Clinical Rheumatology (2019) 38:513–522
https://doi.org/10.1007/s10067-018-4293-x

ORIGINAL ARTICLE

Gender differences in patients with fibromyalgia: a gait analysis

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Received: 24 June 2018 / Revised: 15 August 2018 / Accepted: 9 September 2018 / Published online: 21 September 2018

Abstract

This study analysed the spatio-temporal parameters, asymmetry, variability and bilateral coordination of gait in women and men with fibromyalgia and healthy subjects walking at their usual velocity and at a faster walking velocity. Fifty-five women and 12 men with fibromyalgia were analysed. A healthy group of 44 women and 17 men was analysed as the control group. A GAITRite system was used to obtain the spatio-temporal gait parameters for the participants when walking at their usual velocity and at a faster velocity. Coefficients of variation, bilateral coordination and gait asymmetry indexes were calculated. All groups exhibited a significant increase ($p < 0.001$) in spatio-temporal parameters when walking fast. The fibromyalgia groups showed increased bilateral coordination, asymmetry and variability of stance phase when walking fast. The fibromyalgia women showed significant spatio-temporal, variability and bilateral coordination of gait differences compared with the healthy women. The fibromyalgia men reported significant differences in velocity, cadence, stride length, swing time variability and stance gait asymmetry indices compared with the healthy men. No significant differences were observed between the men and women in the fibromyalgia groups. The findings of the present study did not support gender-specific differences in walking variables and indices in FM patients. The differences found between both genders of FM patients and healthy subjects in walking indices at fast velocities could be a useful tool for diagnoses and evaluation of male and female patients with FM during short-term fast walking tests.

Keywords Asymmetry · Bilateral coordination · Fibromyalgia · Gait · Sex characteristics · Variability

Introduction

Fibromyalgia (FM) is a multidimensional, complex disorder characterized by chronic widespread musculoskeletal pain, fatigue, sleep disturbance and physical and psychological impairment [1]. Other associated features include psychological distress, impaired functioning, sexual dysfunction, anxiety, depression, headache and bowel dysfunction [2]. FM is the second most common rheumatological condition; it affects up to 2% of the general population between 18 and 65 years old [3].

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The prevalence of FM among the Spanish population has been estimated at 2.4%, and FM is significantly more common in women than in men with a prevalence of 0.2% in men and 4.2% in women (female/male ratio of 22:1) [4]. A previous study of the US population concluded that the FM prevalence in women reached its peak (7.9% prevalence) in the 55–64-year age group and declined thereafter, while the prevalence in men also increased with age and peaked in the 45–54-year age group (2.5% prevalence) [5].

FM impact studies in men and women have shown contradictory results. Previous studies have reported that women with FM showed a higher number of symptoms than men with FM. Women with FM have lower pain thresholds, greater diffuse pain, a higher number of tender points, higher levels of fatigue and irritable bowel syndrome, greater sleep disturbance and lower vitality compared to men with FM [6–10]. Lange et al. [11] also identified gender differences in psychological measures, on which women with FM showed greater psychological strain than men with FM. However, in that study, no gender differences in pain measures were obtained.

Conversely, some previous research studies have demonstrated that men with FM report more severe symptoms, such as more depression, greater physical impairment and a greater disease impact than women with FM [9, 12, 13]. However, there are conflicting studies that report that there are no relevant gender differences in the clinical picture of FM in terms of anxiety, depression, sleep disturbance, psychopathology, daily functioning or stress [8, 14–16]. Thus, the assumption of well-established gender differences cannot be supported [14].

In patients with FM, gait analysis is considered a clinically relevant tool that can provide information to help identify FM patient subgroups [17]. However, there is controversy regarding the changes in gait parameters in FM patients. Previous studies reported that women with FM walked at a lower velocity and with a reduced cadence, stride length, swing phase and single support phase and a higher double support phase and stance phase compared with healthy women [18, 19]. However, previous studies did not report differences in spatio-temporal variables [20, 21] or in joint angles and ground reaction forces between women with FM and healthy women [20]. Only one previous study reported spatio-temporal gait differences in men with FM [22] and it concluded that gait disorders in men with FM appear to be less relevant than in females with FM, although no study has examined the gait differences between men and women with FM.

Symmetry of gait provides important information regarding the contribution of each limb to propulsion and control tasks [23] as well as information regarding gait control during each gait phase [24]. Some pathologies, such as Alzheimer's disease or stroke, have a negative effect on gait symmetry [24–26].

Heredia et al. [27] reported that when walking at a preferred speed, women with FM showed greater variability of gait and worse bilateral coordination compared with healthy women; however, when walking at a fast velocity, asymmetry differed between women with FM and healthy women. No asymmetry or variability of gait in men with FM has been reported in previous studies.

Therefore, the purpose of this study was to compare the spatio-temporal parameters, variability, asymmetry and bilateral coordination of gait (BCG) in a group of men with FM, women with FM, healthy men and healthy women walking at preferred and fast walking velocities to describe the gender-related gait disorders in patients with FM.

