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Research Paper – Araştırma Makalesi

THE RELATIONSHIP BETWEEN RESPIRATORY FUNCTIONS AND BALANCE, TRUNK CONTROL, AND FUNCTIONAL CAPACITY IN MULTIPLE SCLEROSIS PATIENTS

MULTİPLE SKLEROZ HASTALARINDA SOLUNUM FONKSİYONLARI İLE DENGE, GÖVDE KONTROLÜ VE FONKSİYONEL KAPASİTE ARASINDAKİ İLİŞKİ

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Özet

Multipl skleroz (MS), denge ve fonksiyonel kapasitenin yanı sıra solunum fonksiyonlarında da bozulmaya neden olur. Bu çalışmanın amacı MS hastalarında denge, gövde kontrolü ve fonksiyonel kapasite ile solunum fonksiyonları arasındaki ilişkiyi araştırmaktı. Çalışmaya 31 MS hastası dahil edildi. Tüm katılımcılara solunum fonksiyon testi ve maksimum inspiratuar ve ekspiratuar basınca ek olarak (MIP, MEP) denge değerlendirmesi için Mini-BESTest, gövde kontrolü için Gövde Bozukluk Ölçeği (GBÖ) ve fonksiyonel kapasite için 2 dakika yürüme testi (2DYT) uygulandı. MS hastalarının dizabilite düzeyi Genişletilmiş Özürlülük Durum Ölçeği (The Expanded Disability Status Scale :EDSS) ile değerlendirildi. MIP ile Mini-BESTest (r:0,411 p:0,022), GBÖ (r:0,490 p:0,009) ve 2DYT (r:0,432 p:0,017) arasında istatiksel olarak anlamlı, orta şiddette ilişki saptandı. MEP değeri Mini-BESTest ve GBÖ ile istatiksel olarak anlamlı ve zayıf şiddette bir ilişkiye sahipken, 2DYT sonuçları ile istatiksel olarak anlamlı bir ilişkiye sahip değildi. FEV_1 (%) ve FEF_{25-75} (%) değerlerinin denge, gövde kontrolü ve fonksiyonel kapasite ile orta şiddette ilişkili olduğu görüldü. FVC (%) değeri Mini-BESTest ile zayıf (r: 0,364, p: 0,044), GBÖ ile orta şiddette (r: 0,431, p: 0,015) ve anlamlı bir ilişkiye sahipti. FEV_1/FVC (%) ve PEF (%) değerlerinin ise sadece Mini-BESTest ile zayıf şiddette bir ilişkisi vardı (r: 0,362, p: 0,046; r: 0,383, p: 0,034). MS hastalarında denge, gövde kontrolü ve fonksiyonel kapasite ile solunum fonksiyonları arasındaki ilişki göz önüne alındığında, erken dönemden itibaren solunum fonksiyonlarına yönelik yaklaşımların da rehabilitasyon programlarına eklenmesi faydalı olabilir.

Anahtar Kelimeler: Multipl skleroz, denge, gövde kontrolü, fonksiyonel kapasite, solunum fonksiyon testleri

Abstract

Multiple sclerosis (MS) causes impairments not only in balance and functional capacity but also in respiratory functions. The aim of the study is to investigate the relationship between balance, trunk control, functional capacity, and respiratory function in people with MS. The study included 31 people with MS. All participants underwent respiratory function tests and, in addition to maximum inspiratory and expiratory pressure (PImax, PEmax), the Mini-BESTest for balance assessment, for trunk control, the Trunk Impairment Scale (TIS) for, and the 2-minute walk test (2MWT) for functional capacity were administered. The Expanded Disability Status Scale (EDSS) was used to assess the level of disability in MS patients. A statistically significant moderate correlation was found between PImax and Mini-BESTest (r: 0.411 p: 0.022), TIS (r: 0.490 p: 0.009), and 2MWT (r: 0.432 p: 0.017). While PEmax value showed a statistically significant and weak correlation with Mini-BESTest and TIS, it did not show a significant relationship with the 2MWT results. FEV_1 (%) and FEF_{25-75} (%) values were moderately associated with balance, trunk control, and functional capacity. The FVC (%) value had a weak (r: 0.364, p: 0.044) relationship with Mini-BESTest, a moderate (r: 0.431, p: 0.015) correlation with TIS, and a significant correlation. The FEV_1/FVC (%) and PEF (%) values had only a weak correlation with Mini-BESTest (r: 0.362, p: 0.046; r: 0.383, p: 0.034). Considering the relationship between balance, trunk control, functional capacity, and respiratory functions in people with MS, approaches targeting respiratory functions might be beneficial additions to rehabilitation programs from the early stages onward.

