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RELATIONSHIP BETWEEN TRUNK AND LOWER EXTREMITY MUSCLES AND BALANCE IN MULTIPLE SCLEROSIS PATIENTS

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Abstract: Multiple sclerosis (MS) is a chronic inflammatory neurodegenerative disease that causes demyelination of nerve fibers. This neurological process causes physical and mental changes in and to the motor, sensory, and cognitive systems. This study aims to determine the relationship between balance and muscle strength in people with multiple sclerosis. This study included 36 MS patients' ⩾18 years old who were treated and followed up according to routine clinical practice at a university hospital in Türkiye, which were observational, non-invasive, and a control group of 32 patients whose relatives were voluntarily evaluated without any neurological problems. Muscle strength was measured manually. In balance analysis, computerized balance analysis system was used. The mean age of the MS group was 46.14 (SD±7.14) and the mean age of the healthy group (HG) was 42.25 (SD±10.81). While muscles of abdominal, hamstring, hip flexor and extensor, tibialis anterior and tibialis posterior muscle strength were found to be positively significant with balance in the MS group, P<0.05, there was no significant relationship between balance and muscle strength of back extansor (P>0.05). This study revealed significant correlations between balance and strength parameters of trunk and lower extremity muscles. Our study suggests that rehabilitation protocols for MS patients should include a critical strength training program, especially for trunk and lower extremity muscles.

Keywords: Multiple sclerosis, Muscle strength, Balance

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1. Introduction

MS, resulting in demyelination, glial reaction, and axonal loss, is a chronic, inflammatory disease that affects the central nervous system (CNS) (Yamout and Alroughani, 2018; Sagawa et al., 2021). MS includes many symptoms such as depression, fatigue, pain, and muscle weakness, gait and balance disorders. Postural imbalance, which affects 80% of patients, is one of the most disabling symptoms of MS (Abdel-Aziz et al., 2015).

Balance disorder (Boes et al., 2012) and severe fatigue (Claros-Salinas et al., 2013) cause limitations in activities such as upright posture and walking (Penner et al., 2007; Heesen et al., 2008). The vast majority of people with MS have postural control and gait abnormalities even early in the disease. More than 50% of people with MS fall each year, many suffer fall-related injuries and limit their activities due to instability, gait disturbance, and fear of falling (Mofateh et al., 2017).

Individuals with MS have more oscillations in the upright position than normal individuals. These oscillations increase when they close their eyes and are more common in progressive MS than in relapsing (Frzovic et al., 2000). The ability to move towards stability limits is also impaired (Daley and Swank, 1981). It has been shown that the center of mass shifts less than healthy controls and their walking speed is lower in their balance during walking (Mofateh et al., 2017).

In addition, the balance of individuals with MS in exercises and dual tasks is worse than in healthy controls. In particular, functions such as decision making and selection process worsen balance more than counting words or numbers. The effect of dual tasks was greater in the mildly affected MS group (Cattaneo et al., 2007; Sosnoff et al., 2011).

The relationship between muscle strength and balance in MS patients has been evaluated by many different methods, both subjective and objective (Cattaneo et al., 2006; Cattaneo and Jonsdottir, 2009). Some of these are dynamic posturography, in which the person is asked to remain as still as possible on a force plate during various balance challenges. Another objective method is to evaluate the balance with eyes open and closed in a fixed standing position. The number of studies examining the relationship between muscle strength and balance is limited in the literature. The muscle strength examined in studies conducted in the MS group consisted of only the lower extremity muscles. Balance requires the extremity and postural muscle strength to work together in a functional way. Therefore, we included more muscle groups in the evaluation to determine the effect of muscle strength on balance. We compared the same parameters with the healthy group. The aim of this study is to examine the relationship between trunk and lower extremity muscle strength and balance with eyes open and closed in MS patients.

2. Materials and Methods

2.1. Participants

This study was planned as a cross-sectional observational study. Thirty-two HG and 36 patients with MS were included in the study (Table 1). Necmettin Erbakan University Health Sciences Scientific Research Ethics Committee approved this study (number: 12/56) and all participants gave informed written consent. HG did not have any neurological or musculoskeletal pathology or disorders. All individuals with MS were between the ages of 18-65, had relapsing remitting MS. Participants with MS with 1+ or 2 plantar flexor spasticity according to the Modified Ashworth Scale (MAS) were included in the study if they met the inclusion criteria. Exclusion criteria are; orthopedic problems, rheumatological problems, recent joint or soft tissue injury and limitation of lower extremity joints, vertigo. The varying muscle strength of individuals with MS was scored as strong and weak instead of right and left.

