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RESEARCH ARTICLE

Investigating the Relationship Between Balance and Upper Extremity Function in People with Multiple Sclerosis

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Abstract

Objective: Upper extremity dysfunction and balance problem are two important symptoms that are common in individuals with multiple sclerosis and reduce their quality of life. However, there is limited evidence of a direct relationship between these two symptoms. Therefore, this study aims to reveal the relationship between balance and upper extremity function, which is essential for pwMS.

Materials and Methods: Nine hundred and sixty-six patients were included [681 (70.5%) female, 285 (29.5%) male]. The Nine-Hole Peg Test (9HPT) was applied to evaluate upper extremity function. With the Activity-Specific Balance Confidence (ABC) Scale patients evaluated their confidence in their balance during activities and balance was tested with the The Timed Up and Go (TUG) test.

Results: There was a significant moderate positive correlation between the 9HPT and TUG (rho=0.566) and a moderate negative correlation with ABC score (rho=-0.464) in total participants. However, while there was a significant moderate negative correlation between 9HPT and ABC score in relapsing form, there was no relationship between 9HPT and TUG in pwMS with progressive form.

Conclusion: There is a significant relationship between upper extremity function and balance. In addition, the trunk, upper and lower extremities should be considered as a whole, since distal stabilization cannot be achieved without poximal stabilization. Consideration should be given to the upper extremity within the scope of balance assessments.

Keywords: Balance, multiple sclerosis, upper extremity

Introduction

Multiple sclerosis (MS) is an inflammatory demyelinating disease of the central nervous system (CNS) resulting in chronic, progressive disability resulting from genetic and environmental factors (1,2). Although the incidence and prevalence of the disease are increasing, it is more common in females and at the age from 20 to 40 years (3,4). Although the symptoms differ according to the area of neurological involvement, the most common symptoms are motor and sensory impairments, cerebellar symptoms, vision loss, pain, bladder dysfunction, and cognitive impairment in people with MS (pwMS) (5,6).

Lower extremity dysfunction is the most common motor disorder reported in 75% of pwMS (7). Lower extremity dysfunction causes a decrease in walking capacity from the early stages of the disease, and it is evident even in patients with low Expanded Disability Status Scale (EDSS) scores (8,9). Therefore, studies have focused on lower extremity function, and upper extremity dysfunction has not been adequately defined (9). Recent studies have shown that upper extremity dysfunction is a widespread motor symptom at a rate of 66% regardless of the disease stage and it affects bimanual activities of daily life such as changing clothes, washing hands, and eating (9-11). The general activity level and participation in daily life decrease due to upper extremity dysfunction, and this circle causes a worse quality of life (12).

Another common symptom that reduces the quality of life, mobility, and independence in pwMS is a balance disorder which reported by pwMS around 75% (13,14). There are three abnormalities associated with balance control in pwMS: lack of postural stability, reduced limits of stability, and slowness to

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return to the starting position when bending over or performing reaching movements (15). During the activities of daily living, the person interacts with the environment (16). Many stimuli from the environment are perceived by the proprioceptive input of the lower and upper extremities (16). Proper trunk control is necessary for obtaining correct proprioceptive input for a proper upper extremity function and subsequent balance (17). Trunk and balance control should be considered for standing activity and for independent upper extremity activities and task performance that requires dexterity (18). As a result, the trunk has a proximal stabilizer role in providing distal mobility, and the reverse of this relationship can be examined in terms of the effect of the extremities on the trunk (19).

At the same time, the use of functional upper extremities is important in providing postural stability and balance compensation movements (20). Considering all these components that provide interaction with the environment, maintaining the balance and using the upper extremity function correctly are essential for daily life, activity, and participation (21).

There are question marks about the relationship between these two common symptoms (21). Chua et al. (22) stated that applying an internal perturbation originating from the upper extremity with functional movement integrated into the balance program would be helpful in determining balance strategies. As a result, when pwMS's participating in daily living activities, both balance strategies and upper extremity functions are of great importance. Furthermore, the inclusion of exercise programs is emphasized. Apart from all these mentioned points, another point that causes a slight difference in the symptoms of pwMS in their daily lives is the type of disease (relapsing form/progressive form) (23). The transition to the progressive form causes an effect in daily life as a result of the increase in symptoms over time, although pwMS do not realize this at the beginning (23). However, little is known about the interrelationship of these two crucial issues. Therefore, this study aims to reveal the relationship between balance and upper extremity function, which is essential for pwMS. The secondary aim of our study is to reveal how MS type affects the relationship between balance and upper extremity.

