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# Investigation of the Relationship Between Trunk Motor Control and Balance, Functional Mobility, and Gait Capacity in Patients with Multiple Sclerosis

## *Multipl Sklerozlu Hastalarda Gövde Motor Kontrolü ile Denge, Fonksiyonel Mobilite ve Yürüyüş Kapasitesi Arasındaki İlişkinin İncelenmesi*

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### Abstract

**Objective:** The functions of the trunk are critical for balance, functional mobility, and gait capacity. Trunk impairment, balance, functional mobility, and gait capacity are affected in patients with multiple sclerosis (PwMS). This study examines the relationship between trunk motor control and balance, functional mobility, and gait capacity in PwMS with mild to moderate disability.

**Materials and Methods:** The study was conducted in 54 PwMS with an age range of 18-65 years. The disability level was determined by the expanded disability status scale. Trunk motor control was assessed using the trunk impairment scale (TIS). Balance was measured with the Mini-BESTest and single-leg stance test. Functional mobility was measured with the timed up and go test (TUG). Gait capacity was measured with the two-minute walk test.

**Results:** The total points of the TIS were correlated with the Mini-BESTest, single-leg stance test (dominant and non-dominant), TUG, and two-minute walk test in PwMS (r=0.652/p<0.001, r=0.389 p=0.004, r=0.458 p<0.001, r=-0.534 p<0.001, r=0.471 p<0.001, respectively).

**Conclusion:** Our study demonstrated that trunk motor control was related to balance and functional mobility and gait capacity in PwMS with mild to moderate disability. These results suggest that a more detailed assessment of the trunk is essential to plan an effective rehabilitation program for the protection and development of balance, functional mobility, and gait capacity in PwMS with mild to moderate disability.

**Keywords:** Multiple sclerosis, trunk motor control, balance, functional mobility, gait capacity

### Öz

**Amaç:** Gövde fonksiyonu denge, fonksiyonel mobilite ve yürüyüş kapasitesi için kritik öneme sahiptir. Multipl skleroz (MS) hastalarında gövde bozukluğu, denge, fonksiyonel mobilite ve yürüyüş kapasitesi etkilenmektedir. Bu çalışmanın amacı, hafif-orta derecede özürlülüğü olan MS hastalarında gövde motor bozukluğu ile denge, fonksiyonel mobilite ve yürüyüş kapasitesi arasındaki ilişkiyi incelemekti.

**Gereç ve Yöntem:** Çalışma, yaş aralığı 18-65 olan 54 MS hastasında yapıldı. Özür düzeyi, genişletilmiş özürlülük durumu ölçeği ile belirlendi. Gövde motor bozukluğu, gövde bozukluk ölçeği (GBÖ) kullanılarak değerlendirildi. Denge, Mini-BESTest ve tek ayak üzerinde durma testi ile ölçüldü. Fonksiyonel mobilite, kalk ve yürü testi (TUG) ile değerlendirildi. Yürüyüş kapasitesi, iki dakika yürüme testi ile değerlendirildi.

**Bulgular:** GBÖ toplam puanının MS hastalarında Mini-BESTest, tek ayak üzerinde durma testleri (dominant ve dominant olmayan), TUG ve iki dakika yürüme testi ile korele olduğu bulundu (r=0,652/p<0,001, r=0,389/p=0,004, r=0,458/p<0,001, r=-0,534/p<0,001, r=0,471/p<0,001, sırasıyla).

**Sonuç:** Çalışmamızda, hafif-orta derecede özürlülüğü olan MS hastalarında gövde motor bozukluğunun sadece denge ile değil, aynı zamanda fonksiyonel hareketlilik ve yürüme kapasitesi ile de ilişkili olduğu gösterilmiştir. Bu sonuçlar, gövdenin daha ayrıntılı değerlendirilmesinin, hafif-orta derecede özürlülüğü olan MS hastalarında denge, fonksiyonel mobilite ve yürüyüş kapasitesinin korunması ve geliştirilmesi için etkili bir rehabilitasyon programı planlamak amacıyla önemli olduğunu göstermektedir.