2.2. Stabilometric Test

The STABYLO platform produced by Diagnostic Support was used for the stabilometric evaluation. The 40x80 cm sensing surface with 12,800 active sensors is used to examine body oscillations in an upright position and to evaluate body strategies in a certain time period (maximum 51.2 seconds) by keeping the eyes fixed. In this study, body oscillations were recorded as area in cm2 with eyes open and closed (López-Rodríguez et al., 2007).

2.3. Muscle Test

Manual muscle strength measurement, which provides a rough evaluation of muscle strength, is a method highly preferred by physiotherapists due to its practicality in clinical practice. A professor of orthopedics at Harvard Medical School, Dr. Robert W. Lovett explained the Manual Test method in his published book. In the muscle test, the patient is placed in the starting position and asked to do the movement (Lovett and Martin, 1916). The therapist evaluates by looking at the muscle resistance that occurs against the resistance given by the hand. Muscle strength is graded between 0 (complete paralysis) and 5 (normal). "0 = complately paralised no muscle contraction or no contraction; the patient is unable to even contract the muscle. 3= Movement with gravity alone; movement against gravity 5= movement against gravity with full resistance or Normal strength is shown by movement against substantial resistance." (Bohannon, 1986).

2.4. Statistical Analysis

Normality of data was assessed visually using quantile plots and confirmed with Shapiro–Wilk tests. Since our data were not normally distributed, Mann Whithney U test was used to determine the difference between groups. Characteristics were expressed with mean and standard deviation. Spearman correlation coefficient was used to test the correlation between quantitative data. Significance level P< 0.05 was accepted (Önder, 2018).

3. Results

It was determined that there was no significant difference between the age, height, weight, average BMI score of the groups, and gender and BMI distributions (P>0.05, Table 1), and that the groups had homogeneous/similar characteristics. The difference between the balance parameters of MS patients and CG was evaluated by comparing them with the Mann Whitney U test (Table 2).

The muscle strength analyzes of the MS and CG are shown in Table 3. A significant difference was found in all muscles between the two groups (P<0.05).

As a result of the correlation between muscle strength of individuals with MS and HG balance with eyes open and closed, all muscle groups except back extensors of MS patients were found to be associated with balance in general (Table 4) (P<0.05).

Table 1. Distribution of descriptive characteristics by groups

Features	MS (N: 36) $\bar{x}$ ± SS		HG (N: 32) $\bar{x}$ ± SS	
Age	46.14±7.36		42.25±10.81	
Height	163.36±.16.89		1.67±.070	
Weight	66.92 ±21.03		69.50±8.72	
BMI	26.96±19.98		24.95±3.40	
EDDS	4.06±.81			
	n	%	n	%
Gender				
Man	11	30.55	13	40.62
Woman	25	69.44	19	59.37

Mann Whitney U test.

Table 2. Balance parameters in MS and CG

Parameters	MS (N: 36) Median(min-max)	HG (N:32) Median (min-max)	Z	P
Romberg	222.82 (59.40-765.30)	136.10 (47.25-799.30)	2.34	0.019
SL(eo)	373.00 (76.50-715.20)	129.15 (48.90-703.10)	4.07	0.000
SL(ec)	521.70 (83.80-980)	156.70 (47.25-799.30	5.09	0.000

Z= Mann Whitney U test, SL= swing lenght, eo= eyes open, ec= eyes close.

Table 3. Muscle strength analysis of MS and HG

Muscle Strength	MS (N: 36) $\bar{X}$ ± SS	CG (N: 32) $\bar{X}$ ± SS	Z	P
Back Extensor Muscles	4.06±0.86	4.81±0.39	-3.90	0.000
Abdominal Muscles	4.00±0.82	4.84±0.36	-4.47	0.000
Hip Flexor Muscles(strong)	4.42±0.69	4.91±0.29	-3.45	0.001
Hip Flexor Muscles(weak)	4.00±0.79	4.81±0.39	-3.45	0.001
Hip Extansor Muscles(strong)	3.89±0.82	4.94±0.24	-4.56	0.000
Hip Extansor Muscles(weak)	3.47±0.73	4.88±0.33	-5.92	0.000
Knee Flexor Muscles(strong)	3.92±0.77	4.94±0.24	-5.31	0.000
Knee Flexor Muscles(weak)	3.50±0.73	4.84±0.36	-6.45	0.000
Knee Extansor Muscles(strong)	4.42±0.77	4.94±0.24	-3.40	0.001
Knee Extansor Muscles(weak)	4.11±0.78	4.81±0.39	-3.98	0.000
Foot Dorsiflexor Muscles(strong)	4.58±0.69	4.94±0.24	-2.37	0.001
Foot Dorsiflexor Muscles(weak)	4.39±0.90	4.88±0.33	-2.60	0.009
Foot Plantar Flexor Muscles(strong)	4.50±0.69	4.88±0.33	-2.55	0.001
Foot Plantar Flexor Muscles(weak)	4.36±0.72	4.88±0.33	-3.38	0.001