Methods

Participants

We studied 55 women with FM (age, 49.8 (8.9) years; height, 1.57 (0.06) m; body weight, 69.3 (13.4) kg) and 12 men with FM (age, 45.8 (7.4) years; height, 1.73 (0.05) m; body weight, 81.1 (7.8) kg) who met the American College of Rheumatology criteria for FM [1]. The convenience sample was recruited from a local association of FM patients in Granada, Spain. The control group was also convenience-recruited from a group of volunteer individuals via email or telephone contact. The inclusion criteria were a negative history of musculoskeletal disease, neurological disorders and gait abnormalities. The 44 healthy women (age, 47.2 (6.8) years; height, 1.57 (0.04) m; body weight, 67.6 (13.5) kg) and 17 healthy men (age, 43.2 (6.5) years; height, 1.74 (0.06) m; body weight, 78.1 (10.1) kg) were matched with the FM patients based on age, height and body weight. To ensure that the impact of FM was similar in both gender groups, the Fibromyalgia Impact Questionnaire was administered, and no significant differences between groups were found (men with FM score 76.05 (15.06); women with FM score 75.91 (15.06)). All the participants provided their informed consent to clinical assessment before they were enrolled in the study.

Protocol and instruments

Gait analysis was performed using a walkway instrumented for measuring the kinematic parameters of gait (GAITRite system; CIR Systems, Inc., Clifton, NJ, USA). Each participant in the study walked five trials unassisted at a comfortable speed along an 18.6-m walkway (Fig. 1). The GAITRite system was located in the middle of the walkway to avoid nonstabilized walking periods at the beginning and end of the test (Fig. 1). The participants walked in a quiet, well-lit room wearing their own footwear according to the European guidelines for spatio-temporal gait analysis in older adults [28]. After walking at the preferred velocity, the subjects recovered for 5 min and then walked under the same conditions for five trials at a fast speed. Gait analysis was performed in both groups by the same investigator using the same equipment and measurement protocol. The investigator provided the same verbal commands for each participant. For the preferred speed condition, the verbal command was "Walk at your preferred speed, as you do when you stroll down the street." For the fast condition, the verbal command was "Walk at fast velocity without running, as you do when you are late for an appointment."

Outcome variables

Velocity is the distance walked per second (cm/s); cadence is steps per minute (steps/min); stride length is the heel-to-heel distance of the same lower limb during the gait cycle (cm); single support ratio is the single-limb

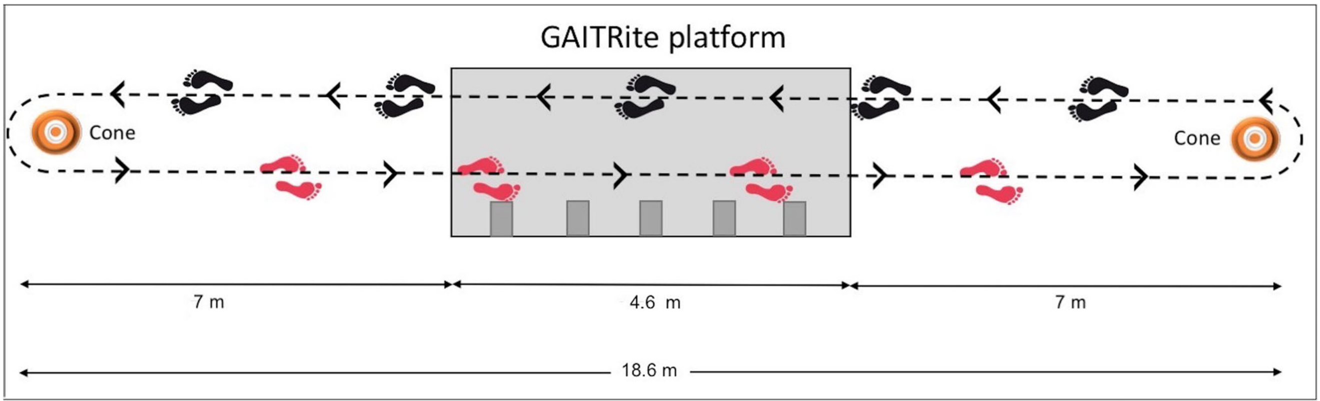

Fig. 1 Walkway protocol with the GAITRite system in the middle

support phase duration/gait cycle duration (%); double support ratio is the double-limb support duration/gait cycle duration (%); swing phase ratio is the swing phase duration/gait cycle duration (%); stance phase ratio is the stance phase duration/gait cycle duration (%).

To reduce the error due to size differences between groups, the velocity, cadence and stride length were normalized using the subject's stature using the equations proposed by Hof et al. [29].

In addition, the swing phase, stance phase, single support phase and double support phase were normalized as a percentage of the gait cycle (%GC).

The coefficients of variation (CV) for swing time, stance time and step width were calculated according to the equation CV = 100 x standard deviation/mean.

