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Different levels of physical activity and postural balance in women with multiple sclerosis

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HIGHLIGHTS

• Higher level of physical activity is related to better postural balance in women with Multiple Sclerosis with mild and moderate disability.
• CoP speed and Cop area were sensitive posturography parameters for the postural balance measurement.
• Different strategies to increase physical activity levels and posture balance in women with Multiple Sclerosis should be development.

ABBREVIATIONS

CoP	Center of pressure
EDSS	Expanded Disability Status Scale
ES	Effect size
FAMS	Functional Assessment of Multiple Sclerosis
FSS	Fatigue Severity Scale
HL	High-level
LL	Low-level
MFIS	Modified Fatigue Impact Scale
MS	Multiple Sclerosis
PA	Physical activity
PDDS	Patient Determined Disease Scale
pwMS	People with MS
QoL	Quality of life
TUG	Timed Up and Go
6MWT	6 Minutes Walking Test

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BACKGROUND: Multiple Sclerosis (MS) presents some clinical manifestations that may indicate motor, sensory and cognitive dysfunctions. Motor dysfunctions in MS are related to balance impairment, muscle weakness, gait, and fatigue and can lead to a significant decrease in quality of life. Postural balance is crucial for daily life activities and can be assessed by posturography.
AIM: The primary objective was to evaluate the influence of different levels of habitual physical activity (PA) on postural balance in women with MS. Additionally, we included an evaluation of walking, mobility, fatigue, and quality of life.
METHOD: This is a cross-sectional study with 25 women with MS. Habitual PA was measured using the Baecke-Questionnaire, separated into low-level (LL) and high-level (HL) PA. Posturography was used to evaluate postural balance and obtain displacement of the center of pressure (CoP-speed, CoP-area). We evaluated gait spatiotemporal-parameters (GAITRite), walking performance (6MWT), functional mobility (TUG), fatigue (FSS, MFIS), and quality-of-life (FAMS).
RESULTS: The difference in CoP-speed and CoP-area was significant ($p < 0.05$) with LL group presented greater values than the HL group. We found a medium effect size CoP-speed (Cohen's d = 0.6) and higher CoP-area (Cohen's d = 1.1). No significant differences with the other variables were found.
CONCLUSION: The results showed that the group with a LL PA presented worse postural balance compared to the group HL. Although level of PA and balance seem to be related, the results of this cross-sectional study could not confirm a causal inference. It is important to develop different strategies to increase PA levels and posture balance in women with MS.

KEYWORDS: Posturography | Functional performance | Center of pressure

INTRODUCTION

Multiple sclerosis (MS) is an inflammatory disorder of the brain and spinal cord in which focal lymphocytic infiltration leads to damage of myelin and axons [1]. MS is one of the world's most common neurologic disorders, and in many countries, it is the leading cause of nontraumatic neurologic disability in young adults, with a female predominance (ratio 2:1) [2]. In most patients, MS clinical manifestations indicate motor, sensory and cognitive dysfunctions [1]. Some dysfunctions in people with MS (pwMS) are related to balance problems, muscle weakness, abnormal walking, spasticity, and fatigue [3,4]. In fact, motor dysfunction is associated with physical and psychological disabilities and a variety of other functional limitations that have a significant impact on the individual's daily life [5].

Meta-analyses and systematic reviews of randomized controlled trials have demonstrated that pwMS who engage in exercise and lifestyle physical activity (PA) experience many benefits. And evidence-based guidelines have been developed to increase the level of PA in pwMS [6,7]. However, pwMS typically engages in low levels of health-promoting PA compared with adults from the general population [7]. The concept of PA can be defined as any bodily movement initiated by skeletal muscle contraction that leads to energy expenditure and includes the two domains *lifestyle* PA (leisure, occupational, or household activities) and *exercise* [8]. The term exercise refers to bodily movements within a study's structured exercise intervention, while the term PA considers both domains which are assessed by actigraphy or questionnaires [9]. These two activities are distinct from *rehabilitation* [8]. Rehabilitation in MS involves strategies to improve or maintain function, prevent complications and enhance quality of life. Therefore, interventions in PA and physical rehabilitation aim to improve not only walking performance and balance, but also other aspects such as strength, spasticity, fatigue, and quality of life [4,10–12]. Due to its wide impact on the individual's health and overall well-being, the measurement of PA, postural balance, and other domains (physical, cognition, and psychosocial) are increasingly described as an important piece of information in the assessment of pwMS [6,10,13].