Materials and Methods

Study Design

This cross-sectional study was implemented in the MS Center of Dokuz Eylul University. The baseline data used in the analyses were obtained from the ongoing data on "Follow-up of physical, psychosocial and cognitive influences in people with multiple sclerosis: a prospective cohort study" (ClinicalTrials.gov identifier: NCT03878836). The research protocol was approved by the Dokuz Eylul University University Ethics Committee (protocol number: 2959-GOA and approval number: 2016/27-08). Written consent was obtained from all individuals participating in the study.

Participants

The inclusion criteria were having MS based on the 2017 version of McDonald's criteria (24) and a relapse-free period of at least 30 days. The exclusion criteria were relapse during the study period, having another neurological disorder or any orthopedic surgery history comprising the hip, knee, ankle-foot, or spine, affecting balance and gait. The data of eligible people with MS were obtained from the registry database [iMed (version 6.9.0; MSBase Foundation)] collected between October 2016 and October 2020 for the current study.

Outcome Measures

Demographic and clinical characteristics of the pwMS, such as gender, age, disease duration, MS type, and MS diagnosis year, were recorded from the medical reports.

The EDSS is the most widely used scale to assess disability in people with MS (25). EDSS scoring is based on the neurological examination of eight functional systems and the patient's ambulation status. Functional systems are pyramidal, cerebellar, brainstem, sensory, bladder and intestinal, visual, cerebral, and others (25). The same neurologist calculated EDSS scores of all people with MS by examination.

The Nine-Hole Peg Test (9HPT) is a valid, reliable, and widely used tool to measure finger dexterity in pwMS (26). Test materials consist of nine holes on a flat, a small test battery, and nine matching rods. The subjects are asked to take the sticks one by one from the chamber in the test battery and place them into the holes on the battery, then take the sticks out of the holes and put them back into the chamber. Two repetitions are performed for both extremities, and the score is recorded in mean time (26).

The Activity-Specific Balance Confidence (ABC) Scale, consisting of 16 items, is a reliable and valid measurement tool for pwMS. Participants were asked to rate their confidence in their balance between 0% (no confidence) and 100% (full confidence) while performing 16 different daily activities (27).

The Timed Up and Go (TUG) Test is a reliable, simple, and objective measurement method for assessing balance and functional mobility (28). The person is asked to get up from a chair, walk 3 meters, turn around, walk back to the chair, and sit, and the score is calculated by measuring how many seconds he or she completes the test (28).

Statistical Analysis

Normal distribution of data was checked using the Kolmogorov-Smirnov test and histograms. Since the data showed non-normal distribution, non-parametric statistics were used. Descriptive analyses were presented by giving median and interquartile ranges for continuous variables and numbers and percentages for categorical variables. The Spearman's correlation coefficients were used to investigate the relationship between the balance and upper extremity function. A correlation ≤0.30 was considered small, between 0.31 and 0.59 as moderate, and ≥0.60 as strong (29). Statistical significance was set at p<.05. Data were analyzed using the IBM® SPSS® Statistics software (Version 25.0. Armonk, NY: IBM Corp.).

Results

A total of 966 pwMS were included in this study. The mean EDSS of the study participants was 1.56±1.66 (range: between 0 and 6.5). There was a significant difference between pwMS with relapsing form and pwMS with progressive form in all variables (p<0.05). Demographic and clinical characteristics of the pwMS are shown in Table 1.

There was a significant moderate positive correlation between the N-HPT and TUG (rho= 0.566) and a moderate negative correlation with ABC score (rho= -0.464) in all participants. The relationship between N-HPT and TUG and ABC score was consistent in pwMS with relapsing form. However, while there was a significant moderate negative correlation between N-HPT and ABC score, there was no relationship between N-HPT and TUG in pwMS with progressive form (Table 2).

Discussion

This study reveals a moderate correlation between upper extremity function and balance, which are two essential parameters that should be followed from an early period of MS. Symptoms in pwMS often appear as a cluster of symptoms rather than a single problem. The resulting cluster of symptoms reduces the quality of life by affecting the activities of daily living and participation (30,31).

Johansson et al. (7) reported that 76% of pwMS, whose EDSS scores ranged from 0 to 9.5, had manual dexterity problems. Bertoni et al. (11) reported that 75% of pwMS had bilateral upper extremity dysfunction, even at an early stage of the disease. When bilateral upper extremity involvement is examined according to ICF, upper extremity dysfunction, impaired tactile sensitivity, and decreased muscle strength are found to be mostly reported impairment at the body structure and functions level (11). At the activity level, limitations in object manipulation were observed even in individuals with an EDSS score below four and in gross motor movements and muscle strength in individuals with EDSS >6.5 (11). Subsequently, these problems affect the performance of many participation activities, thus reducing functional independence and quality of life (26,27,31)

Balance impairment, another element of the symptom cluster, is a common symptom that increases the risk of falling and limits life activities in pwMS (32). Among the causes of balance impairment that increase the risk of falling are motor dysfunction, sensory disturbances, lack of integration of sensory inputs, and inadequate motor response (14). It has been stated that somatosensory disorders in individuals with MS are the predictors of balance limitation (16). Although the sense of proprioception, touch, and vibration are more affected in the lower extremities than in the upper extremities, the involvement of both extremities is associated with balance limitation (16).

