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RESEARCH ARTICLE

Association Between Lower Limb Spasticity and Falls in Persons with Multiple Sclerosis

Zuhal Abasıyanık[1,2], Cavid Baba[1], Turhan Kahraman[2], Ozge Ertekin[4], Serkan Ozakbas[3], *on behalf of Multiple Sclerosis Research Group*

[1]Dokuz Eylul University, Graduate School of Health Sciences, Izmir, Turkey
[2]Izmir Katip Celebi University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Izmir, Turkey
[3]Dokuz Eylul University Faculty of Medicine, Department of Neurology, Izmir, Turkey
[4]Dokuz Eylül University, School of Physical Therapy and Rehabilitation, Izmir, Turkey

Abstract

Objective: Falls and spasticity are among the most prevalent complaints in persons with multiple sclerosis (pwMS). Limited evidence exists on the direct relationship between lower limb spasticity and falls in pwMS. This study aimed to explore the association between lower limb spasticity, walking, and falls in pwMS.

Materials and Methods: Thirty-nine patients were included (age: 35.4±9.52; 54% female, 46% male). The timed 25-foot walk (T25FW) and multiple sclerosis walking scale-12 (MSWS-12) were applied to evaluate walking. Participants reported their number of falls within the last three months. The severity of spasticity in lower limb muscles, comprising hip adductors, knee flexors and extensors, and plantar flexors, was tested using the modified ashworth scale.

Results: Fifteen participants were fallers. Spasticity levels in the ankle plantar flexors were significantly greater ($p=0.009$) in fallers. The number of falls correlated with ankle plantar flexors and knee extensors (rho=0.497, rho=0.329; $p<0.05$, respectively). The severity of spasticity in all muscle groups was negatively correlated with walking (rho=0.335-0.692, $p<0.05$).

Conclusion: There was a significant correlation between the degree of ankle plantar flexor and knee extensor spasticity and the number of falls in pwMS. This significant association between spasticity and fall history highlights the importance of designing therapeutic interventions optimizing lower limb spasticity.

Keywords: Multiple sclerosis, falls, walking, gait, spasticity

Introduction

Multiple sclerosis (MS) is an inflammatory disease characterized by delay and/or blockage in nerve conduction in neurons via myelin fibers and axonal damage. Various heterogeneous symptoms occur due to the dysfunctional nerve conduction (1,2).

Spasticity is among the most common motor manifestations of MS resulting from central nervous neurodegeneration (3). Despite periodic changes, nowadays, spasticity is defined as "involuntary muscle hyperactivity in the presence of central paresis" by the Interdisciplinary working group movement disorders (4).

The prevalence of spasticity ranges from 52% to 84% in the MS population (5,6). Although spasticity occurs in the upper limbs, lower limb spasticity is predominant in MS. Several studies have revealed that lower limb spasticity related to walking, postural control, and severe disability profoundly affects the quality of life in persons with multiple sclerosis (pwMS) (7,8). Furthermore, spasticity affects daily life activities in those with MS (9).

Address for Correspondence: Zuhal Abasıyanık, Dokuz Eylul University, Graduate School of Health Sciences, Izmir, Turkey
E-mail: zuhalabasiyanik@gmail.com **ORCID-ID:** orcid.org/0000-0003-3086-8102
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Falls are one of the most frequent problems influencing the quality of life in MS. Many motor, sensory, cognitive, psychosocial, and clinical factors related to falls have been described recently (10-12). So far, the association between spasticity and falls has been explained based on the assumption that lower limb spasticity influences mobility in pwMS. There is limited empirical evidence on the direct link between lower limb spasticity and falls in pwMS. This pilot investigation aimed to expand previous findings on the relationship between spasticity and walking exploring the correlations between lower limb spasticity and falls in pwMS.

Materials and Methods

Participants and Procedure

The participants were directly recruited from the MS Clinic of the Dokuz Eylul University. Written informed consent was received from all subjects. A secondary data analysis was approved by the Dokuz Eylul University Ethics Committee (approval number: 2017/14-07). The inclusion criteria comprised a clinically definitive diagnosis of MS, age range between 18-64 years, relapse-free within 30 days. Participants were excluded based on the presence of a neurological disorder beside MS, non-ambulatory, musculoskeletal disorder that may affect balance and gait, and severe cognitive impairment preventing understanding of the assessments.

Assessments

Participants underwent an expanded disability status scale assessment by a senior neurologist (13). Age, sex, and clinical course of MS were recorded.