BCG was measured using the relationship between the step timing of the left and right legs following the equations proposed by Plotnik et al. [25]. First, we calculated the phase (φ) quantifying the phase relationship between the step timing of the left and right legs; second, we calculated the BCG as the CV of φ (φ_CV) and the mean value of the absolute differences between the phase at each stride and 180° (φ_ABS), according to Plotnik et al.'s equations [25]:

$$BCG = \varphi\_CV + \left(100^{*}\ \varphi\_ABS/180\right)$$

Gait asymmetry (GA) was analysed using the symmetry ratio and symmetry index equations proposed by Paterson et al. ([24] and the symmetry angle [25] and GA [30] of swing time and stance time according to the following equations:

$$\text{Symmetry ratio} = ST_{right}/ST_{left}$$

$$\text{Symmetry index} = \left[\left(ST_{right} - ST_{left}\right)/0.5\left(ST_{right} + ST_{left}\right)\right]*100\%$$

$$\text{Gait asymmetry} = |100^{*}\left[\ln\left(ST_{right}/ST_{left}\right)\right]|$$

$$\text{Symmetry angle} = \left[\left(45^{\circ} - \arctan\left(ST_{right}/ST_{left}\right)\right)^{*}\ 100\%\right]/90$$

where ST is the analysed spatio-temporal variable of the right or left lower limb.

Statistical analysis

The data were analysed using SPSS software v.24 (IBM Corp., Armonk, NY). Data normality was analysed using the Kolmogorov-Smirnov test, which yielded a normal variable distribution ($p > 0.05$). Two-way ANOVA was performed using walking velocity (within-subject analysis) and group (between-group analysis) as fixed factors. The walking velocity factors were preferred gait velocity and fast velocity, while the group factors were healthy men, healthy women, men with FM and women with FM. We compared the FM groups with their respective healthy groups and compared the genders within the FM group. Comparisons between the healthy women and the healthy men were not considered.

The level of statistical significance was established at $p < 0.05$. To estimate the effect sizes of the velocity (preferred and fast), group and interaction effects, the partial eta squared (η^2) was computed for each variable to evaluate the magnitude of the differences obtained.

Results

Results from a two-way analysis of variance (ANOVA) indicated significant differences in the spatio-temporal gait parameters within-subject, between group, and in the interaction analysis, except that the interaction analysis for the gait velocity variable did not show any significant differences (Table 1). The two bilateral coordination variables showed significant values in the within-subject comparison. The PCI also showed significant values for the between-subject comparison. For variability variables, swing time CV showed significant values in the between-subject analysis, while stance and step time CV also showed significant values for the within-subject analysis. The interaction was significant in the step time CV interaction analysis. In the asymmetry variables with respect to those related to swing time, significant values for the between-group analysis were shown, while the asymmetry

Table 1 *F* ratios and *p* values and effect size: within groups (preferred walking vs. fast walking), between group (healthy and FM groups) and the interaction in each dependent variable included in the study

Gait variables	Comparisons	*F* value	*p* value	Effect size (partial η^2)
Spatio-temporal parameters				
Normalized velocity (dimensionless)	Within-subject	621.215	< 0.001	0.835
	Between groups	29.296	< 0.001	0.415
	Interaction	2.211	0.09	0.05
Normalized cadence (dimensionless)	Within-subject	311.025	< 0.001	0.715
	Between groups	16.869	< 0.001	0.29
	Interaction	3.168	0.03	0.071
Normalized stride length (dimensionless)	Within-subject	538.300	< 0.001	0.813
	Between groups	24.925	< 0.001	0.376
	Interaction	7.896	< 0.001	0.160
Swing phase (%GC)	Within-subject	340.655	< 0.001	0.733
	Between groups	14.963	< 0.001	0.266
	Interaction	3.356	0.02	0.075
Stance phase (%GC)	Within-subject	346.694	< 0.001	0.737
	Between groups	14.88	< 0.001	0.265
	Interaction	3.477	0.02	0.078
Single support phase (%GC)	Within-subject	339.897	< 0.001	0.733
	Between groups	14.918	< 0.001	0.265
	Interaction	3.299	0.02	0.074
Double support phase (%GC)	Within-subject	358.756	< 0.001	0.743
	Between groups	14.965	< 0.001	0.266
	Interaction	3.643	0.01	0.081
Bilateral coordination				
Phase	Within-subject	24.727	*< 0.001*	0.165
	Between groups	1.729	0.17	0.04
	Interaction	1.309	0.27	0.03
PCI	Within-subject	10.370	*0.002*	0.077
	Between groups	4.562	*0.005*	0.10
	Interaction	0.810	0.50	0.02
Gait variability				
CV swing time	Within-subject	3.885	0.05	0.03
	Between groups	16.511	< 0.001	0.284
	Interaction	1.879	0.137	0.04
CV stance time	Within-subject	7.849	0.006	0.06
	Between groups	6.610	< 0.001	0.137
	Interaction	2.664	0.05	0.06
CV step time	Within-subject	21.668	< 0.001	0.148
	Between groups	9.905	< 0.001	0.192
	Interaction	2.825	0.04	0.063
Gait asymmetry				
Swing time ratio	Within-subject	0.032	0.85	0.000
	Between groups	3.932	0.01	0.086
	Interaction	0.489	0.69	0.012
Swing time GA	Within-subject	0.009	0.92	0.000
	Between groups	4.224	0.01	0.092
	Interaction	0.519	0.67	0.012
Swing time index	Within-subject	0.008	0.92	0.000
	Between groups	4.239	0.01	0.092
	Interaction	0.518	0.67	0.012
Swing time SA	Within-subject	0.008	0.93	0.000
	Between groups	4.254	0.01	0.093
	Interaction	0.517	0.67	0.012
Stance time ratio	Within-subject	7.335	0.01	0.055
	Between groups	3.755	0.01	0.083
	Interaction	2.405	0.07	0.055
Stance time GA	Within-subject	6.767	0.01	0.051
	Between groups	3.676	0.01	0.081
	Interaction	2.680	0.05	0.06
Stance time index	Within-subject	6.765	0.01	0.051
	Between groups	3.676	0.01	0.081
	Interaction	2.680	0.05	0.06
Stance time SA	Within-subject	6.762	0.01	0.051
	Between groups	3.680	0.01	0.081
	Interaction	2.679	0.05	0.06