Keywords: Multiple sclerosis, balance, trunk control, functional capacity, respiratory function tests

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1. INTRODUCTION

Multiple sclerosis (MS) is a disease of the central nervous system, which is chronic, autoimmune, and inflammatory (Frohman, Racke and Cedric, 2006, pp. 942-55). Depending on the location and size of the lesion, the symptoms and severity of MS vary (O'connor, 2002, pp. 1-33). Depending on the affected area, somatosensory findings, motor findings, postural control, balance and coordination disorders, visual, and cognitive findings, fatigue, bladder-bowel problems, and sleep disorders can be observed (Frohman, Racke and Cedric, 2006, pp. 942-55).

One symptom that starts from the early phases of the disease in patients with MS and becomes an important cause of mortality in the advanced stages of MS is respiratory dysfunction (Fry et al., 2007, pp. 162-72). Several factors underlie respiratory dysfunction, tailored to the individual, including the presence of lesions in brain regions associated with respiration and the concomitance of trunk and respiratory muscle weakness (Fry et al., 2007, pp. 162-72; Rietberg et al., 2017, pp. 1-35; Reyes, Ziman and Nosaka, 2013, pp. 1386-94; Altıntaş et al., 2007, pp. 242-46). Most of the respiratory muscles are included in the core stabilizing muscles. Core muscles control trunk for balance and mobility (Pfalzer and Fry, 2011, pp. 32-42). The diaphragm forms the roof of the core stability muscles and plays a significant role in thoracic mobility. The diaphragm's importance in maintaining and sustaining balance is significant (Pollock et al., 2000, pp. 402-06). Balance is a skill that refers to the ability to maintain the body upright against gravity and reflects the stability limits (Remelius et al., 2008, pp. 93-108). Balance impairment in MS patients is one of the most common issues and one of the factors leading to disability (LaRocca, 2011, pp. 189-201). Lesions in the brain stem and cerebellum lead to loss of postural control and balance. The causes of balance loss include visual symptoms, optic neuritis, vestibular changes, somatosensory changes, lesions in ventromedial pathways, tone changes, muscle weakness, and incoordination (LaRocca, 2011, pp. 189-201).

Movement disorders, such as walking problems, are widespread in individuals with MS. These problems negatively affect their quality of life (Westerdahl et al., 2021, pp. 1-7).

While there are studies in the literature that evaluate respiratory functions, balance, and functional capacity separately in MS patients. However, there has been no detailed study examining the relationships between these parameters (Ozen et al., 2023, pp. 1-8). Therefore, the aim of the study was to examine the correlation between respiratory function, balance, and functional capacity in individuals with MS.

2. MATERIALS AND METHODS

2.1. Participants

The study was performed at the Prof. Dr. Cemil Taşçıoğlu City Hospital between April 2022 and December 2023. The study was approved by the Marmara University Non-Interventional Clinical Research Ethics Committee (Decision No: 07.01.2022.91). The study included a total of thirty-one people with MS. The inclusion criteria were having received an MS diagnosis according to McDonald's diagnostic criteria by a neurologist, being between the ages of 18-65, having an EDSS score between 1.5-5.5, and having not had an attack of the disease in the last three months. Individuals diagnosed with musculoskeletal, neurological, or cardiopulmonary diseases that could affect the study results were excluded. All participants signed the informed consent form.