Z= Mann Whitney U test.

Table 4. The relationship between muscle strength and balance scores of MS patients: correlation analysis results

Muscles	Group	Romberg		Balance(eo)		Balance(ec)	
		r	P	r	P	r	P
Back Extansor Muscles	MS	-0.315	0.062	-0.222	0.192	-0.191	0.264
	HG	0.026	0.888	-0.033	0.859	0.095	0.604
Abdominal Muscles	MS	-0.422*	0.010	-0.536**	0.001	-0.455**	0.005
	HG	0.107	0.055	-0.033	0.859	0.061	0.742
Quadriceps Muscles (strong)	MS	0.072	-0.676	-0.382*	0.001	-0.336*	0.045
	HG	0.056	0.761	0.028	0.879	0.098	0.594
Quadriceps Muscles (weak)	MS	-0.013	0.449	-0.366*	0.028	-0.338*	0.044
	HG	0.009	0.962	-0.052	0.777	0.026	0.888
Hip Flexor (strong)	MS	-0.092	0.595	-0.371*	0.027	-0.277	0.102
	HG	-0.006	0.975	0.064	0.728	0.075	0.681
Hip Flexor (weak)	MS	-0.179	0.298	-0.278	0.100	-0.339*	0.043
	HG	0.095	0.604	0.052	0.777	0.191	0.296
Hamstring Muscles (strong)	MS	0.039	0.972	-0.379*	0.023	-0.331*	0.049
	HG	0.056	0.761	0.028	0.879	0.098	0.594
Hamstring Muscles (weak)	MS	0.004	-0.983	-0.391*	0.018	-0.378*	0.023
	HG	0.033	0.859	-0.023	0.899	0.144	0.430
Gluteus Maximus (strong)	MS	0.006	0.972	-0.437**	0.008	-0.340*	0.043
	HG	0.056	0.761	0.028	0.879	0.098	0.594
Gluteus Maximus (weak)	MS	0.109	0.052	-0.367*	0.027	-0.367*	0.027
	HG	0.020	0.911	0.031	0.867	0.092	0.594
Tibialis Anterior (strong)	MS	-0.295	0.081	-0.454**	0.005	-0.447**	0.006
	HG	0.056	0.761	0.028	0.879	0.098	0.594
Tibialis Anterior (weak)	MS	-0.182	0.288	-0.369*	0.027	-0.338*	0.044
	HG	0.020	0.911	0.028	0.879	0.092	616
Tibialis Posterior (strong)	MS	-0.227	0.183	0.-148	0.388	-0.185	0.281
	HG	0.020	0.911	0.028	0.879	0.092	0.303
Tibialis Posterior (weak)	MS	-0.271	0.110	0.-355*	0.034	-0.353*	0.035
	HG	0.020	0.911	0.028	0.879	0.092	0.303

4. Discussion

The main findings of our study were the occurrence of muscle weakness and deterioration of balance in patients with MS. In addition, we have shown that muscle weakness and balance problems can also occur in the early period.

Muscle strength and balance were evaluated in healthy and MS individuals. Muscle strength is decreased in individuals with MS, consistent with the literature (Cattaneo et al., 2002; DeBolt and McCubbin, 2004; Chung et al., 2008; Cameron and Lord, 2010; Broekmans et al., 2011; Citaker et al., 2013). In the literature, it has been shown that adults with MS have less lower extremity strength than their peers, and that reduced lower extremity strength is also associated with impaired balance, which causes an increased prevalence of falls (Cattaneo et al., 2002; Cameron and Lord, 2010).