**Anahtar Kelimeler:** Multipl skleroz, gövde motor bozukluğu, denge, fonksiyonel mobilite, yürüme kapasitesi

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## Introduction

Multiple sclerosis (MS) is a chronic, inflammatory disease of the brain, optic nerve, and spinal cord mediated by the immune system (1). Motor, sensory, vision, and central processing deficits are typical in patients with MS (PwMS) and contribute to impaired balance and gait (2). Several systematic studies have demonstrated that balance abnormalities are common in PwMS, including those with significant impairments and minimal or no clinically measurable impairments. Gait disturbance is common in PwMS, and walking tolerance, gait speed, and gait quality are the components of measures in MS-related disability and disease progression. Many studies have also found that PwMS walk more slowly, take shorter steps (decreased step length), step more slowly (decreased cadence), have less joint motion during gait, and demonstrate more variability in most gait parameters than healthy controls (3,4). Mobility impairment is a major consequence of MS (5). The decline in functional mobility is associated with the loss of social connections, reduced participation, and altered abilities to perform self-care, productivity, and leisure activities (6).

Optimal trunk control relies on the adequate somatosensory, motor, and musculoskeletal systems, frequently compromised in the MS population (5). Trunk control, also termed core stability, is affected to varying degrees in PwMS (7,8). Lanzetta et al. (7) showed that trunk stability decreased during arm movements while sitting in PwMS compared with healthy individuals. Yoosefinejad et al. (8) evaluated core stability with core strength and core endurance tests and showed that core strength and endurance decreased in ambulatory MS patients compared to healthy individuals. Trunk motor control affects sitting and standing and is essential for maintaining body position, staying still when position changes, tracking displacements and optimizing steps while walking. Trunk motor control is among the most critical factors that ensure balance and walking in different environments and conditions during functional activities (9,10,11,12). Therefore, trunk motor control may be associated with balance, functional mobility, and walking capacity in PwMS. In addition, based on the knowledge that trunk motor control affects many functions, it appears that approaches to improve trunk control are beginning to be included in physiotherapy and rehabilitation programs in PwMS (13,14). Therefore, demonstrating the relationship between trunk control and balance, functional mobility, and gait capacity may shed light on rehabilitation practices. This study investigates the relationship between trunk motor control and balance, functional mobility, and gait capacity in PwMS with mild to moderate disability. The hypothesis of the study is that trunk motor control is related to balance, functional mobility, and gait capacity in PwMS with mild to moderate disability.

## Materials and Methods

### Sample Size Calculation

The sample size was calculated using SPSS Sample Power 3.0 software (IBM Corporation, Armonk, NY). A previous study found a modest correlation (r=0.5) between reported trunk motor control and balance. The investigators anticipated that it would be equally relevant in PwMS (15). The calculations were based on the expected correlation coefficient of 0.50, assumed an alpha level ($\alpha$) of 0.05, and the desired power of 95%. The estimated sample size was calculated as a minimum of 46 participants.

### Individuals

A total of 54 PwMS were screened for study eligibility, and 52 patients were recruited as study participants. The inclusion criteria were as follows: The diagnosis of MS by the same neurologist (Ö.A.) according to the McDonald criteria, older than 18 years old, and an expanded disability status scale (EDSS) score between 1 and 4.5. Patients were excluded in the following cases: (1) Having any disease that may affect physical functions except for MS, (2) having any orthopedic lower extremity problems that may impair balance, (3) using medication that might affect gait and balance, (4) history of an episode of MS attack in the previous six months, and (5) a mini-mental state examination (MMSE) score of fewer than 24 points (16), and the inability to follow instructions.