Significant level: $p < 0.05$

%GC, percentage of gait cycle; PCI, bilateral coordination index; CV, coefficient of variation; GA, gait asymmetry; SA, symmetry angle variables related to stance time also showed significant results in the within-subject analysis (Table 1).

Within-subject analysis

All groups showed a significant increase in velocity, cadence, swing and single support phase ($p < 0.001$) and a significant decrease in stance and double support phase ($p < 0.001$) between the preferred walking speed and the fast walking speed (Table 2).

Regarding BCG and CV, both FM groups showed a significant increase (Table 3). Regarding GA, only stance time indices showed a significant increase between the preferred and fast speeds in the FM groups (Table 1).

Between-group analysis

The spatio-temporal parameters of gait for the women with FM showed significantly lower velocity, cadence, stride length, swing phase and single support phase and significantly higher stance phase and double support phase compared with healthy women at both preferred and fast velocities. Among the men, the FM group showed significantly lower velocity and stride variables at preferred and fast velocities and significantly lower cadence at the preferred velocity compared with healthy men. Other significant spatio-temporal variables were compared between the men with FM and healthy men and between the women with FM and the men with FM (Fig. 2).

Regarding BCG, the women with FM showed significantly higher phase coordination indexes at both velocities compared with the healthy women. There were no significant differences between the men and the healthy men or between the women with FM and the men with FM (Fig. 3). At both velocities, the women with FM showed significantly higher CV values during the swing, stance and step phases compared with the healthy women. The men with FM showed significant CV values for swing time compared with the healthy men at both velocities. There were no significant differences between the women with FM and the men with FM (Fig. 3).

Regarding GA, the men with FM showed a significant increase for all parameters of stance phase asymmetries (index, ratio, GA and symmetry angle) during the stance phase at fast velocity compared with the healthy men. No significant differences were observed in any GA indices between the women with FM and the healthy women or between the women with FM and the men with FM (Fig. 4).

Discussion

In this study, we compared the differences in spatio-temporal gait parameters, asymmetry, variability and bilateral coordination indices of gait in FM and healthy groups that were subdivided by gender. No previous studies have compared gait differences between male and female FM patients while walking at normal and fast velocities.

As expected, all the groups showed significant changes in the spatio-temporal gait variables when walking at fast velocity compared with walking at their preferred velocity, as reported by previous authors [31]. Furthermore, when the women with FM were compared with the healthy women, significant differences in all spatio-temporal gait variables were found, consistent with previous studies [18, 19]. The men in the FM group showed significant differences in velocity, cadence and stride length compared to the healthy men, consistent with the findings of previous studies [22]. Therefore, the detriment in the spatio-temporal gait variables in FM patients of both genders has been suggested to be due to FM symptoms such as pain, bradykinesia and generalized reduction in muscular strength, which interferes with FM patients' walking ability, as described in previous studies [18, 19, 32].