2.2. Outcome measures

Respiratory Function: Respiratory function was assessed using a manual spirometer by the ATS/ERS criteria (MIR Spirolab III). Forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), FEV_1/FVC ratio (Tiffeneau-Pinelli index), peak expiratory flow (PEF), and forced expiratory flow at 25-75% (FEF_{25-75}%) were assessed. The results were reported as percentages of the expected values (Miller et al., 2005, pp. 319-38)

Respiratory Muscle Strength (RMS): RMS was assessed by use of a respiratory pressure meter (Micro Medical MicroRPM, UK) according to ATS/ERS criteria. As a result of the measurement, the maximum inspiratory (PImax) and expiratory (PEmax) muscle strength of the individual is recorded. The results were expressed in cmH_2O (Laveneziana, Albuquerque and Aliverti, 2019, pp. 1-34).

Mini-BESTest: The Mini-BESTest is a quantitative assessment tool designed to identify impairments in the underlying systems of reduced balance and postural control. The test evaluates the performance of the balance system. In the test, the lowest functional level is "0", and the highest functional level is "2". The total score that can be obtained from the Mini-BESTest varies from a minimum of "0" to a maximum of "28" (Franchignoni et al., 2010, pp. 323-31). The Turkish validity and reliability of this scale was carried out by Goktas et al. (2020, pp. 303-310)

Trunk Impairment Scale (TIS): This scale was designed in 2004 to assess the performance and coordination of the trunk. Its validity and reliability have been proven in various neurological diseases (Verheyden et al., 2004, pp. 326-34; Verheyden et al., 2006, pp. 23-28; Verheyden et al., 2007, pp. 1304-08). TIS consists of three subcategories and 17 items. Measurements were taken three times, and the best results achieved by individuals were used. The lowest score is 0, and the maximum score is 23. A high score indicates good trunk control (Verheyden et al., 2004, pp. 326-34). The Turkish validity and reliability of this scale was carried out by Sag et al. (2019, pp. 303-310)

2-Minute Walk Test (2MWT): 2MWT is used to measure functional capacity, the distance walked by an individual along a 30-meter length in 2 minutes was recorded in meters (Gijbels, Eijnde and Feys, 2011, pp. 1269-72). The 2MWT was preferred to avoid fatigue in MS patients.

2.3. Statistical Analysis

IBM SPSS 29.0 was used for data analysis. Descriptive statistics were expressed as mean and standard deviation for numerical variables with a normal distribution, and median and interquartile range for numerical variables that did not have a normal distribution. Frequencies and percentages were used for categorical variables. The Kolmogorov-Smirnov test was used for assessing the normality of the data. The relationship between variables was given by the Spearman's rho correlation coefficient. A p-value <0.05 was considered statistically significant. Correlation coefficients were described as weak (0.00 to 0.40), moderate (0.40 to 0.70), and strong (0.70 to 1.00) (Akoglu, 2018, pp. 91-93).

3. RESULTS

A total of thirty-one Relapsing-Remitting MS patients were included in this study. Of the cases included in the study, twenty-one were female and ten were male. The demographic data of individuals are shown in Table-1.

Table 1: Demographic and Clinical Characteristics of The Patients

		X±SD / Median (min-max)
Age (years) (X±SD)		46.29 ± 9.01
BMI (kg/m^2) (X±SD)		24.24 ± 3.52
Gender (n (%))	Female	21 (67.75%)
	Male	10 (32.25%)
Duration of disease, years (median, min-max)		8 (1-26)
EDSS score (X±SD)		2.74 ±1.20

X±SD: Mean±Standard deviation, n: number of individuals, %: percentage, kg: kilogram, m: meter, EDSS: Expanded Disability Status Scale

The FVC (%) value showed a weak correlation with the Mini-BESTest (r: 0.364) and a moderate correlation with the TIS (r: 0.431). FEV_1/FVC (%) and PEF (%) values were weakly related to the Mini-BESTest (r: 0.362, r: 0.383). FEV_1 (%) and FEF_{25-75} (%) values were found to be moderately associated with all three outcome measures. The PImax of the individuals was found to be significantly and moderately correlated to the Mini-BESTest (r: 0.411), TIS (r: 0.432), and 2-minute walking distance (r: 0.432) among the outcome measures.. The PEmax was weakly correlated to the Mini-BESTest and TIS, while it did not show a significant correlation with the 2-minute walking test results. The results are given in Table-2.