All movements that the patients needed to perform were first introduced by explaining and showing each step by the same physiotherapist in a quiet, well-illuminated room in the morning. The physiotherapist accompanied the patient to prevent falling when performing the tests. Patients were frequently asked if they felt tired. The proper rest intervals were given as often as needed during the measurements. The study was carried out at the university physiotherapy and rehabilitation department. This study was approved by the Ankara Yildirim Beyazit University Local Ethics Committee (date and decision no: 13.11.2019-19). Also, written informed consent was obtained from all the participants who participated in the study.

### Procedure

A neurologist performed the neurologic examination using the EDSS (17). The EDSS level was expressed as a mild disability for any score between 1 and 3.5 and moderate disability for any score between 4 and 4.5. Participant characteristics and duration of the disease were recorded. The mental state was evaluated using the standardized mini-mental test by the same neurologist. Outcome measures were evaluated once by the same physiotherapist (M.E.Y.) in a quiet, well-illuminated room in the morning. Trunk motor control, balance, functional mobility, and gait capacity were evaluated in this order. Two-minute rest periods were given between measurements.

### Measurements

### Trunk Motor Control

The motor deficiencies caused by MS and trunk-related functions were evaluated using the trunk impairment scale (TIS). The test consists of three subheadings: static seating balance, dynamic seating balance, and body coordination. In the static sitting balance section (0-7 points), the patient's ability to maintain the straight sitting position was assessed in conditions with: (1) The feet are supported on the floor, (2) the physiotherapist crosses the strongest leg over the weakest leg, and (3) the patient actively crosses the strongest leg over the weakest leg. Lateral flexion movements initiated from the upper and lower parts of the trunk were evaluated in the dynamic sitting balance section (0-10 points). Finally, the rotation movement of the shoulder and pelvis was graded in the coordination section (0-6 points). Each item was scored with a value ranging from 0 to 3 depending on how much movement can be done and whether compensation was used during the movement. The score that can be obtained from the TIS ranges from 0 to 23 points. Higher scores indicate a better physical condition of the trunk. The TIS provides a reliable assessment of the trunk and is a valid scale for measuring trunk motor performance in PwMS (18).

### Balance

Balance was evaluated with the Mini-BESTest. The Mini-BESTest evaluates four components of balance with 14 performance tests: 1. Anticipatory, 2. reactive postural control, 3. sensory orientation, and 4. dynamic gait. In the anticipatory section: The ability to (1) stand up from sitting, (2) rise to toes, and (3) standing on one leg; in the reactive postural control section: compensatory stepping correction (1) forward, (2) backward, and (3) lateral directions; in the sensory orientation: Eyes open and closed balance ability on various floor conditions, and finally in the dynamic gait section: balance skills in various gait patterns were evaluated. For each title, the participant's performance was scored as 0 (unable), 1 (moderate), or 2 (normal). The total score ranges from 0 to 28 points. Higher scores indicate better dynamic balance function of the patient. In addition, the duration of the single-leg stance tests included in the Mini-BESTest was added to the study for use in statistical analysis. Patients were instructed to stand by raising one foot to the level of the opposite knee joint from the starting position of both feet in contact with the floor and standing safely. The time elapses from raising the foot to contact with the floor was recorded as the test result. The test was performed bilaterally with two repetitions for each lower extremity after one practice trial, and the longest possible test period was recorded as the final score (19). Preliminary evidence supports the between-rater reliability and the test-retest reliability and convergent validity of the Mini-BESTest in heterogeneous neurological populations, including PwMS (20,21).

### Functional Mobility

The timed up and go test (TUG) is a reliable and straightforward test widely used to evaluate functional mobility. Participants were seated on a standard armless chair for this test, and a cone was placed three meters away from the chair. Patients were instructed to stand up, and (1) walk towards the cone, (2) turn around the cone, (3) walk back to the chair, and (4) sit back on the chair. Participants were given two trials to complete the TUG after one practice trial, and the average time across the two trials was computed as the final score. The TUG is a valid test for measuring functional mobility in PwMS (22).

