Physical function interfering with pain and symptoms in fibromyalgia patients

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ABSTRACT

Objectives. *The aim of this study was to assess the relationship between variables of physical assessment – muscular strength, flexibility and dynamic balance – with pain, pain threshold, and fibromyalgia symptoms (FM).*

Methods. *Our sample consists of 55 women, with age ranging from 30 to 55 years (mean of 46.5, (standard deviation, SD=6.6)), mean body mass index (BMI) of 28.7(3.8) and diagnosed for FM according to the American College of Rheumatology criteria. Pain intensity was measured using a visual analogue scale (VAS) and pain threshold (PT) using Fisher's dolorimeter. FM symptoms were assessed by the Fibromyalgia Impact Questionnaire (FIQ); flexibility by the third finger to floor test (3FF); the muscular strength index (MSI) by the maximum volunteer isometric contraction at flexion and extension of right knee and elbow using a force transducer, dynamic balance by the time to get up and go (TUG) test and the functional reach test (FRT). Data were analysed using Pearson's correlation, as well as simple and multivariate regression tests, with significance level of 5%.*

Results. *PT and FIQ were weakly but significantly correlated with the TUG, MSI and 3FF as well as VAS with the TUG and MSI ($p<0.05$). VAS, PT and FIQ was not correlated with FRT. Simple regression suggests that, alone, TUG, FR, MSI and 3FF are low predictors of VAS, PT and FIQ. For the VAS, the best predictive model includes TUG and MSI, explaining 12.6% of pain variability. For TP and total symptoms, as obtained by the FIQ, most predictive model includes 3FF and MSI, which respectively respond by 30% and 21% of the variability.*

Conclusion. *Muscular strength, flexibility and balance are associated with pain, pain threshold, and symptoms in FM patients.*

Introduction

Fibromyalgia (FM) is a rheumatologic syndrome characterised by a plethora of symptoms, such as chronic and diffuse musculoskeletal pain, fatigue, and sleep disorders (1-3). Studies on FM are becoming increasingly more frequent, since its high prevalence (4-6), important impact on the health system (7, 8), to the sufferer's quality of life (9, 10), as well as its physical (11) and psychological burdens (12, 13), are now well documented.

Recent studies highlight the importance of central sensitisation (allodynia), consequent upon alterations on the neurotransmitters that modulate pain, on the pathophysiology of FM (13). Indeed, according to Staud & Rodrigues (14), Simms (15) and Olsen & Park (16), FM should not be seen as a primary musculoskeletal dysfunction, and no muscular abnormalities have been documented as being typical of the disease (16). On the other hand, Le Goff reported several studies that found muscular abnormalities especially in histological patterns (18). This controversial question is still being investigated by the scientific community with recent results highlighting new points (19).

Nonetheless, the important physical incapacity driven by the pain and other symptoms of FM (11, 20) ultimately has the potential to reduce physical activity and may predispose the patients to sedentary lifestyles (21-23) and even to kinesophobia (24). Sufferers sometimes have considerably reduced muscular strength (23) and muscular resistance (25). Maquet *et al*. (26) found that, compared to individuals without FM, sufferers had a decrease of 39% in muscular strength, 40% in the resistance and 81% on endurance. Nørregaard *et al*. (27) reported a 20–30% decrease in the maximal spontaneous strength of the flexors and extensor muscles of the knee and elbow in individuals with FM.

Some authors have focused on the relationship between physical capacity and symptoms of FM. According to Jones *et al*. (22), reduced physical function is associated with intensity of pain and fatigue in individuals with FM (22). Furthermore, gender, age, intensity of fatigue, balance problems, and level of physical activity predict physical functions in FM (28). Different levels of physical disability, associated to differential severity of psychological symptoms, seem to be relevant to the point of suggesting the existence of subgroups of individuals with FM (29).

A better knowledge of the relationship between physical function and severity of symptoms of FM is necessary in order to determine causality, as well as to be a guide for effective therapies. Since the evidence that physical exercises are associated with improvement of symptoms of FM is strong (30, 31), herein we hypothesize that some symptoms can be explained by musculoskeletal factors such as muscular strength, flexibility, and functional balance (equilibrium). Accordingly, we aimed to investigate the relationship between physical health variables – strength, flexibility and functional balance – with pain, pain threshold and symptoms of FM overall, in individuals with FM.

Methods

Sample

Our sample consists of 55 women referred to the service of physical therapy in FM, Clinic Hospital, University of São Paulo (HCFMUSP), during the years of 2008 and 2009 (18 months). Age ranged from 30 to 55 years. FM was diagnosed by rheumatologists with expertise in the syndrome, according to the criteria of the American College of Rheumatology (ACR) (1).

