	23.93 ± 3.54	0.275
EDSS, score (X ± SD)	2.12 ± 1.07	-	-
Duration of illness, years (Median (IQR)	4 (3-7)	-	-

p>0.05; MS: Multiple Sclerosis; BMI = Body Mass Index; EDSS: Expanded Disability Status Scale.

Table 2. *Comparison of balance, core stability and trunk position sense test results of multiple sclerosis patients and healthy controls.*

		MS Group		Control Group		
		Median (IQR)	Minimum-Maximum	Median (IQR)	Minimum-Maximum	p
Balance Tests						
Postural Stability Tests (point)	Right	0.80 (0.60-2.00)	0.30-4.00	0.50 (0.40-0.60)	0.30-0.70	**<0.001**
	Left	0.90 (0.60-1.70)	0.30-4.00	0.50 (0.40-0.50)	0.20-1.10	**<0.001**
Modified Sensory Organization Test (point)	Condition 1	0.48 (0.36-0.66)	0.17-2.77	0.30 (0.27-0.44)	0.19-0.60	**<0.001**
	Condition 2	0.89 (0.76-1.51)	0.44-2.91	0.59 (0.38-0.76)	0.21-1.54	**<0.001**
	Condition 3	0.95 (0.75-1.38)	0.43-2.65	0.59 (0.50-0.70)	0.35-1.02	**<0.001**
	Condition 4	2.90 (2.06-3.34)	1.18-5.32	1.63 (1.42-1.87)	1.01-2.28	**<0.001**
Core Endurance Tests (s)						
Trunk Flexor Test		17.52 (6.76-29.63)	0.73-86.25	44.04 (29.00-56.50)	20.00-93.11	**<0.001**
Trunk Extensor Test		24.24 (16.04-44.26)	6.29-72.46	59.77 (49.50-66.99)	30.00-110.29	**<0.001**
Trunk Lateral Endurance Tests	Right	13.51 (5.69-22.56)	0.69-55.31	34.57 (29.19-60.86)	7.06-121.06	**<0.001**
	Left	11.77 (7.30-28.81)	0.00-59.30	37.55 (24.73-61.23)	11.61-90.16	**<0.001**
		X ± SD	**95% CI**	**X ± SD**	**95% CI**	**p**
Trunk Reposition Test						
Lumbosacral Reposition Tests (degree)	Condition 1	3.57 ± 1.36	3.17-3.98	1.87 ± 0.93	1.51-2.24	**<0.001**
	Condition 2	3.70 ± 1.25	3.32-4.08	2.03 ± 0.74	1.71-2.26	**<0.001**
	Condition 3	3.83 ± 1.17	3.47-4.18	2.21 ± 1.05	1.81-2.64	**<0.001**

p<0.05; Condition 1: Eyes open-firm surface; Condition 2: Eyes closed-firm surface; Condition 3: Eyes open-foam surface; Condition 4: Eyes closed-foam surface; CI: Confidence Interval

Table 3. *The investigation of the relationship between balance and core stability in patients with multiple sclerosis.*

		Core Endurance							
		Trunk Flexor Test		Trunk Extensor Test		Tunk Lateral Endurance Tests			
						Right		Left	
		r	p	r	p	r	p	r	p
PST	Right	-0.536	**<0.001**	-0.456	**0.002**	-0.518	**<0.001**	-0.463	**0.001**
	Left	-0.584	**<0.001**	-0.406	**0.006**	-0.502	**<0.001**	-0.500	**<0.001**
MSOT	Condition 1	-0.574	**<0.001**	-0.538	**<0.001**	-0.552	**<0.001**	-0.482	**<0.001**
	Condition 2	-0.447	**<0.001**	-0.421	**0.001**	-0.437	**<0.001**	-0.429	**<0.001**
	Condition 3	-0.562	**<0.001**	-0.538	**<0.001**	-0.536	**<0.001**	-0.465	**<0.001**
	Condition 4	-0.572	**<0.001**	-0.542	**<0.001**	-0.602	**<0.001**	-0.584	**<0.001**

p<0.05; PST: Postural Stability Test; MSOT: Modified Sensory Organization Test; Condition 1: Eyes open-firm surface; Condition 2: Eyes closed-firm surface; Condition 3: Eyes open-foam surface; Condition 4: Eyes closed-foam surface.

Table 4. *The investigation of the relationship between balance and trunk position sense in patients with multiple sclerosis.*

		Lumbosacral Reposition Test					
		Condition 1		Condition 2		Condition 3	
		r	p	r	p	r	p
PST	Right	0.508	**<0.001**	0.500	**<0.001**	0.404	**<0.001**
	Left	0.440	**<0.001**	0.510	**<0.001**	0.406	**<0.001**
MSOT	Condition 1	0.375	**0.002**	0.357	**0.004**	0.362	**0.003**
	Condition 2	0.386	**0.002**	0.368	**0.003**	0.429	**<0.001**
	Condition 3	0.406	**0.001**	0.417	**0.001**	0.448	**<0.001**
	Condition 4	0.458	**<0.001**	0.450	**<0.001**	0.400	**0.001**

p<0.05; PST: Postural Stability Test; MSOT: Modified Sensory Organization Test; Condition 1: Eyes open-firm surface; Condition 2: Eyes closed-firm surface; Condition 3: Eyes open-foam surface; Condition 4: Eyes closed-foam surface.