### Gait Capacity

The gait capacity of the participants was evaluated using the two-minute walk test. The test was implemented between two cones placed 30-meter apart on a flat and quiet corridor. The participants were instructed to walk between the two cones within two minutes. Patients were allowed to rest, if needed, during the test period. After all the instructions for the test were clearly stated, no further motivational communication was provided. The total distance the patient walked in two minutes was recorded as the test result. The two-minute walk test is a valid scale for measuring gait capacity in PwMS (23).

### Statistical Analysis

Analyses were performed using IBM SPSS Statistics 21.0 (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). The variables were investigated using visual (histograms, probability plots) and analytical methods (Kolmogorov-Smirnov test) to determine whether they were normally distributed. Descriptive statistics were calculated for all variables. Normally distributed data are shown as mean ± standard deviation, non-normal distributions are shown as median (minimum-maximum), and ordinal variables are shown as frequency and percentage. Spearman correlation analysis was used to determine the relationship between the variables in patients with MS. Statistical significance was set at alpha $<0.05$. Correlation analysis results were classified as follows: 0.00-0.20 (poor correlation), 0.21-0.40 (fair correlation), 0.41-0.60 (moderate correlation), 0.61-0.80 (good correlation), and 0.81-1.00 (very good correlation) (24).

## Results

Two of the 54 participants did not meet the inclusion criteria. The MMSE scores of two MS patients were below 24 points. The study was completed with 52 PwMS. Forty-four of 52 patients were relapsing-remitting type, and eight were secondary progressive MS. Forty-eight PwMS with mild disability, and four PwMS with moderate disability were included in the study.

Demographic and clinical characteristics of the PwMS are given in Table 1. TIS, Mini-BESTest, the single-leg stance test, TUG test, and two-minute walk test results of PwMS are given in Table 2.

When the relationship of balance with trunk motor control was analyzed, all subparameters and the total points of the TIS were positively correlated with all subparameters of the Mini-BESTest between moderate and good levels, and positively correlated single-leg stance tests between fair and moderate levels in PwMS with mild to moderate disability. When the relationship

Table 1. Demographic and clinical characteristics of the participants with multiple sclerosis (n=54)

| Characteristics | | MS participants |
|---|---|---|
| **Age, years (X ± SD)** | | 40.13±9.71 |
| **BMI, kg/m² (X ± SD)** | | 25.80±4.11 |
| **Gender, n (%)** | **Female** | 35 (67.3) |
| | **Male** | 17 (32.7) |
| **Duration of illness, years [(median (min; max)]** | | 6 (1; 23) |
| **EDSS, score [(median (min; max)]** | | 2.50 (1; 4.5) |

X: Mean, SD: Standard deviation, min: Minimum, max: Maximum, MS: Multiple sclerosis, BMI: Body mass index, EDSS: Expanded disability status scale of functional mobility with trunk motor control was analyzed, all subparameters and the total points of the TIS were moderately and negatively correlated with TUG in PwMS with mild to moderate disability. When the relationship of balance with trunk motor control was analyzed, it was seen that all subparameters and the total points of the TIS were moderately and positively correlated with the two-minute walk test in PwMS with mild to moderate disability (Table 3).

## Discussion

This study investigated the relationship between trunk motor control and balance, functional mobility, and gait capacity in PwMS with mild to moderate disability. Consistent with our hypothesis, we found that trunk motor control was associated with balance, functional mobility, and gait capacity in PwMS with mild to moderate disability.