The deficits in pwMS can result in postural instability and gait abnormalities which are associated with accidental falls and fear of falling [11]. PwMS walk slower, taking shorter steps, with increased step width, and spend more of their gait cycle in double support phase than their healthy peers [14–16]. Problems with postural balance represent one of the worst symptoms experienced by pwMS, affecting almost 90% of this population [12,17]. Postural balance is the ability of the body to pre-empt or react to conditions threatening stability and maintain or adjust body position to prevent a fall [11,12]. Postural balance deficits in MS are conceptualized as three interrelated problems: decreased ability to maintain position, limited and slowed movement towards limits of stability, and delayed responses to postural displacements and perturbations [12,18]. Other potential benefits associated with PA include improvements in strength and muscle activity, improvement in functional capacity, enhanced cognitive function, and neurobiological processes that could promote neuroprotection and neuroplasticity, and reduce long-term disability [19]. These affect multiple sensorimotor processes (visual, vestibular, proprioception) to generate coordinated movements that maintain the center of pressure (CoP) within the limits of stability, improving balance and gait patterns [20].

It is well known that posturography in MS can detect balance deficits early, even when there is minimal or no clinically detected disability [18,21,22]. Posturography is a consistent tool for classifying individuals with MS, even in homogeneous MS samples. It reveals subtle postural balance decreases in pwMS that would usually be untraceable using clinical scales [21,23–26]. Static posturography involves the electronic evaluation of the center of pressure (CoP), recording a wide range of parameters [27]. The CoP displacement speed (CoP speed) and CoP 95% elliptical area (CoP area) are sensitive parameters for the assessment of balance impairment. They are able to detect changes in balance from early stages to severe stages of disability in MS [23].

The role of physical rehabilitation in improving postural balance deficits and in reducing fear and the risk of accidental falls is well established [21,22,29]. The degree of pwMS disability does not seem to be the main factor influencing participation in PA [30]. Functional capacity and performance are domains of a functional status of pwMS that should be further explored to optimize care. However, little is known about functional performance as a measure of habitual PA [3]. Furthermore, only a few studies compared different levels of habitual PA and postural balance using posturography in homogeneous MS samples [3,21]. In this study we hypothesized that women with relapsing-remitting MS, and low level of PA would have worse performance in postural parameters than the group with a high level of PA. We aim to evaluate different levels of habitual of PA on postural balance, in women with MS by using static posturography. As a secondary purpose, we included an evaluation of gait spatiotemporal parameters, walking performance, functional mobility, fatigue, and quality of life.

METHODS

Participants

The sample of this cross-sectional study included 25 women with relapsing-remitting Multiple Sclerosis. Participants were recruited from neurologist and physiotherapist referrals and advertisements in clinics. All volunteers underwent medical evaluation. The Expanded Disability Status Scale (EDSS) was used to determine neurological impairment and disability [31] and Patient Determined Disease Scale (PDDS) to define the impact of the disease on mobility [32]. Eligibility criteria: clinical diagnosis of relapsing-remitting MS according to the 2017 McDonald criteria [33]; EDSS ≤ 6.0; PDDS≤ 5; aged > 18 years; having had the same drug therapy for the last three months and not relapse in the last six months. The assessment took place on two different days with 24 hours for rest. The exclusion criterion was not having attended one of the tests. Patients who met the inclusion criteria signed a term of free and informed consent in accordance with the Declaration of Helsinki. Ethical approval for this study was obtained from the Research Ethics Committee FS-UnB (CAAE: 66560117.0800005346).