Spasticity

Spasticity of the lower limb muscles, including hip adductors, knee flexors, extensors, and ankle plantar flexors of both limbs, was bilaterally tested by a physiotherapist using the modified ashworth scale (MAS) including every other assessment. The MAS is a six-point scale (from 0 to 4) assessment. The average MAS scores of both legs were calculated for the data analysis (14).

Falls

A fall was defined as "an event where the participant unintentionally landed on the ground or a lower level." Participants reported their number of falls within the last three months. Since falls were reported retrospectively, this period was chosen to avoid recall bias. Faller participants were those who reported at least one fall over the last three months.

Walking

The fastest walking speed was tested using timed 25-foot walk (T25FW) test in a 7.62-meter walkway (15). The impact of the disease on walking ability from the patient perspective was evaluated using the 12-item multiple sclerosis walking scale-12 (MSWS-12) (16).

Statistics Analyses

All data analyses were conducted using SPSS version 25.0 (Armonk, NY: IBM Corp). Since the MAS comprises a 1+ score, raw scores were converted to a 0-5 point scale (17). Variable distributions were checked for normality using the Shapiro-Wilk W test, the histogram and plot investigation. Chi-square/Fisher's Exact test and Mann-Whitney U tests were used to test for group disparities. Spearman Rank correlation coefficients were measured to ascertain the association between spasticity, number of falls, and walking. The correlation coefficients between 0.1 and 0.29, 0.3 and 0.49, and 0.5 and 1.0 were considered weak, moderate, and strong correlations, respectively. The significance level was set at $p<0.05$.

Results

The medians and interquartile ranges of the entire group, fallers, non-fallers for the demographics and clinical information are illustrated in Table 1. Of the 39 pwMS, 15 (38.46%) were fallers.

Group differences for the degree of spasticity and walking between fallers and non-fallers are displayed in Table 2. The

Table 1. Demographic and clinical characteristics of the participants

	Total (n=39)	Fallers [n=15 (38.46%)]	Non-fallers [n=24 (61.54%)]
Age (years)	35.4±9.52	37.7±9.28	34.5±8.95
Gender, n (%)			
Female	21 (53.84%)	9 (60%)	13 (54.17%)
Male	18 (46.15%)	6 (40%)	11 (45.83%)
EDSS (0-10)	2.69±1.25	2.8±1.25	2.62±1.27
Clinical course of MS, n (%)			
Relapsing-remitting	35 (89.7%)	13 (86.7%)	22 (91.7%)
Secondary-progressive	4 (10.3%)	2 (13.3%)	2 (8.3%)

p>0.05 for all variables, EDSS: Expanded disability status scale, MS: Multiple sclerosis

Table 2. Comparison of spasticity and walking scores between fallers and non-fallers

	Fallers (n=15)	Non-fallers (n=24)	p
Hip adductors	1 (0-1.5)	0.5 (0-1)	0.484
Knee extensors	0 (0-1)	0 (0-0.5)	0.135
Knee flexors	1 (0.25-1.75)	0 (0-1)	0.071
Ankle plantar flexors	2.5 (2.0-3.0)	1 (0.25-2)	0.009*
T25FW	7.59 (4.44-9.19)	5.91 (5.04-8.34)	0.246
MSWS-12	39 (29-44.5)	37.5 (20.5-46)	0.484

*p<0.05, T25FW: Timed 25-foot walk, MSWS-12: Multiple sclerosis walking scale

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Table 3. Correlation coefficients between the degree of spasticity in lower limbs and other outcome measures

	Number of falls		T25FW		MSWS-12	
	rho	p	rho	p	rho	p
Hip adductors	0.144	0.38	0.595	$<$0.001*	0.440	0.05*
Knee extensors	0.329	0.04*	0.390	0.014*	0.335	0.037*
Knee flexors	0.315	0.055	0.372	0.02*	0.372	0.02*
Ankle plantar flexors	0.497	0.05*	0.692	$<$0.001*	0.610	$<$0.001*

*p<0.05, T25FW: Timed 25-foot walk, MSWS-12: Multiple sclerosis walking scale

degree of spasticity in the ankle plantar flexors was significantly greater (p=0.009) in fallers than in non-fallers. Other outcomes disclosed no significant differences between the two groups (p>0.05).