Table 2: Correlation Between Test Parameters and Other Outcome Measures

Outcome Measures	X±SD	Mini-BESTest		TIS		2MWT	
		r value	**p value**	**r value**	**p value**	**r value**	**p value**
PImax (cmH_2O)	62.16 ± 19.14	0.411	0.022	0.490	0.006	0.432	0.017
PEmax (cmH_2O)	79.74 ± 21.43	0.361	0.046	0.384	0.033	0.297	0.111
FEV_1 (%)	82.97 ± 16.05	0.424	0.018	0.460	0.009	0.382	0.037
FVC (%)	87.39 ± 14.86	0.364	0.044	0.431	0.015	0.264	0.158
FEV_1/FVC (%)	99.32 ± 9.16	0.362	0.046	0.113	0.546	0.263	0.161
FEF_{25-75} (%)	66.87 ± 23.12	0.470	0.008	0.364	0.044	0.418	0.022
PEF (%)	54.58 ± 17.31	0.383	0.034	0.328	0.072	0.227	0.227

Mini-BESTest: Mini-Balance Evaluation Systems Test, TIS: Trunk Impact Scale, 2MWT: 2 minutes walking test, PImax: Maximum Inspiratory Pressure, PEmax: Maximum Expiratory Pressure, FEV_1: Forced expiratory volume in 1 second, FVC: Forced vital capacity, FEF_{25-75}: Forced expiratory flow rate between 25% and 75%, PEF: Peak expiratory flow rate.

4. DISCUSSION

In our study, we analyzed the correlation between respiratory functions and balance, trunk control, and functional capacity in MS patients. PImax, FEV_1 (%), and FEF_{25-75} (%) values were found to be correlated with balance, trunk control, and functional capacity, while PEmax and FVC (%) values were correlated with balance and trunk control. PEF (%) and FEV_1/FVC (%) values were only associated with balance. PImax and PEmax values of the patients were found to be lower than healthy individuals according to their age levels (Sheraz et al., 2023, pp. 690-700). Additionally, the respiratory functions were below the expected values.

The FVC value is obtained by emptying all air in the lungs with expiration. The FEV_1 value represents the forced expiratory volume in one second (Ulubay, 2017, pp. 37-46). These values, which are directly affected by expiratory muscle strength, were found to be related to balance and trunk control, similar to the relationship found for the PEmax value in our study. While there are no studies in the literature that examine the relationship between respiratory function tests and balance and trunk control, similar studies have been conducted in stroke patients. In the study by Lee and Kim (2018, pp. 700-03), which evaluated trunk control with the TIS in stroke patients, there was a moderate relationship between the FEV_1 value and some of the trunk control and balance tests. FVC results were not provided in this study. In the study by Meng Li and colleagues (2024, p. 59), they used the TIS in stroke patients and reported a mild relationship between both the FEV_1 value and the FVC value with balance and trunk control. The results in our study show similarities with the results in the literature.

The PEF value indicates the maximum airflow rate obtained during forced expiration in a respiratory function test, while the FEF_{25-75} value indicates the mid-flow rate during forced expiration. When examining studies in the literature, it was found that there was a low correlation between the timed up and go test results and the PEF and FEF_{25-75} values in MS patients (Charro et al., 2023, pp. 1-9). In studies conducted in stroke patients, it was also reported that there was a correlation between PEF values and trunk control and balance (Lee and Kim, 2018, pp. 700-03; Meng Li et al., 2024, p. 59). In our study, while the PEF (%) value was found to be statistically significantly and weakly associated with balance, no significant relationship was found with trunk control. However, the level of significance in trunk control was close to being significant. In future studies, using more detailed methods to evaluate trunk control, minor changes in trunk control could better identify the effect on the PEF value. The FEF_{25-75} value was found to be related to balance, trunk control, and functional capacity values in our study. These results were similar to the results in the literature.