Table 1. Demographic and clinical characteristics of the participants

	All participants (n=966)	pwMS with relapsing course (n=911)	pwMS with progressive course (n=55)	p value
Age (years)	36.0 (15.0)*	35.0 (16.0)*	48.0 (14.0)*	<0.001
Gender, n				
Female	681 (70.5%)	651 (71.5%)	30 (54.5%)	0.008
Male	285 (29.5%)	26 (28.5%)	25 (45.5%)	
EDSS score, possible range: 0-10	1.5 (2.0)*	1.0 (2.0)*	6.0 (0.50)*	<0.001
Disease duration (years)	5.0 (10.0)*	5.0 (9.0)*	16.0 (8.0)*	<0.001
Classification				
CIS	4 (0.4%)	4 (0.4%)	NA	-
RRMS	907 (93.9%)	907 (93.9%)	NA	
SPMS	43 (4.5%)	NA	43 (4.5%)	
PPMS	12 (1.2%)	NA	12 (1.2%)	
N-HPT	20.62 (5.21)*	20.43 (4.60)*	28.05 (8.91)*	<0.001
TUG, sec.	7.31 (2.69)*	7.19 (2.26)*	20.96 (18.69)*	<0.001
ABC, possible range: 0-100	84.38 (36.88)*	86.25 (32.5)*	38.13 (29.38)*	<0.001

*Values are presented as median (interquartile range) unless specified.

EDSS, Expanded Disability Status Scale, CIS: Clinically isolated syndrome, RRMS: Relapsing-remitting multiple sclerosis, SPMS: Seconder progressive multiple sclerosis, PPMS: Primer progressive multiple sclerosis, N-HPT: Nine-Hole Peg test, TUG: The Timed Up and Go test, NA: Not applicable

Table 2. Correlation between upper extremity function and balance in pwMS

	Total participants			pwMS with relapsing course			pwMS with progressive course		
Test variables	N-HPT	TUG	ABC	N-HPT	TUG	ABC	N-HPT	TUG	ABC
N-HPT	1.000			1.000			1.000		
TUG	0.566**	1.000		0.518**	1.000		0.179	1.000	
ABC	-0.464**	-0.572**	1.000	-0.407**	-0.517**	1.000	-0.433**	-0.063	1.000

pwMS: People with MS, N-HPT: Nine-Hole Peg Test, TUG: The Timed Up and Go test

**Correlation is significant at the 0.01 level (2 tailed)

Aruin et al. (33) investigated the effect of Anticipatory Postural Adjustments (APAs) control-focused training, including ball throwing, on improving balance control in pwMS. They showed that perturbation occurred with arm activation and APA formation, which is seen as early muscle activation, increased (33). This result has provided preliminary evidence that balance and postural control are involved in maintaining movement during upper extremity function (33). In another study examining the relationship between upper extremity movement and postural stability, it was stated that participation of the postural system was required to maintain balance depending on the strength of upper extremity movement (34). Chua et al. (22) revealed an increase in balance corrections due to perturbation provided by arm movements during the balance provided in fixed stance. Similarly, as in above- mentioned studies, our findings support the relationship between balance and upper extremity functions.

Study Limitations

We should note that our study has some limitations. First, we did not assess the trunk stabilization, which is necessary to perform upper extremity function. Second, using more objective measurement methods would have given us better results. Using the measurement of postural stability limits as an objective method to evaluate the relationship between balance and upper extremity could strengthen our study. We recommend using these measurement methods for future studies. Finally, using the cut-off value in our measurement methods could have been sharper to classify in terms of disability.

Conclusion

As a result, it is necessary to maintain balance during the upper extremity activities such as dressing, cleaning, and transfer activities in daily life. At the same time, since distal stabilization cannot be achieved without proximal stabilization, the trunk, upper and lower extremities should be considered as a whole. Within the scope of balance assessments, the upper extremity should be given as much importance as the lower extremity.

Ethics

Ethics Committee Approval: The research protocol was approved by the Dokuz Eylul University Ethics Committee (protocol number: 2959-GOA and approval number: 2016/27-08).

Informed Consent: Written consent was obtained from all individuals participating in the study.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: N.A.Y., Concept: S.D., N.A.Y., A.T.O., Design: S.D., N.A.Y., A.T.O., Data Collection or Processing: S.D., N.A.Y., A.T.O., Analysis or Interpretation: A.T.O., Literature Search: S.D., A.T.O., Writing: S.D., A.T.O.

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