Measures Day 1

Habitual physical activity

Habitual PA level was assessed using the Baecke-Questionnaire. It is an easy-to-use recording tool for the past 12 months.

This instrument is a short questionnaire that is easy to self-administer, making it a very attractive assessment tool for routine use in a busy clinical setting [34]. It measures qualitative and quantitative indices, addressing dimensions such as work PA, sports and programmed exercises, and leisure with locomotion activities. A total score is obtained from the sum of the index values for the different dimensions and the global PA, with higher scores indicating higher levels of PA [35]. The Baecke-questionnaire is composed by 16 questions scored in a Likert scale from 1 to 5 for each question, where a specific formula provides a score between 1 and 5 for each assessed domain, with a total PA score ranging from 3 to 15 (by the sum of three domains score). The Baecke score classification, by quartile, is used due to the lack of a cutoff point of this instrument to define the level of PA, as adopted in previous studies [36,37]. In our study the group with values above the median (8.0) was classified as high levels of PA group (HL) and the other with values below the median was classified as low levels of PA (LL).

Perceived fatigue

Fatigue was measured by the Fatigue Severity Scale (FSS) and 21-item Modified Fatigue Impact Scale (MFIS). The FSS is a 9-item questionnaire that evaluates the impact of disabling fatigue on daily functioning. MFIS measures the effects of fatigue on physical, cognitive, and psychosocial domains. All the items are rated on a 5-point Likert scale (0–4), providing subscales scores (physical: 0–36, cognitive: 0–40, and psychosocial: 0–8) and the total score (0–84), where higher values indicate a greater degree of fatigue [38].

Postural balance

Postural balance was evaluated using a force platform (AccuSway Plus, AMTI, United States) that measures displacements of the center of pressure (CoP). The force platform signals were sampled at 100 Hz and data were filtered using a 10 Hz low-pass cutoff frequency. The software AMTI Balance Clinic was used for signal recording [39]. Postural balance was measured under the following experimental condition: stable surface and eyes open. Participants were asked to maintain a barefoot standing posture with their feet 10 cm apart, arms held alongside the body, while fixating a reference point located at eye level (1.0m in front of them). They performed three 30-second trials for each experimental condition, and they were able to rest for 30 seconds between the trials. The mean values were used. The variables analyzed were the CoP displacement speed (cm/s) and CoP 95% elliptical area (cm^2) [40].

Functional mobility

The Functional mobility was evaluated by the Timed Up and Go (TUG) test [41]. Participants were instructed to complete a trial for familiarization. After, they completed this course as safely and as fast as possible, by standing up (without the help of hands), walking towards and around a cone/mark on the floor; walking back to the chair, and then sitting down. Participants completed three trials but only the first two tests were computed for the average [42]. They rested 1 minute between the trials.

Measures Day 2

Gait Spatiotemporal Parameters

The GAITRite (CIR-Systems) was used to measure gait spatiotemporal parameters at a comfortable speed. The GAITRite included eight sensor blocks on a mat producing an active area of 24 inches (61cm) wide and 192 inches (488cm) long, totaling 18,432 sensors, 120Hz sampling rate [16]. The average of two trials of walking barefoot at comfortable speed was considered for data analysis. The following parameters were analyzed: base support (cm), swing phase (%), stance phase (%), and single support (%), in percentual of the gait cycle.

Walking performance

The 6MWT (6 Minutes Walking Test) using a 30-meter hallway [43] provided standardized measures of walking speed and endurance for MS. Participants were instructed to walk as fast as possible without rest or encouragement for 6 minutes.

