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Original Research

Investigation of the Relationship between Disability Level and Core Stability in Patients with Multiple Sclerosis

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Abstract

Objectives: Optimal core stability relies on somatosensory, motor and musculoskeletal systems that are often compromised with the progression of the disability level in the Multiple Sclerosis (MS) population. The aim of this study was to investigate the relationship between disability level and core stability in patients with MS.
Materials and Methods: Thirty-seven MS patients (26 female and 11 male) with mild to moderate disability were included in the study. Kurtzke Expanded Disability Status Scale (EDSS) was used to evaluate the level of disability of patients with MS. Core endurance tests including the flexion endurance test, extension endurance test, right and left side bridge tests and core power tests including the sit-ups test and modified push-ups test were evaluated.
Results: When the relationship between disability level and core stability was examined in patients with MS, it was seen that the EDSS was modaretely and negatively correlated with flexion endurance test, modified Biering-Sorensen test, right and left side bridge tests, sit-ups test and modified push-ups test (r=-0.572, r=-0.445, r=-0.585, r=-0.653, r=-0.571, r=-0.532 respectively; $p<0.05$).
Conclusion: Disability level was associated with core endurance and core power, which are the sub-parameters of core stability in patients with MS. Therefore, clinicians should consider evaluation directed at core endurance and core power in MS patients with mild to moderate disability.

Keywords: *Multiple Sclerosis, disability, core enduranc, core power*

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Introduction

Multiple Sclerosis (MS) is a chronic, demyelinating and inflammatory disease of the central nervous system (CNS) and is characterized by clinical symptoms arising from lesions in the spinal cord, brain or optic nerve (Abdel et al., 2015; Cameron and Nilsagard, 2018). These lesions accumulate over time and occur in different areas of the central nervous system causing symptoms. Depending on these symptoms, the level of neurological impairment and disability increases, activities of daily life decrease and quality of life deteriorates in patients with MS (Cameron and Nilsagard, 2018; Confavreux, Vukusic, Moreau and Adeleine, 2000).

Expanded Disability Status Scale (EDSS) is one of the most comprehensive clinical rating scales used in the evaluation of disability and neurological disorder in patients with MS. This scoring system could be stratified patient's functional status such as the function of pyramidal, brainstem, cerebellar, sensory, bowel/bladder, visual and cerebral (Kurtzke, 1983). Balance, walking, mobility and muscle strength are the basic components of EDSS. As the EDSS score increases, balance, mobility and walking disorders increase and muscle strength decreases in patients with MS (Bertoni, Lamers, Chen, Feys and Cattaneo, 2015; Fjeldstad, Pardo, Bemben and Bemben, 2015; Sosnoff et al., 2011).

Core stability, which is formed by the endurance, power and strength of core muscles, is shown among the most important factors that ensure the balance, walking and muscle strength of the individual in different environments and conditions during functional activities (Arntzen et al., 2019; Arntzen, Straume, Odeh, Feys and Normann, 2020; Bertoni, Lamers, Chen, Feys and Cattaneo, 2015; Fjeldstad, Pardo, Bemben and Bemben, 2015; Hodges and Richardson, 1997a; Preuss and Fung, 2008). Core stability, which is called trunk control and defined as the ability to control the movement and position of the trunk on the leg and pelvis, decreases in patients with MS (Kibler, Press and Sciascia, 2006; Preuss and Fung, 2008; Yoosefinejad, Motealleh, Khademi and Hosseini, 2017). Optimal trunk control relies on musculoskeletal, motor and somatosensory systems that are often compromised in patients with MS (Cameron and Lord, 2010). Trunk control is achieved through compensatory postural adjustments and anticipatory postural adjustments. Less effective anticipatory postural adjustments, increased reliance on compensatory postural adjustments and impaired core muscle activation have been reported in patients with MS (Krishnan, Kanekar and Aruin, 2012a; Krishnan, Kanekar and Aruin, 2012b).

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It is showed that core stability affects many parameters such as balance, mobility, walking and muscle strength which contribute to neurological impairment and disability level (Cameron and Lord, 2010; Comber, Sosnoff, Galvin and Coote, 2018; Freund, Stetts and Vallabhajosula, 2016; Kalron and Givon, 2016; Karatas, Çetin, Bayramoglu and Dilek, 2004; Willson, Dougherty, Ireland and Davis, 2005). However, there are no studies showing the relationship between disability level and core stability in patients with MS. Therefore, the purpose of this study was to investigate the relationship between disability level and core stability in patients with MS.

Materials And Methods

Study Design

This study was carried out in Gazi University Faculty of Health Sciences Department of Physiotherapy and Rehabilitation between April 2021 and May 2021. Ethical permission was obtained from the Ankara Yıldırım Beyazıt University Ethics Committee with the decision number of 43 on 16/04/2021 for the study. The study was carried out in accordance with the principles defined in the Helsinki Declaration. Individuals were informed about the study, and each participant signed an informed consent.