Correlations coefficients between the spasticity scores and the number of falls, and walking scores are represented in Table 3. There were moderate associations between the number of falls and spasticity in the ankle plantar flexors and knee extensors (rho=0.497, rho=0.329; p<0.05, respectively). Spasticity of the entire lower limb was correlated with walking scores. Strong correlations between spasticity severity in the ankle plantar flexors and T25FW (rho=0.692) and MSWS-12 (rho=0.610) were found. The degree of spasticity of the hip adductors was strongly correlated with T25FW (rho=0.595). There were moderate correlations between spasticity severity in the knee flexors and knee extensors and walking performance (rho=0.335-0.390, p<0.05).

Discussion

This study aimed to clarify the direct association between lower limb spasticity and falls in pwMS. The three main findings from this pilot study included (1) A significant association between the number of falls and severity of the spasticity in ankle plantar flexors and knee extensors; (2) Greater spastic severity in ankle plantar flexors than in non-fallers; (3) Performance and perceived walking ability were associated with the severity of spasticity in hip adductors, knee flexors, extensors, and ankle plantar flexors.

These results were similar to some studies reporting an association between lower limb spasticity and walking in pwMS (5,18). Additionally, it has been revealed that individuals with lower limb spasticity have more impaired spatiotemporal parameters and decreased range of motion than those without spasticity (8,19). However, most previous studies have questioned overall spasticity, which was not reported in different muscle groups. Spasticity affects different muscle groups in different locations, including hip adductors, knee extensors and flexors, and triceps surae muscles in pwMS (3). Similar to this study was Norbye et al. (18) who evaluated the same muscle groups with MAS and reported a similar significant correlation between the 2-minute walk test and severity of spasticity in plantar flexors and knee extensors (rho=-0.69 and rho=-0.45, respectively). Plantar flexor spasticity is more associated with gait in both studies confirms the importance of ankle motor control on gait (20). Further exploration is needed to examine the effects of plantar flexor spasticity on gait metrics using instrumental tests at different disability levels.

The significant relationship between spasticity in knee extensors, ankle plantar flexors, and the number of falls complies with the findings of Nilsagård et al. (21). They found a significant association between the mean spasticity level of the lower limbs and falls, and spasticity was a predictor of falls. In contrast, Cattaneo et al. (22) did not delineate an association between the spasticity scores of the most spastic quadriceps, plantar flexors, and falls. In this study, the mean value of both limbs was analyzed, similar to the Nilsagård et al. (21). Moreover, the only measurement that differed between fallers and non-fallers was plantar flexor spasticity. This could be explained by the fact that the activation of plantar flexors suppresses the dorsiflexors during walking and decrease the foot clearance during the swing phase. However, the degree of spasticity in the hip adductors, knee flexors, and walking outcomes was not significantly correlated with the number of falls in this study. We believe this finding may be attributable to having a similar overall disability score in the fallers and non-fallers.

Study Limitations

Although we included a similar number of participants in studies examining spasticity in pwMS, the small sample size is a limitation of our study. Moreover, our findings for associating spasticity and fall cannot be generalized to non-ambulatory pwMS since only ambulatory participants were included. Although there is no gold-standard measurement, we evaluated spasticity using MAS based on subjective clinical assessment rather than instrumented measurements. Furthermore, detailed assessment methods that include rapid passive joint movements, could be more effective in evaluating the existence and severity of spasticity.

Conclusion

Our findings demonstrated a significant association between the degree of ankle plantar flexor and knee extensor spasticity and the number of falls in pwMS. The plantar flexors were the muscle group most associated with falling and walking. Furthermore, our results confirmed the previous studies regarding the significant association between walking and lower limb spasticity in pwMS. This significant association between spasticity and fall history highlights the importance of designing therapeutic interventions to optimize lower limb spasticity. Moreover, larger sample studies are needed to explore the relationship between spasticity severity in the lower extremities and falls across different disability levels.

Ethics

Ethics Committee Approval: A secondary data analysis was approved by the Dokuz Eylul University Ethics Committee (approval number: 2017/14-07).

Informed Consent: Written informed consent was received from all subjects.

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Authorship Contributions

Surgical and Medical Practices: C.B., Concept: Z.A., C.B., T.K., O.E., S.O., Design: Z.A., T.K., O.E., S.O., Data Collection or Processing: Z.A., C.B., Analysis or Interpretation: Z.A., O.E., S.O., Literature Search: Z.A., O.E., Writing: Z.A., O.E., S.O.

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