Studies examining the relationship between muscle strength and balance in MS in the literature are limited in terms of the muscle groups evaluated. In general, knee flexor and extensor muscle groups were evaluated. In studies evaluating the lower extremity, the trunk muscles were generally not included (Citaker et al., 2013). When the oscillations are examined in the literature, a significant increase in body oscillation has been reported in the MS group compared to the CG (Broekmans et al., 2011). Consistent with the literature in our study, oscillations with eyes open and closed increased in MS patients. In a study evaluating home-based progressive resistance exercise (PRT), DeBolt and McCubbin (2004) found no significance in the balance test (body sway) performed on a strength platform, but it was shown to reduce antero-posterior sway by 10.3% in the PRT group. Sabapathy et al. (2011) found an effect in the functional reach test for the PRT group.

Our MS group was typical for MS patients considering the age and sex ratio. The male/female ratio is approximately 2/3. Porosinska et al. (2010) examined balance in 32 MS patients and 30 HG. Ground reaction force and oscillation were worse in the whole MS group compared to the HG, with eyes open (eo) and eyes closed (ec). In our study, eyes open and closed balance worsened compared to the CG.

Compared to HG, chorea muscles are weaker in MS patients. The decreased endurance in MS patients can be attributed to the conversion of type I (slow) muscle fibers to type II (fast) fibers. Slow fibers fatigue less than fast fibers (Dalgas et al., 2010). Altered peripheral function in MS patients may result not only from central, long-term changes, but also from chronically reduced muscle activity (Wens et al., 2014). When the studies are examined, the chorea muscles that control the trunk movement and extremities, which are impaired by the movement of the extremities, are closely related to balance (Freeman et al., 2010; Yahia et al., 2011). In our study, it is seen in Table3 that especially abdominal muscles are associated with eye open and closed balance.

In the study of Yahia et al. (2011) found a positive correlation between muscle strength and gait parameters, especially for eyes-closed (EC) quadriceps and hamstring muscles. In our study, a negative correlation was found between hamstring muscle strength and balance (EC).

In a study by Çitaker et al. (2013) hip flexor-extensor-abductor adductor, knee flexor-extensor, and ankle dorsal flexor muscle strength were found to be associated with the balance test on one foot in ambulatory MS patients.

In the study conducted by Freeman et al. (2010) a significant increase in balance and mobility was observed with 8-week chorea stabilization exercises. In our study, there is a significant relationship between the abdominal muscles, which is one of the chorea muscles, and balance. However, no relationship was found between back muscles and balance with eyes open and closed. It is thought that this is due to the fact that muscles such as the multifidius, which constitute chorea stability, are not evaluated separately.

As a result, in our study, strengthening exercises should be added to the treatment program for all muscles, not only the trunk or only the extremities, but especially for the antigravite muscles, where muscle strength effects are high in MS. In the future, studies that examine the balance in detail with muscle strengthening exercises can be done.

5. Conclusion

Abdominal, gluteus maximus, quadriceps, hamstring, tibialis anterior, tibialis posterior eyes are associated with open and closed balance in mild to moderately handicapped MS patients. Therefore, strengthening these muscles can help improve balance and reduce disability in this population. This study was not designed to respond to all causes of imbalance in patients with MS. Some lower extremity muscle strengths (hip rotators, inverters, and evertors) were not investigated in this study. Future studies investigating the relationship between muscle strength, spasticity, proprioception, ataxia, coordination, endurance, pain and standing balance may help to better understand imbalance in MS patients.

Limitations

Bohannon R. (2005) stated that manual muscle testing can be used in practice, but it has deficiencies. The most important limitation is that the muscle test was performed manually, not with a dynamometer. Mild and moderately disabled patients with MS were included in this study. Therefore, the results cannot be generalized to severely disabled MS patients. Ankle inverter and evertor muscle strength can also affect standing balance, and these factors were not evaluated in this study. Spasticity, ataxia or coordination problems may be related to standing balance, these factors were investigated, but these parameters were not analyzed due to the limited number of patients with spasticity or ataxia.

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	F.E.	A.U.U.	N.A.Y.	A.F.D.	A.Ş.
C	40	10	10	30	10
D	60	10	10	10	10
S	25	50	25		
DCP	20	20	20	20	20
DAI	10	10	10	35	35
L	20	20	20	20	20
W	20	20	20	20	20
CR	20	20	20	20	20
SR	10	35	35	10	10
PM	60	10	10	10	10
FA	20	20	20	20	20

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author sdeclared that there is no conflict of interest.

Ethical Approval/Informed Consent

All experiments were done according to the National Guidelines on Animal Experimentation and were approved by the University Health Sciences Ethical Committee (approval date: July 07, 2021, protocol code: 2021/12-56).

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