Quality of life (QoL)

Quality of life was measured by the Functional Assessment of Multiple Sclerosis (FAMS), a disease-specific 44-item questionnaire that investigates patient’s perception of QoL in six domains: mobility, symptoms, emotional well-being/depression, general contentment, thinking/fatigue, and family/social well-being. All the items are rated on a 5-point Likert scale (0–4), providing a score ranging from 0 to 176, with higher scores indicating the best quality of life [44].

Statistical analysis

Data were expressed as means and standard deviations, quartiles, or absolute frequencies as appropriate. To investigate the data distribution, the Shapiro-Wilk test was performed. The median of the PA scores were used to classify participants into low or high physical activity groups. To verify the homogeneity of variances between groups, Levene's test was used. Between group comparisons were conducted using independent samples t-test or Mann-Whitney U test. The statistical analysis considered Cohen's d coefficient or rank biserial correlation to assess the effect size (ES). The magnitude of ES is interpreted as follows: a small ES is considered to be around 0.2, a medium ES around 0.5, and a large ES 0.8 or higher. Statistical significance was set at $p < 0.05$. All statistical analyses were conducted with Statistical Package for Social Sciences software version 20.0 (IBM Corporation, Armonk, NY, USA).

RESULTS

The demographic characteristics and clinical data of all participants, separated by group (LL and HL), and comparison are presented in Table 1. No significant difference was found in demographic and clinical characteristics between HL and LL groups (p>0.05). The total sample was considered homogeneous in terms of body mass index, disease duration, EDSS and PDDS.

Table 1. Characteristics of participants. [a]

Variables	Total (n=25)	LL group (n=11)	HL group (n=14)	p (value)
Age (years)	44.92 ± 9.38	42.55 ± 10.06	46.79 ± 8.73	.271
Weight (kg)	66.93 ± 13.21	66.36 ± 9.65	67.38 ± 15.81	.853
Height (m)	1.62 ± 0.05	1.61 ± 0.06	1.63 ± 0.05	.654
Body mass index (kg/m²)	25.79 ± 5.25	25.56 ± 3.12	25.97 ± 6.58	.501
Disease duration (years)	8.12 ± 5.57	7.27 ± 3.95	8.79 ± 6.65	.680
EDSS, median	2.0 (2.0-3.5)	1.5 (1.0-3.0)	2.0 (1.1-2.0)	.718
PDDS, median	1.0 (0.0-3.0)	1.0 (0.0-2.5)	2.0 (0.0-3.0)	.773
Baecke, median	8.0 (7.8-8.5)	7.3 (7.0-7.5)	8.5 (8.1-9.0)	<.001

[a] Data are presented as mean ± standard deviation or median (interquartile range). EDSS: Expanded Disability Status Scale; PDDS: Patient-Determined Disease Scale. * *p<.05*

Table 2 shows the level of physical activity in the sample total and a comparison between the different groups (HL and LL). Each variable: postural balance, gait spatiotemporal parameters, walking performance, and functional mobility is presented. The p value was obtained by Mann-Whitney test in CoP speed, area and TUG, the other variables were obtained by t test.

Table 2. Postural balance, gait parameters, walking performance and functional mobility in female PwMS according to the physical activity level.

	Total (n=25)	LL group (n=11)	HL group (n=14)	*ES*	*P (value)*
Postural balance					
Stable surface, eyes open					
CoP Speed (cm/s)	1.1 (0.8-1.2)	1.2 (1.1-1.7)	1.0 (0.8- 1.1)	0.6	.038*
CoP Area (cm²)	2.0 (1.3-4.0)	3.9 (2.0-5.9)	1.5 (1.3- 2.5)	1.1	.013*
Gait *spatiotemporal parameters*					
Base Support (cm)	12.0 ± 3.9	12.1 ± 4.4	11.6 ±3.2	0.2	.561
Swing phase (% cycle)	36.3 ± 3.6	36.8 ± 3.0	36.4 ± 3.5	0.1	.772
Stance phase (% cycle)	63.4 ± 3.3	63.1 ± 2.9	63.4 ± 3.5	-0.1	.797
Single Support (%cycle)	36.8 ± 2.9	36.6 ± 3.1	36.8 ± 2.7	-0.1	.841
Walking performance					
6MWT (m)	487.0 ± 118.0	507.0 ± 111.9	470.3 ± 124.79	0.3	.443
Functional mobility					
TUG (s)	8.9 (7.1-11.3)	9.5 (7.5-9.8)	7.9 (7.2- 11.5)	0.04	.926