To date, studies have compared males and females with FM with their respective control groups and have found a remarkable detriment in gait among women with FM. In the current study, the authors performed additional gait analyses

Table 2 Average (standard deviation) of each spatio-temporal gait parameters in the different groups. *$p < 0.001$ within-subject comparison

	FM women		FM men		Healthy women		Healthy men	
Variables	Pref	Fast	Pref	Fast	Pref	Fast	Pref	Fast
Velocity (dimensionless)	0.27 (0.01)	0.37* (0.01)	0.28 (0.01)	0.38* (0.02)	0.35 (0.01)	0.44* (0.01)	0.34 (0.01)	0.45* (0.01)
Cadence (dimensionless)	0.73 (0.01)	0.87* (0.01)	0.71 (0.02)	0.84* (0.03)	0.83 (0.01)	0.94* (0.01)	0.78 (0.01)	0.90* (0.01)
Stride length (dimensionless)	0.75 (0.01)	0.84* (0.01)	0.79 (0.03)	0.90* (0.03)	0.85 (0.01)	0.94* (0.01)	0.88 (0.01)	1.02* (0.01)
Swing phase (%GC)	36.6 (0.30)	38.5* (0.29)	36.6 (0.37)	38.7* (0.37)	39 (0.21)	40.5* (0.20)	37 (0.27)	39.3* (0.29)
Stance phase (%GC)	63.3 (0.30)	61.4* (0.29)	63.3 (0.37)	61.2* (0.38)	60.9 (0.21)	59.4* (0.20)	62.9 (0.27)	60.6* (0.29)
Single support phase (%GC)	36.6 (0.30)	38.5* (0.29)	36.6 (0.37)	38.7* (0.37)	39 (0.21)	40.5* (0.20)	37 (0.27)	39.3* (0.29)
Double support phase (%GC)	26.7 (0.60)	23.1* (0.58)	26.9 (0.74)	22.7* (0.76)	22 (0.42)	19.1* (0.39)	25.8 (0.56)	21.5* (0.58)

FM, fibromyalgia; Pref, preferred walking velocity; Fast, fast walking; GC, gait cycle

Table 3 Bilateral coordination, coefficient of variability and asymmetry indexes as average (standard deviation) in FM and healthy groups walking at fast and preferred velocity. Significant level computed for within-group comparison

	FM women			FM men			Healthy women			Healthy men		
	Pref.	Fast	Sig.	Pref.	Fast	Sig.	Pref.	Fast	Sig.	Pref.	Fast	Sig.
Bilateral coordination												
Phase	180.2 (0.05)	180.6 (0.07)	0.003	180.5 (0.16)	181.1 (0.48)	0.01	180.3 (0.06)	180.5 (0.09)	NS	180.1 (0.17)	180.6 (0.24)	NS
PCI	3.78 (0.19)	4.21 (0.19)	0.04	3.63 (0.36)	4.57 (0.67)	0.02	2.99 (0.13)	3.21 (0.14)	NS	3.32 (0.28)	3.60 (0.26)	NS
Coefficient variability												
CV swing time	4.92 (0.24)	5.40 (0.25)	0.01	4.46 (0.32)	5.26 (0.83)	0.04	3.60 (0.12)	3.60 (0.11)	NS	3.52 (0.18)	3.43 (0.17)	NS
CV stance time	3.77 (0.17)	4.75 (0.35)	0.001	3.51 (0.33)	5.02 (0.84)	0.02	3.15 (0.14)	3.36 (0.21)	NS	3.42 (0.26)	3.25 (0.17)	NS
CV step time	3.99 (0.16)	4.98 (0.30)	< 0.001	3.52 (0.32)	5.31 (0.88)	0.001	3.12 (0.12)	3.45 (0.14)	NS	3.32 (0.29)	3.70 (0.26)	NS
Asymmetry indexes												
Swing time ratio	3.31 (0.45)	3.43 (0.61)	NS	2.83 (0.65)	3.24 (0.80)	NS	2.18 (0.22)	1.92 (0.26)	NS	1.17 (0.17)	0.89 (0.16)	NS
Swing time GA	3.31 (0.50)	3.43 (0.61)	NS	2.83 (0.65)	3.24 (0.80)	NS	2.18 (0.22)	1.92 (0.26)	NS	1.17 (0.17)	0.89 (0.16)	NS
Swing time index	3.30 (0.50)	3.42 (0.61)	NS	2.83 (0.65)	3.24 (0.80)	NS	2.18 (0.22)	1.92 (0.26)	NS	1.17 (0.17)	0.89 (0.16)	NS
Swing time SA	1.05 (0.16)	1.09 (0.19)	NS	0.90 (0.21)	1.03 (0.25)	NS	0.69 (0.07)	0.61 (0.08)	NS	0.37 (0.06)	0.28 (0.05)	NS
Stance time ratio	1.02 (0.01)	1.02 (0.01)	0.02	1.02 (0.01)	1.03 (0.01)	0.006	1.01 (0.01)	1.01 (0.01)	NS	1.01 (0.01)	1.01 (0.01)	NS
Stance time GA	1.73 (0.25)	2.25 (0.31)	0.02	1.84 (0.28)	3.15 (0.60)	0.006	1.36 (0.13)	1.39 (0.19)	NS	1.22 (0.18)	1.13 (0.18)	NS
Stance time index	1.73 (0.25)	2.25 (0.31)	0.02	1.84 (0.28)	3.15 (0.60)	0.006	1.36 (0.13)	1.39 (0.19)	NS	1.22 (0.18)	1.13 (0.18)	NS
Stance time SA	0.55 (0.08)	0.72 (0.10)	0.02	0.59 (0.09)	1.00 (0.19)	0.006	0.43 (0.04)	0.44 (0.06)	NS	0.39 (0.06)	0.36 (0.06)	NS