Balance deficit is a common symptom of MS. Most MS patients suffer from a spectrum of balance problems ranging from minimal disability to severe disability (4). Freund et al. (2) showed that isometric trunk flexion endurance was correlated with several postural control measures, and isometric trunk extension endurance was correlated with only one postural control parameter in PwMS. Corporaal et al. (25) reported that PwMS had significantly higher trunk sway than healthy controls, and balance was highly correlated with trunk sway for all two-legged stance tasks in

**Table 2. Trunk motor control, balance, functional mobility, and gait capacity test results of the participants with multiple sclerosis (n=54)**

| | | | Median (min; max) |
|---|---|---|---|
| Trunk impairment scale | Static seating balance | | 7 (3; 7) |
| | Dynamic seating balance | | 8 (4; 10) |
| | Coordination | | 5 (2; 6) |
| | Total | | 17 (7; 23) |
| Mini-BESTest | Anticipatory | | 5 (2; 6) |
| | Reactive postural control | | 3 (0; 6) |
| | Sensory orientation | | 5 (2; 6) |
| | Dynamic gait | | 7.5 (1; 10) |
| | Total | | 20 (6; 27) |
| | Single-leg stance test | Dominant | 7.52 (0; 120) |
| | | Non-dominant | 7.71 (0; 120) |
| TUG test (s) | | | 10.86 (5.73; 25.36) |
| | | | X ± SD |
| Two-minute walk test (m) | | | 140.3±35.85 |

X: Mean, SD: Standard deviation, min: Minimum, max: Maximum, BESTest: Balance evaluation systems test, TUG: Timed up and go test, s: Second; m: Meter

**Table 3. The investigation of the relationship of trunk motor control with balance, functional mobility, and gait capacity in participants with multiple sclerosis**

| | | | Trunk impairment scale | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Static seating balance | | | Dynamic seating balance | | Coordination | | Total | | | |
| | | | r | p | r | p | r | p | r | p |
| Mini-BESTest | Anticipatory | | 0.510 | <0.001* | 0.556 | <0.001* | 0.521 | <0.001* | 0.567 | <0.001* |
| | Reactive postural control | | 0.409 | 0.003* | 0.322 | 0.020* | 0.461 | 0.001* | 0.401 | 0.003* |
| | Sensory orientation | | 0.408 | 0.003* | 0.425 | 0.002* | 0.478 | <0.001* | 0.529 | <0.001* |
| | Dynamic gait | | 0.665 | <0.001* | 0.588 | <0.001* | 0.523 | <0.001* | 0.616 | <0.001* |
| | Total | | 0.620 | <0.001* | 0.603 | <0.001* | 0.601 | <0.001* | 0.652 | <0.001* |
| | Single-leg stance test | Dominant | 0.448 | 0.001* | 0.332 | 0.016* | 0.291 | 0.036* | 0.389 | 0.004* |
| | | Non-dominant | 0.425 | 0.002* | 0.466 | <0.001* | 0.361 | 0.009* | 0.458 | 0.001* |
| TUG test (s) | | | -0.587 | <0.001* | -0.467 | <0.001* | -0.446 | 0.001* | -0.534 | <0.001* |
| Two-minute walk test (m) | | | 0.387 | 0.005* | 0.373 | 0.006* | 0.526 | <0.001* | 0.471 | 0.001* |

*p<0.05; BESTest: Balance evaluation systems test, TUG: Timed up and go test, s: Second; m: Meter

PwMS. These results are essential in terms of supporting our study results. We found that all subparameters and the total points of the TIS were correlated with all subparameters of the Mini-BESTest and single-leg stance tests in PwMS with mild to moderate disability. Also, our results showed that trunk motor control is more critical to achieving balance, especially when the support surface is reduced and during anticipatory postural adjustments, postural responses to perturbations, sensory orientation, and dynamic gait in PwMS with mild to moderate disability. Postural stability of the trunk is a component of balance and optimal core/trunk muscle activation, a prerequisite for anticipatory postural adjustments and compensatory postural adjustments (9,26,27). Trunk control is associated with balance in PwMS with mild to moderate disability, considering the importance of trunk control in maintaining balance.