[a] Data are presented as mean ± standard deviation or median (interquartile range) * *p< .05*

The differences in postural balance for CoP speed and CoP area were significant ($p< 0.05$) between the groups. The LL group resulted in greater CoP displacement and greater CoP speed than HL group. A medium effect size to CoP Speed and higher to CoP Area was found too. In the other variables, only a small effect size in base support, gait parameters, and walking performance was found.

Table 3 shows a comparison between the different groups (HL and LL) in perceived fatigue and quality of life. The p value was obtained by Mann-Whitney test in some FAMS variables (Symptoms, Emotional well-being, General).

Table 3. Perceived fatigue and Quality of life in women with multiple sclerosis according to the physical activity level.[a]

	Total (n=25)	LL group (n=11)	HL group (n=14)	*ES*	*p (value)*
Perceived fatigue					
FSS	42.9 ± 14.0	46.0 ± 9.2	40.4 ± 16.8	0.4	.641
MFIS Total	44.1 ± 16.9	47.2 ± 17.2	41.5 ± 16.8	0.3	.460
MFIS Physical	20.6 ± 7.1	22.5 ± 6.6	19.1 ± 7.4	0.5	.337
MFIS Cognitive	20.8 ± 8.4	23.2 ± 7.7	18.8 ± 8.8	0.5	.249
MFIS Psychosocial	3.8 ± 1.8	4.2 ± 1.9	3.6 ± 1.8	0.3	.506
Quality of life					
FAMS Total	139.1 ± 34.5	134.8 ± 35.7	142.5 ± 34.3	-0.2	.687
FAMS Mobility	18.8 ± 4.9	18.7 ± 4.2	18.9 ± 5.9	-0.04	.912
FAMS Symptoms	18 (14-23)	20 (15.5-23)	16.5 (12-23)	-0.04	.762
FAMS Emotional well-being	21 (18-27)	22 (14-26.5)	21 (19-26.7)	0.06	.721
FAMS General Contentment	20 (16-24)	22(12.5-22.5)	19.5 (18-25.5)	-0.3	.350
FAMS Thinking/ Fatigue	19.1 ± 6.2	18.2 ± 5.1	19.7 ± 6.8	-0.3	.392
FAMS Family/ Social	20.8 ± 4.7	17.5 ± 5.2	20.3 ± 6.9	-0.4	.934

[a] Data are presented as mean ± standard deviation or median (interquartile range). * $p< .05$

In the fatigue parameters and quality of life no significant difference was found ($p>0.05$), but only a small to medium effect size in fatigue was found. Fatigue in the physical domain was more perceived by group LL.

DISCUSSION

This study aimed to evaluate the influence of habitual PA level on postural balance in women with MS. We also assessed gait spatiotemporal parameters, walking performance, functional mobility, fatigue, and quality of life. The results are newsworthy, showing significant differences in the displacement of CoP speed and CoP area between HL and LL. Only a small effect size was found in walking and fatigue in LL group. No significant differences with the other variables were found.

Remarkably, a little difference in physical activity level seems to be sufficient to significantly influence postural balance in women with relapsing-remitting MS, and mild to moderate disability. Higher values of CoP speed and CoP area in the LL group mean worse postural stability. Both speed and area of CoP are important variables to be evaluated pwMS clinically and in rehabilitation programs [23]. Recent studies indicate that physical activity may potentially modify the disease. A report demonstrates that 20% of pwMS meet the general and MS specific PA recommendations [45]. There is extensive evidence for the benefits of PA to reduce fatigue and the risk of falling, improve balance and walking, neuromuscular and physical functioning, and quality of life [6,7,9,20,46]. In this respect, it is a paradox that PA is not systematically addressed or measured in the follow-up of pwMS throughout the disease course [46]. PwMS are more sedentary than healthy controls, engage in less light, moderate and vigorous activity. They perform less steps during free living activity and generate a lower activity count than healthy controls [47].