Participants

The inclusion criteria were as follows: Participants with confirmed diagnosis of clinically definite MS, EDSS range of 0.5-4.5 who are able to gait independently. The exclusion criteria were: Patients with acute attacks (three months before the study), circulatory system and orthopedic problems, vision problems, pain in the ankle, knee, ankle or spine which causes muscle weakness or decrease of sense and a Mini-Mental State Examination Test score of less than 25 points (Folstein, Folstein and McHugh, 1975).

Procedure

Participants' characteristics and duration of the disease were recorded. All assessments were performed by the same physiotherapist. (TO). Between the measurements, 2-minute rest periods were given.

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Outcome Measures

Disability level

Expanded Disability Status Scale (EDSS) was used to evaluate the disability level of patients with MS. The scale consists of two parts that evaluate functional systems (pyramidal, sensory, visual, brainstem, cerebellar, bowel, bladder, cerebral or other) and the mobility level with these systems. Functional systems are graded from 0 (no disability) to 5 or 6 (serious disability). The second part is scored between 0 (normal neurological examination) and 10 (death) based on the individual's functional system scores and walking distance. The level of disability increases with the increase of the test score (Kurtzke, 1983).

Core stability

Core stability was evaluated separately with core endurance and core power tests.

Core endurance

Core endurance was evaluated with the flexion endurance test, modified Biering-Sorensen test, and left and right side bridge tests according to McGill’s procedure. The purpose of the core endurance tests was to hold a static position as long as possible. For the measurements, a stopwatch was used and the results were recorded in seconds. All tests were performed twice, and the best measurement result was recorded after one practice trial. To avoid fatigue effect, participants practiced each body positions for a maximum of 5 seconds to avoid fatigue effects. The results from previous studies indicate that four core endurance tests have excellent reliability coefficients: the flexion and extension endurance test intraclass correlation coefficient (ICC) = 0.97, and the left and right side bridge tests (Lateral-l/Lateral-r) ICC = 0.99 (McGill, Childs and Liebenson, 1999).

Flexion endurance test: The participants were positioned withthe trunk at 60º flexion, knees and hips were at 90º flexion position, the arms were bended across the chest with the hands placed on the opposite shoulder, and the feet were fixed. The trunk support was removed, and the participants were asked to maintain their positions as long as possible. The test was terminated as soon as the participants could not maintain their position (Figure 1).

Modified Biering-Sorensen test: The participants were positioned in the prone position with the knees, hip and pelvis fixed on the treatment table. The upper extremities and trunk

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were supported by a chair at the same height as the treatment table. The supperted chair was removed, and the participants maintained the horizontal body position for as long as possible with upper extremities crossed over back of the neck. The test was terminated as soon as the participants could not maintain their position (Figure 1).

Side bridge test: The participants were positioned in the side lying position to make the lower arm in vertical position on the ground, the elbow at 90º flexion position, the forearm on treatment table, the top arm bended across the thorax with the hand placed on the opposite shoulder, lower extremities in extension, and the top foot in front of the lower foot on the treatment table. The test was terminated as soon as the participants could not maintain their position. It was evaluated both on the left and right sides (Figure 1).

Figure 1: The core endurance tests

Core power

Core power was evaluated with sit-ups test and modified push-ups test. The number of times the subject was able to complete each test for 30 seconds was recorded. All tests were

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performed twice, and the best measurement result was recorded after one practice trial (Baltacı, Tunay, Tuncer and Ergun, 2006).

Sit-ups test: While the knees are in the flexion position in the supine position and the feet were fixed by the physiotherapist, individuals were asked to perform trunk flexion (Figure 2).

Modified push-ups test: The patient was positioned in a prone position, hands at shoulder level, elbows in flexion and alongside the trunk. The patient was asked to lift the head, shoulders and trunk from the ground with the elbows in full extension (Figure 2).

Figure 2: The core power tests

Statistical Analysis

The power analysis by using G * Power 3.1 showed that the post-hoc power was 0.80 using a two-tailed correlation test (alpha at 0.05) (Faul, Erdfelder, Lang and Buchner, 2007). For statistical analyses, SPSS 20.0 (SPSS Inc., Chicago, USA) was used. The variables were investigated using analytical (Shapiro-Wilk test) and visual methods (probability plots, histograms) to determine whether they were normally distributed. Data were expressed as means (±SD) or medians (IQR 25-75). To determine the relationship between the variables in patients with MS, spearman correlation analyses were used. Statistical significance was set at alpha <0.05. The results of the correlation analysis were classified as follows: 0.81-1.00 (very good correlation), 0.61-0.80 (good correlation), 0.41-0.60 (moderate correlation), 0.21-0.40 (fair correlation), and 0.00-0.20 (poor correlation) (Altman, Machin, Bryant and Gardner, 2013).