The FEV_1/FVC value is used to provide information about the type of respiratory function impairment in an individual. In a study by Charro and colleagues looking at the impact of respiratory functions on balance, the FEV_1/FVC value was found to be related to balance at a low level of significance (2023, pp. 1-9). Ray and colleagues (2015, pp. 2407-12) examined the correlation between fatigue and respiratory function in MS patients and used the 6MWT in addition to fatigue. In the study, no significant relationship was found between the FEV_1/FVC value and the 6-minute walk distance. In our study, the FEV_1/FVC value was not related to any of the other outcome measures except for balance. The results of our study were like those in the literature.

When citing studies from the literature, we found only one study that examined the correlation between RMS and balance. In a study performed by Charro and colleagues (2023, pp. 1-9), the relationship between PImax values and the Berg Balance Scale was examined, demonstrating a statistically significant and moderate positive relationship. There are some studies investigating the correlation between RMS and balance in patients with stroke. In a study conducted by Lee and Kim (2018, pp. 700-03) on chronic stroke patients using the TIS for trunk control and the Wii Balance Board for trunk balance, they found that PImax and PEmax values were particularly associated with trunk balance during extension. In a study by Meng Li and colleagues (2024, p. 59), which used the Berg Balance Scale to measure balance, a moderate positive relationship was reported between balance and PImax, and a mild positive correlation with PEmax. Our study results appear to be similar to those reported in the literature.

Inspiration muscle training increases diaphragm thickness and function. The diaphragm contracts during mobilization to stabilize the spine and maintain balance (Hodges et al., 1997, pp. 505-39). Additionally, the diaphragm works in harmony with torso muscles to stabilize the torso during body control and increases intra-abdominal pressure to stabilize the lumbar region. We believe that the correlation between balance and inspiratory muscle strength in our study could be attributed to the influence of the diaphragm and other torso muscles on balance (Sheraz et al., 2023, pp. 690-700).

The PEmax value in the evaluation of expiratory muscle strength is affected by the abdominal muscles and accessory respiratory muscles (Shi et al., 2019, pp. 1-11). During the measurement of the PEmax value, the individual is asked to perform forced expiration. The trunk muscles (rectus abdominis, oblique muscles, and transversus abdominis) responsible for forced expiration also provide core stabilization (Rabe et al., 2007, pp. 532-55). This explains the correlation found between expiratory muscle strength and trunk control and balance in our study.

There are numerous studies in the literature examining the correlation between RMS and functional capacity. However, the results in the literature are contradictory. In a study where the correlation between RMS and walking distance, quality of life, and fatigue in female MS patients was examined, a positive relationship was found between the 6-minute walk distance and PImax and PEmax values (Balkan and Salcı, 2020, pp. 145-49). Wetzel and colleagues (2011, pp. 166-80) also reported in their studies with MS patients that there was a correlation between RMS and walking distance. Ray and colleagues, on the other hand, stated that RMS did not affect functional capacity in MS patients (Ray, Mahoney and Fisher, 2015, pp. 2407-12). In another study, it was found that there was no relationship between RMS and the 6-minute walk distance (Wetzel, Fry and Pfalzer, 2011, pp. 166-80). In our study, while a moderate relationship was found between PImax values and the 2-minute walk distance, no relationship was found with PEmax values. We believe that these conflicting results in the literature may stem from various reasons such as the average age of the patients, differences in statistical methods used, the severity of the disease, among others.

Limitations of our study can be considered the small number of patients evaluated. Additionally, individuals could have been evaluated based on their disability levels. More precise results can be obtained by grouping patients according to their EDSS scores in future studies.

5. CONCLUSION

Our study revealed that RMS is associated with motor performance in individuals with MS, such as balance, trunk control, and functional capacity. Considering the decrease in RMS from the early stages of MS, it may be beneficial to assess respiratory parameters in patients and incorporate them into the exercise planning of those in need. It is noticeable that there have not been many studies conducted in this area in the literature. We believe that more comprehensive studies are needed to evaluate these functions based on the severity of the disease.

Conflict of interest

The authors declare that they have no conflicts of interest.

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