4. DISCUSSION

This study shows that core stability, position sense of trunk and balance are affected in PwMS compared to healthy controls. In addition, it indicates a relationship between imbalance and insufficient core stability and position sense of trunk in PwMS.

Patients with MS were found to have less core endurance in comparison to healthy controls in our study. Yoosefinejad et al (35) showed that core endurance decreased in PwMS with EDSS between 1.0 and 4.5, and also proposed that it was necessary to examine the relationship between balance and core endurance in PwMS. In our study, the relationship between core endurance and balance suggests that as the core endurance decreases, postural sway increases in PwMS. The decrease in core endurance seems to be a disadvantage when balance is maintained. Hodges and Richardson (5) reported that the first active muscles are transversus abdominus, internal-external oblique, rectus abdominus and lumbar multifidus muscles with lower limb movements in healthy people. They stated that this sequential contraction of core muscles reduced the perturbations caused by lower extremity movements and thus maintained postural control and balance. This study is important in terms of showing the importance of core muscles in maintaining balance. There is only one study examining the relationship between core endurance and balance in PwMS in the literature. Freund et al (13) showed that isometric flexion endurance of trunk was correlated with several measures of postural control, and isometric extension endurance of trunk was correlated with only one postural control parameter in PwMS. We also evaluated the right and left trunk lateral endurance tests in our study and we found all components of core endurance associated with balance.

Although studies examining the relationship between core stability and balance in PwMS are insufficient, there are studies showing that core muscle strength, core endurance and balance improve at the end of core stability-based training (9, 10, 12). The case series study by Freeman et al (10) demonstrated improvement in balance in ambulatory PwMS following eight weeks of individualized core stability training. Arntzen et al. reported that core stability training for 6 weeks improved trunk control and balance in the long and short terms compared to standard care in PwMS (9). Bulguroglu et al (12) showed that core stability based instrumented and mat Pilates were improved core muscle strenth, core endurance and balance in PwMS. These studies showed that balance and trunk could affect each other in PwMS. Although these studies are training studies, it is important to show that the balance is related with trunk performance in PwMS.

Patients with MS were found to have decreased position sense of trunk in comparison to healthy controls in our study. The decrease in position sense of trunk was found to be associated with balance impairment. This study is the first to show that position sense of trunk of PwMS is less in comparison to healthy controls, and the position sense of trunk is related to the balance in PwMS. The relationship between PST and lumbosacral reposition tests is important in terms of demonstrating the importance of position sense of trunk in maintaining balance in PwMS. In addition, the relationship between MSOT and lumbosacral reposition tests shows that position sense of trunk is important in maintaining balance whenever proprioceptive, visual, and vestibular senses are used together and these senses are reduced separately in PwMS. Previous studies examined the relationship between balance and position sense of trunk in patients with stroke, patients with ataxia, elderly persons, and patients with low back pain (20-23). Ryerson et al (20) reported that position sense of trunk was less in patients with stroke compared to the non-neurologically impaired subjects, and position sense of trunk is associated with balance in patients with stroke. Onursal Kılınç et al (21) indicated that position sense of trunk was less in patients with ataxia in comparison to healthy people, and position sense of trunk was associated with postural control in patients with ataxia. Goldberg et al (22) indicated that position sense of trunk was less in balance-impaired older adults in comparison to young adults and unimpaired older adults. Additionally, they reported that position sense of trunk was correlated with balance in balance-impaired older adults. Radebold et al (23) indicated that when the proprioceptive sense was reduced, the activation of trunk muscles was delayed, and postural control was disturbed in lumbar spine in patients with low back pain. Similar to these studies, position sense of trunk was associated with balance in the present study. This suggested that loss of position sense of trunk reflected balance impairments in PwMS.

The inclusion of only mild to moderate PwMS could be a limitation of this study. As the disease progresses, both the endurance and strength of the core muscles and the position sense of trunk may decrease with the increase of central nervous system involvement. This will cause limitations in all daily life activities related to balance. Therefore, evaluation and training of core stability and position sense of trunk should be kept in mind in PwMS with advanced EDSS level.

5. CONCLUSION

Balance, core stability and position sense of trunk were affected in PwMS in comparison to healthy controls, and balance was related to core stability and position sense of trunk in PwMS. These results suggest that approaches to improve core stability and position sense of trunk should be included in rehabilitation programs for improving balance in PwMS.

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Author Contributions:

Research idea: TO, AGG, FS

Design of the study: TO, AGG

Acquisition of data for the study: TO, AGG, CO, YA, KE, Cİ

Analysis of data for the study: TO, AGG, CO, YA, KE, Cİ

Interpretation of data for the study: TO, AGG, FS, CO, YA, KE, Cİ

Drafting the manuscript: TO, AGG

Revising it critically for important intellectual content: TO, AGG

Final approval of the version to be published: TO, AGG, FS

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