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Results

There were a total of 37 patients in the study, 26 (76.5%) female and 11 (23.5%) male. The demographic characteristics, level of disability, and duration of diagnosis of the participants were given in Table 1.

Table 1: The demographic and clinical characteristics in patients with Multiple Sclerosis

	MS patients n=37
Age, years X ± SD	37.68 ± 8.43
Height, m X ± SD	163 ± 8.36
Body weight, kg X ± SD	66.71± 11.62
BMI, kg/m^2 X ± SD	24.87 ± 3.99
Gender, female/male n (%)	26 (76.5) / 11 (23.5)
Duration of illness, years Median (IQR 25-75)	4 (4-9)
EDSS(0-10), score Median (IQR 25-75)	2 (1-3)
EDSS	**n (%)**
0.5	3 (8.1)
1	8 (21.6)
2	8 (21.6)
2.5	5 (13.5)
3	7 (18.9)
3.5	3 (8.1)
4	3 (8.1)

MS: Multiple Sclerosis; kg: Kilogram; m^2: Square meter; %: Percent; X: Mean; SD: Standard deviation; IQR: Interquartile range; BMI: Body Mass Index; EDSS: Expanded Disability Status Scale.

The results of the core endurance and core power test were as follows: flexion endurance test: 20 (7.23-30.52); modified Biering-Sorensen test: 25.51 (15.71-41.13); side bridge test/right: 15.48 (8.54-27.66); side bridge test/left: 12.75 (7.84-31.52); sit-ups test: 15 (12-19); modified push-ups test: 12 (8-17) (Table 2).

Table 2: Core stability test results of patients with Multiple Sclerosis

Core stability			**MS patients Median (IQR 25-75)**
Core endurance tests	**Flexion endurance test**		20 (7.23-30.52)
	Extension endurance test		25.51 (15.71-41.13)
	Side bridge test	**Right**	15.48 (8.54-27.66)
		Left	12.75 (7.84-31.52)
Core power tests	**Sit-ups test**		15 (12-19)
	Modified push-ups test		12 (8-17)

MS: Multiple Sclerosis; IQR: Interquartile range.

When the relationship between disability level and core stability was examined in patients with MS, it was seen that the EDSS was moderately and negatively correlated with flexion endurance test, extension endurance test, right and left side bridge tests, sit-ups test and modified push-ups test (r=-0.572, r=-0.445, r=-0.585, r=-0.653, r=-0.571, r=-0.532 respectively; $p<0.05$) (Table 3).

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Table 3: Investigation of the relationship between disability level and core stability in patients with Multiple Sclerosis

Core Stability			**EDSS**	
			r	**p**
Core endurance tests	**Flexion endurance test**		-0.572	**<0.001**
	Extension endurance test		-0.445	**0.006**
	Side bridge test	**Right**	-0.585	**<0.001**
		Left	-0.653	**<0.001**
Core power tests	**Sit-ups test**		-0.571	**<0.001**
	Modified push-ups test		-0.532	**0.001**

p<0.05; EDSS: Expanded Disability Status Scale.

Discussion

To the best of our knowledge, this study is the first in this field. Our results show that disability level was associated with core endurance and core power, which are the sub-parameters of core stability, in patients with MS. Disability progression is a prominent feature of MS. Among the symptoms caused by the disease, core stability and balance disturbances, muscular weakness mainly in the lower limbs, and gait disorders stand out because they seem to play a prominent role in patients' loss of functionality (Jørgensen, Dalgas, Wens and Hvid, 2017; Kalron and Achiron, 2013; Kjølhede et al., 2015; Prosperini, Fortuna, Giannì, Leonardi and Pozzilli, 2013). When we examine the studies on core stability in patients with MS, it was indicated that core stability decreased from the early stage of the disease. Yoosefinejad, Motealleh, Khademi and Hosseini (2017) evaluated core stability with core endurance and core strength tests and showed that core endurance and strength decreased in ambulatory MS patients (EDSS mean score: 1.09) compared to healthy individuals (Yoosefinejad, Motealleh, Khademi and Hosseini, 2017). This study is important because it shows that core stability is decreased in MS patients with mild disability. Freund, Stetts and Vallabhajosula (2016) showed that MS patients (EDSS mean score: 4.13) had a comparative lesser performance on both isometric trunk flexion and extension endurance tests compared to healthy individuals which may have functional consequences (Freund, Stetts and Vallabhajosula, 2016). This study is important because it shows that core stability is decreased in MS patients with moderate disability. Lanzetta, Cattaneo, Pellegatta and Cardini (2004) showed that trunk stability decreased during arm movements while sitting in patients with MS compared to healthy individuals (Lanzetta, Cattaneo, Pellegatta and Cardini, 2004). When the literature is examined, it is seen that the decreased core stability in MS patients is associated with parameters such as balance, walking, and mobility that can increase the level of disability (Cameron and Lord, 2010; Comber, Sosnoff, Galvin and Coote, 2018; Freund, Stetts and Vallabhajosula, 2016; Kalron and Givon, 2016).