FM, fibromyalgia; Pref, preferred speed; Sig, significance value; PCI, bilateral coordination index; CV, coefficient of variation; GA, gait asymmetry; SA, symmetry angle

between men and women with FM, and no significant differences were found for any of the spatio-temporal variables, BCG, asymmetries and variability of gait indices. Supporting these results, previous authors have reported no significant differences between men and women with FM with respect to psychosocial symptoms, daily function and overall disease severity [7, 8, 10, 15]. While some authors have reported that men with FM showed more severe symptoms and disease impact, lower physical function and lower quality of life than women with FM [9, 12, 13], other studies have concluded that women with FM have more tender points with lower pain thresholds and more fatigue, diffuse pain and sleep disturbance than men with FM ([6, 7, 9, 10].

Regarding the BCG, variability and asymmetry indices of the FM patients compared with the healthy groups, both the male and female FM groups showed higher swing time variability while they walked at the two analysed gait velocities. This finding has been previously related to an increase in the number of falls [33]. In addition, at the two tested velocities, the women with FM showed higher variability in step and stance time, variables that are related to future disability [34], they also showed low balance control during gait [21], psychomotor dysfunction [33] and an increase in the mechanical and metabolic cost [35], variables that are often associated with an impaired or unusual gait [36]. These findings, together with the significantly higher BCG values reported in FM women, could be related to the poor ability to coordinate the gait cycle of one leg with respect to the other [25]; furthermore, these findings support studies that reported higher fatigue and other physical dysfunction symptoms in women with FM compared with men with FM [8, 13, 14, 16]. In contrast, the men with FM showed higher stance asymmetry values than the healthy men while walking at a fast velocity, variables that are associated with a higher risk of falls and lower extremity musculoskeletal injuries [11].

The healthy groups did not show any changes in bilateral coordination, variability or asymmetry of gait between the preferred and fast gait velocities, while both genders of FM patients showed a significant increase in variability, BCG and stance asymmetry indices, reflecting the disordered

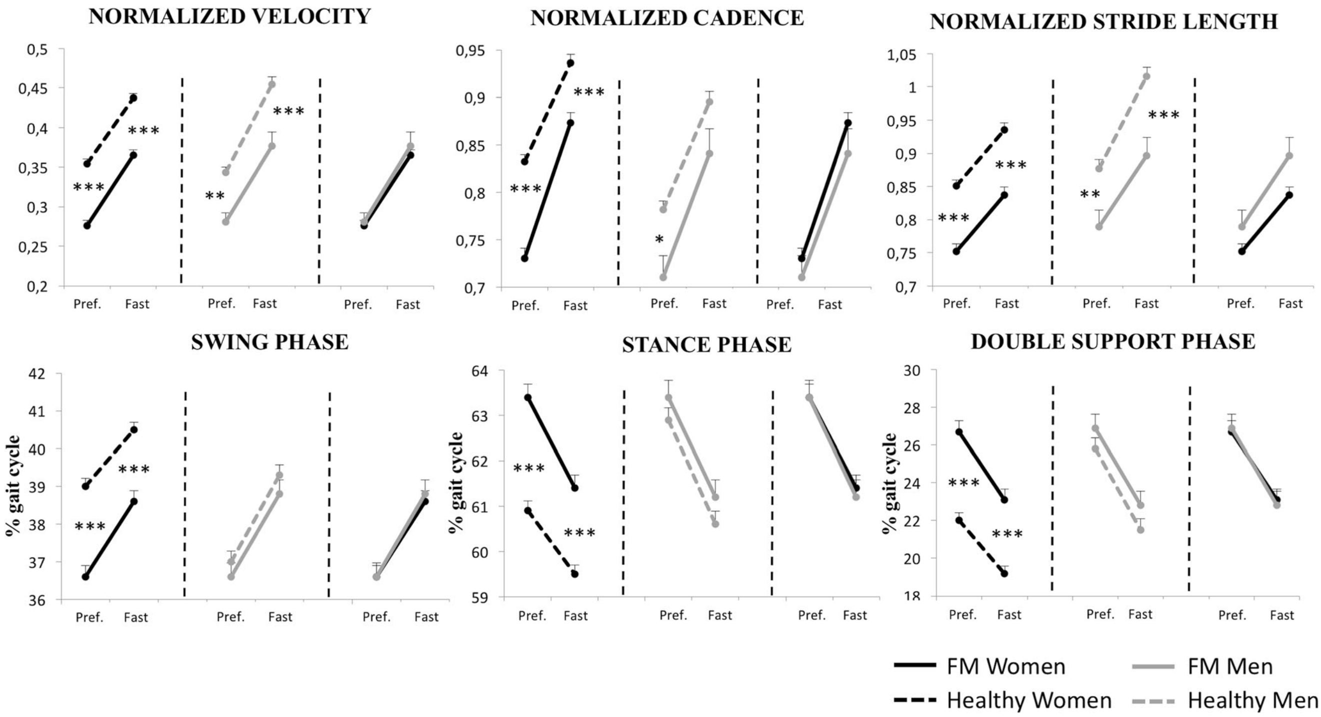

Fig. 2 Spatio-temporal gait parameters for FM patients and healthy subjects walking at fast and preferred velocities. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$ between groups. Pref: walking at preferred velocity; fast: walking at fast velocity