Functional mobility, a subparameter of mobility, decreases in PwMS (22). Freund et al. (2) showed that PwMS trunk flexion endurance was positively correlated with gait speed and step activity. Corporaal et al. (25) showed that the trunk sways of PwMS increased more during walking tasks than healthy individuals. In accordance with the literature, we reported that all subparameters and the total points of the TIS were correlated with the TUG test in PwMS with mild to moderate disability. The TUG measures walking speed, muscle function, balance, agility, and coordination components. The features of the TUG (e.g., sitting-to-standing, walking, turning) are essential for activities of daily living and maintenance of independence (22). Core muscle activation is vital for movement quality while walking, and impairments in this area may lead to fewer and shorter steps, a reduced gait speed, increased fall risk, decreased activities of daily living, and increased cognitive attention toward walking (3,28,29,30,31). Also, trunk stability provides proximal stability for distal mobility during many activities, such as gait and running, and helps to maintain and change posture. Functional mobility may be related to trunk motor control. The trunk functions are the critical points during balance activities, such as sitting-to-standing, turning, and walking activity, which are subparameters of functional mobility in PwMS with mild to moderate disability.

Gait disorders are very common in PwMS. They present throughout the disease, generally with no apparent disability (EDSS 0-1.5), and often worsen over time. PwMS walk more slowly than age- and sex-matched healthy controls during the TUG test (32). We found that all subparameters and the total points of the TIS were correlated with the two-minute walk test results in PwMS with mild to moderate disability. Ketelhut et al. (33) examined the relationship between trunk muscle activity and walking. They found that the activity levels of obliquus externus, obliquus internus, and rectus abdominus muscles were increased on the less affected side. Also, the volume of transversus abdominus, quadratus lumborum, and lumbar extensor muscles was greater on the more affected side in PwMS with no visible gait disturbance.

The researchers stated that this was a necessary compensatory strategy to maintain balance and posture during walking in PwMS (33). This study shows that compensatory mechanisms to maintain balance in the trunk begin to develop while walking despite no visible gait disturbance and supports the relationship between the trunk and walking. Optimal trunk control is required to control proper gait patterns and extremity movements during many activities (34,35). In addition, the changes in gait reported in PwMS in the present study are consistent with their reported changes in balance control. Walking may be seen as a sequence of standing still, leaning forward, and then catching oneself with one foot. PwMS have an impaired ability to stand still, lean, and respond to the perturbation produced by leaning. Thus, the changes in gait observed in PwMS are primarily the result of changes in postural control (3). Based on this information, the decrease in trunk control causes balance disturbance and affects gait. Therefore, trunk motor control is related to gait.

### Study Limitations

The limitations of our study were that MS patients with only mild to moderate disability were included in the study, and lower limb muscle strength and sensation were not evaluated.

## Conclusion

In conclusion, our study showed that trunk motor control was related to balance disorder and functional mobility and gait capacity disorders in PwMS with mild to moderate disability. These results suggest that a more detailed assessment of the trunk is essential to plan an effective rehabilitation program for the protection and development of balance, functional mobility, and gait capacity in PwMS with mild to moderate disability.

### Ethics

**Ethics Committee Approval:** This study was approved by the Ankara Yildirim Beyazit University Local Ethics Committee (date and decision no: 13.11.2019-19).

**Informed Consent:** Also, written informed consent was obtained from all the participants who participated in the study.

**Peer-review:** Externally peer-reviewed.

### Authorship Contributions

Concept: N.Ö.Ü., T.Ö., Y.A., Ö.A., Design: N.Ö.Ü., T.Ö., Y.A., Ö.A., Data Collection or Processing: M.E.Y., Analysis or Interpretation: N.Ö.Ü., T.Ö., Y.A., Literature Search: N.Ö.Ü., T.Ö., M.E.Y., Y.A., Writing: N.Ö.Ü., T.Ö., M.E.Y., Y.A.

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