Postural stability of the trunk is one the components of balance and optimal activation of core muscles is a precondition for compensatory postural adjustments and anticipatory postural adjustments. The function of trunk muscles is the main factor during gait and running, and helps to maintain and change the posture (Genthon, Vuillerme, Monnet, Petit and Rougier, 2007; Hodges and Richardson, 1997a; Kibler, Press and Sciascia, 2006; Preuss and Fung, 2008). Hodges and Richardson (1997b) showed that regardless of the direction of limb movement, trunk muscle activity precedes the activity of the muscle that moves the limb (Hodges and Richardson, 1997b). It has been shown that the transversus abdominis and multifidus muscles are activated to stabilize the lumbar spine in healthy people, 30 msec from shoulder movement and 110 msec before lower extremity movement. This situation indicates the necessity of the stability of the spine before limb movement. Based on these results, the researchers concluded that the CNS provides a solid basis for movement of the extremities through the combined contraction of the transversus abdominis and multifidus muscles. In addition, they stated that this sequential contraction in core muscles reduced the perturbations caused by lower extremity movements and thus maintained postural control and balance. Freund, Stetts and Vallabhajosula (2016) reported that isometric flexion endurance of trunk was correlated with several postural control parameters, and isometric trunk extension endurance was correlated with only one postural control parameter in MS patients with moderate disability (Freund, Stetts and Vallabhajosula, 2016). This studies indicated the importance of trunk muscles and function in maintaining balance.

The core region functions as the center of the functional motion chain. During many activities, trunk stability provides proximal stability for distal mobility and function of the extremities. For this reason, the decrease in core stability not only causes a decrease in trunk stabilization but also restricts the functional movement patterns that will occur in the extremities (Borghuis, Hof and Lemmink, 2008; Ketelhut, Kindred and Manago, 2015; Kibler, Press and Sciascia, 2006). Activation of core muscles is believed important for movement quality while

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walking and impairments in core region can lead to shorter and fewer steps, decrease in walking speed, increase in fall risk, and decrease in daily living activities and may increase cognitive attention to walking (Arntzen, Straume, Odeh, Feys and Normann, 2020). Ketelhut, Kindred, and Manago (2015) found that the activity levels of obliquus externus, obliquus internus, and rectus abdominus muscles were increased on the less affected side and the volume of transversus abdominus, quadratus lumborum, and lumbar extensor muscles was greater on the more affected side in patients with MS (Patient Determined Disease Steps median score: 2), who had no visible gait disturbance (Ketelhut, Kindred and Manago, 2015). The researchers stated that this was a necessary compensation strategy to maintain balance and posture during walking in patients with MS. This study is important to show that compensation mechanisms to maintain balance in the trunk begin to develop while walking. Corporaal et al. (2013) showed that the trunk sways of patients with MS increased more during walking tasks compared to healthy individuals (Corporaal et al., 2013). Freund et al. (2016) reported that isometric flexion endurance of trunk was correlated with with walking speed in patients with MS (Freund, Stetts and Vallabhajosula, 2016). Moreno-Navarro et al. (2020) reported that core stability, balance and strength explained 60%-70% of the variance in functional mobility and walking speed in patients with MS (Moreno-Navarro et al., 2020). These results show that the function of the trunk is important and critical for maintaining walking and mobility in patients with MS.

These symptoms and results are important parameters associated with disability level and neurological impairment in patients with MS. The relationship between core stability and many main parameters such as balance, walking, and mobility that increase the level of disability explains the relationship between disability level and core stability in patients with MS.

This study has some limitations. First, only mild and moderate MS patients were included in the study and therefore the study did not generalize to all MS patients. Second, not examining the relationship between the sense of the trunk and the level of disability is another limitation of our study. Finally, the lack of a more detailed evaluation according to gender and the short average time of diagnosis of the patients are other limitations.

Conclusion

In conclusion, disability level was associated with core endurance and core power, which are the sub-parameters of core stability, in patients with MS. Therefore, clinicians should

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consider evaluation directed at core endurance and core power in MS patients with mild to moderate disability. In addition, we think that future studies examining the relationship between the trunk sense and disability level will provide a better understanding of the parameters affecting the disability level in patients with MS.

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Conflict of Interest

The authors report no conflict of interest.

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