coordination between the legs that could be associated with inefficiency, impaired balance control or risk of musculoskeletal injuries [24]. Considering that the increased walking velocity produced changes in BCG, variability and GA only in the FM groups and that a previous study [27] concluded that variability and BCG could be complementary tools for the diagnosis and evaluation of FM in women, our results suggest that BCG, variability and GA while walking at a fast velocity

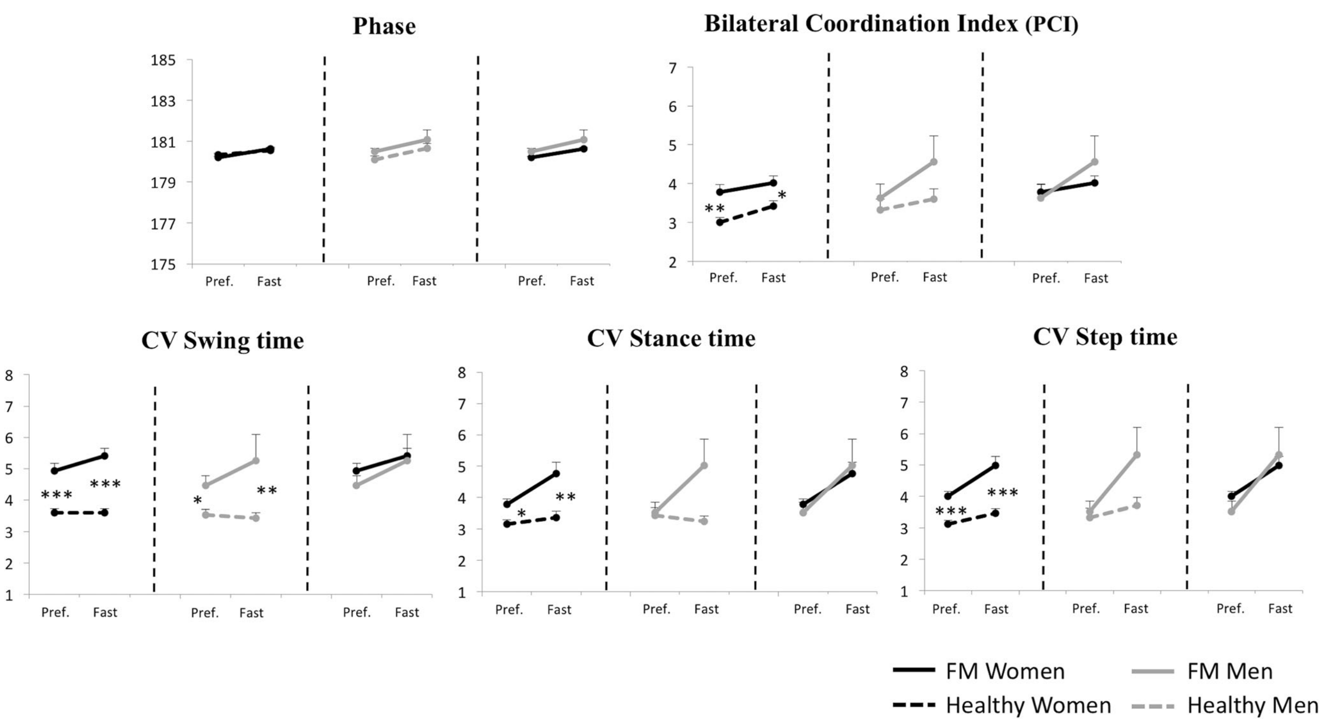

Fig. 3 Bilateral coordination parameters and coefficient of variability for FM patients and healthy subjects walking at fast and preferred velocities. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$ between groups. Pref: walking at preferred velocity; fast: walking at fast velocity