A number of studies aiming to improve balance in pwMS have been conducted, but variability in intervention types, outcome measures, and methodological limitations restrict the ability to draw more definitive conclusions on effectiveness [17]. There is a paucity of balance training interventions specifically adapted for pwMS that utilize a gradual progression of difficulty and complexity in exercises and with a continuously controlled high level of challenge in exercises throughout the intervention period [48]. The previous systematic reviews have shown that exercise programs positively affect motor and psychological issues such as fatigue, balance, quality of life, and physical fitness in pwMS [13,19]. However, most studies do not quantify the level of PA before and after the intervention. Supporting participants to achieve an appropriate intensity of practice of highly challenging balance activities appears to be critical to maximizing effectiveness [17].

A review and meta-analysis recently searched studies on balance in pwMS [17]. To perform the meta-analysis, only the quiet posture condition had enough data and resulted in a total of 12 studies. In terms of CoP displacement, the authors found only eight studies. All the studies that investigated CoP-related measures showed higher values in pwMS compared to healthy controls [12,21,25,49,50]. Other studies evaluated the use of posturography for pwMS and found CoP values that corroborate our findings. One of them suggest that CoP area and CoP speed are parameters that could predict EDSS [23]. In general, current studies demonstrate the importance of evaluation of postural balance by posturography in MS. Including comparative measures after interventions and in clinical rehabilitation [17,18,23,29,51].

Two recent meta-analysis provided evidence that exercise intervention programs in pwMS improve balance. The researchers investigated the level of effort [17,22]. Thus, knowledge of the population's level of physical activity was shown to be essential for assessing the effects of the dose-response relation in a program to improve balance [22]. Several other studies conducted analyses such as the effectiveness of specifics and different interventions to improve balance. All demonstrate that improving the level of PA is essential for cognitive improvement [6,7,10,13].

As a clinical implication, our study emphasizes the importance of increasing PA levels and improving postural balance, even with deficits not clinically perceptible. A worse postural balance can lead to a greater fear of falls and, consequently, to major changes in domains (physical, cognitive, and psychosocial), for instance, leading the individual to reduce the daily walking time [21,52].

The results did not depict significant differences between the HL and LL groups related to the gait spatiotemporal parameters, walking performance, and functional mobility. These assessments were not as sensitive to a small difference in the level of PA in our homogeneous group as postural balance using static posturography. In our study, the level of PA showed a small to medium effect size in fatigue, corroborating other studies that found a weak association between fatigue severity and PA. Age, type of MS, depression, and anxiety are factors that can affect the relationship between fatigue severity and PA [53].

Evaluating women with the same clinical characteristics and levels of disability but with different levels of PA was the major highlight of the present study. We used posturography, which is considered the gold standard for assessing alterations in postural balance in pwMS. Nevertheless, the study has some limitations to be mentioned. This is a cross-sectional study design and there is no evidence of a temporal relationship between exposure and outcome. We applied a PA questionnaire without a cutoff point and classified the groups as HL and LL only in relation to our participants, based on the median found in this particular population. In addition, the analyses were not controlled for potential confounders like medications or MS lesion location.

CONCLUSION

Our results showed a better postural balance in women with a higher level of physical activity than in those with a lower level. Although level of PA and balance seem to be related, the results of this cross-sectional study could not confirm a causal link. However, a higher level of PA should always be considered a goal in pwMS rehabilitation. Thus, is clear that different strategies are needed to be developed to increase PA levels and postural balance in women with MS.

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