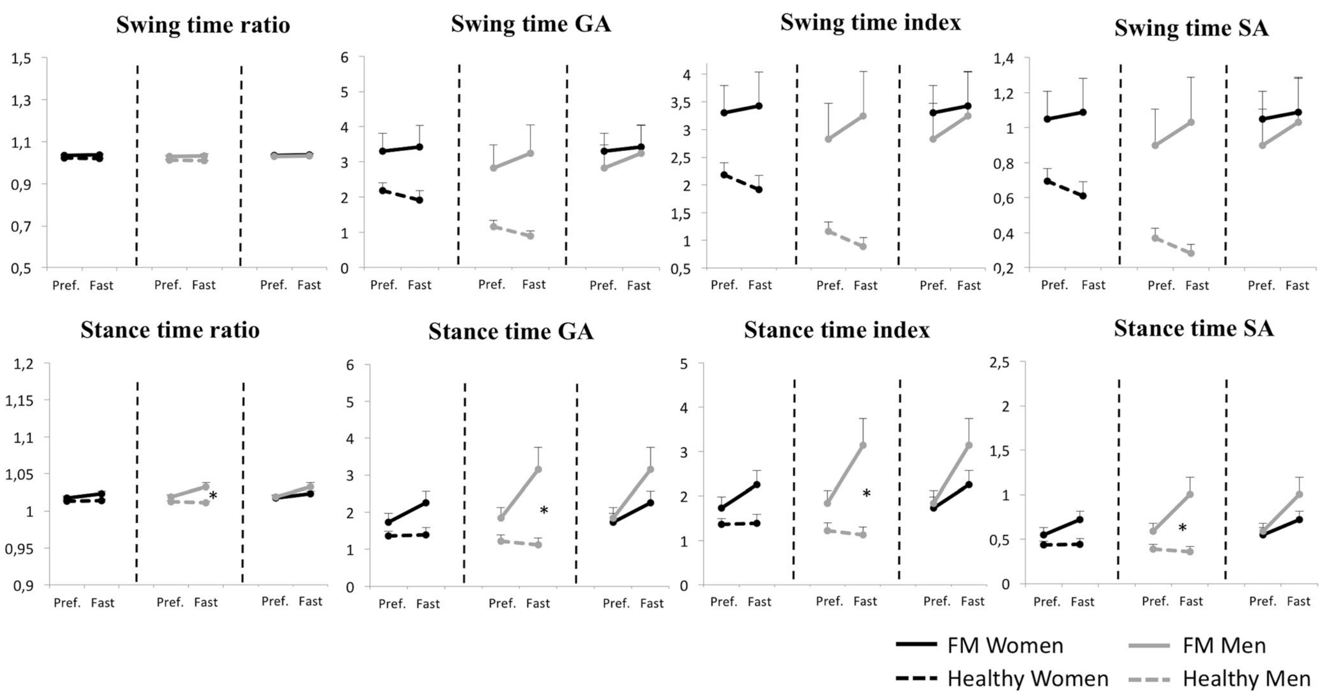

Fig. 4 Asymmetry indexes for FM patients and healthy subjects walking at fast and preferred velocities. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$ between groups. Pref: walking at preferred velocity; fast: walking at fast velocity

could be complementary tests for FM diagnosis in both genders. Future studies should be performed to analyse and establish a pathological range of BCG, variability and asymmetry variables for FM detection and to classify different subgroups of FM patients.

Previous studies have presented an ongoing debate concerning FM as divergent FM symptoms and characteristics appear to be gender-dependent. Some previous studies have described more FM symptoms in females than in males [6–11], while others presented the opposite results [9, 12, 13]. In contrast to these findings as our results demonstrated, no significant differences in spatio-temporal variables, asymmetries and bilateral coordination of gait between males and females with FM who were walking at any preferred or fast velocities were noted. Our data confirmed the findings previously conducted studies in which no gender differences in the clinical picture of FM as pain, severity or impact of FM were found [7, 12, 14, 37, 38] with respect to somatic and psychological symptoms [7, 10, 11, 14, 39] and/or physical function [16, 37].

With respect to human locomotion in FM patients compared to their corresponding healthy controls, previous studies have shown significant differences in all spatio-temporal gait variables [18, 32] with greater gait variability and worse bilateral coordination indices in women [27] and significant differences in velocity, cadence and stride length in men [22]. However, there are no previous studies comparing men and women with FM.

Our findings suggest that FM symptoms cause a similar effect in gait variables and asymmetry, variability and bilateral coordination indices between FM men's and women's short-distance walking at preferred and fast velocities. Therefore, future studies using the long-walking test (6-min walking test) should be carried out to compare both male and female patients with FM in order to understand the effects of FM symptoms on biomechanical and physiological variables.

As a limitation of the present study, the level of physical activity of the participants was not analysed. The lower prevalence of FM in men led to overall lower sample sizes of men with FM compared with women with FM.

Conclusions

The findings of the present study did not support gender-specific differences in walking variables and indices in FM patients. However, confirming differences in spatio-temporal gait variables, only BCG differences among females and only asymmetry among males were observed between FM and healthy subjects. The increase in walking velocity produced changes in BCG, variability and GA only in the FM groups. The differences found between both genders of FM patients and healthy subjects in walking indices (bilateral coordination, variability and gait asymmetry) at fast velocities could be a useful tool for diagnoses and evaluation of male and female patients with FM during short-term fast walking tests.

Acknowledgments The work of Orantes-González, E was supported by the Ministry of Education, Culture and Sports of Spain (ref. FPU13/00162, EST15/00019).

The research programme of the Faculty of Education, Economy & Technology of Ceuta, to support the editing of the manuscript was acknowledged.

Compliance with ethical standards

Disclosures None.

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