Exclusion criteria were: non-controlled systemic disorders (diabetes, hypertension), neurological and musculoskeletal conditions that could compromise assessments, changes in conscience or comprehension levels, relevant joint disorders (severe arthrosis, arthroplasty of the hip or knee, rheumatoid arthritis, etc.), total or partial muscle ruptures, amputations, and other conditions that, to the discretion of the investigators, could interfere with the assessments. Of the 60 eligible subjects, 5 were excluded. Causes were impossibility of attending the revisits due to distance (n=2) or because of work (n=2), and important rheumatologic conditions (n=1).

This study was approved by the Investigation Review Board of the Clinics Hospital of São Paulo University. Participants consented to be in the study and signed the informed consent form during their screening assessment (Process 0337/07).

Procedures

Evaluation was conducted in two different steps, one for assessments through questionnaires and interviews with the investigators (clinical assessment), and other for the physical tests. Clinical assessment consisted of:

1) Questions on demographic data and pain history.

2) Pain at the time of assessment was estimated using a visual analogical scale (VAS) which estimates severity of pain using a visual rule of 10cm (with no numbers). At the extreme left there is an indication for no pain while at the extreme right, unbearable pain. Higher scores indicate more severe pain. The VAS is reliable and highly correlated with other forms of assessment of pain (32).

3) Fibromyalgia Impact Questionnaire (FIQ) (33) was used for the assessment of FM. This questionnaire was translated into Portuguese and validated for the Brazilian population by Marques *et al*. (34). The FIQ captures information on physical impairment, feel good, work missed, do work, work done, pain, fatigue, morning stiffness, morning tiredness, anxiety and depression. This questionnaire has been largely used in research, with good sensitivity, validity and reliability (35). Scores range from 0 to 100, and higher scores are associated with increased impact. As per Bennett, the mean value is 50 and severely affected patients have scores above 70 (35).

Physical tests consisted of the following tests:

1) Flexibility: *third fingertip-to floor* (3FF) test (36) was used in order to assess the global flexibility of the posterior muscles. Distance from the third finger to the floor was measured (metric ruler) with individuals in an orthostatic position, closed legs (adjacent feet), and maximal trunk flexion, with neck in a relaxed position and no flexion of the knees. Adequate flexibility yields individuals to touch the floor (zero value). Since some individuals may surpass the floor, assessments were conducted with participants on a support (step), in order to capture negative values. This test is clinically relevant, and has excellent properties of sensitivity, specificity, and accuracy (36).

2) *Functional reach test* (FRT) (37). This test measures the reaction to anterior shift of the trunk. It is a reliable test to assess the dynamic balance, as proposed by Duncan *et al*. (34), although caution has been recommended regarding the predictive value of this test for estimating falls in the elderly (38, 39). The FR was conducted with patients in the orthostatic position, closed legs and on a fixed, steady base. With arms at a flexion of 90º, they were instructed to reach the furthest possible distance without losing steadiness or balance, and the distance of shift was measured. According to Silveira (40) *et al*., for the Brazilian population, the average of the test in 20 to 40-year-old women is 34.7cm, in 41 to 69-year-old it is 28.5cm, and in 70 to 87-year-old women it is 27.1cm.

3) *Time to get up and go* (TUG) (41, 42), was used as a measure of agility and dynamic balance. It has been proposed that the TUG is a better assessment of dynamic balance than the FR (38), also in predicting falls in the elderly when values are above 30 seconds (43). According to Shumway Cook *et al*. (43), normal TUG values for the elderly should be equal to or lower than 10 seconds; values between 10 and 20 seconds suggest good agility. Bohannon (44) suggests that, for those younger than 60 years, normal values are around 9 seconds. In this test, patients seat in a standardised chair (42cm in height) and are instructed to stand-up, walk for 3 metres, return and

sit again. Time is measured. The TUG was repeated 3 times and the best performance was considered.

4) *Maximum volunteer isometric contraction* (MVIC) was measured trough a force transducer (EMG Sysytem do Brasil). Equipment was positioned in series to flexion/extension of knees and elbow. After being instructed, participants performed three series of MVIC, and the best performance was selected. Root Mean Squares (RMS) were calculated in kilograms. For the muscular strength index (MSI), we included the mean of all movements, normalised by the highest value obtained from the sample, as proposed by Stucki *et al.* (45). In the arthritis rheumatoid population, the mean value for MSI was 41% (46).

5) *Tender points, dolorimetry or pain threshold (PT) and tender points (TP+)* were estimated using Fisher's dolorimeter (47), as *per* the ACR (1) and Okifuji *et al.* (48). The dolorimeter registers pressure applied on the skin in pounds or kg/cm^2, from 1kg/cm^2 to 10kg/cm^2. If subjects feel discomfort in values below 1kg/cm^2, values are defined as being 0.5kg/cm^2. For those reporting discomfort at touch, values are 0.0kg/cm^2. TP+ is defined as pain threshold equal to or lower than 2.6cm^2 (49).

Statistical analyses

Descriptive statistics were conducted. Means and standard deviations (SD) were obtained. Normality was tested with the Kolmogorov-Smirnov test. Significance was defined at the level of 5%.

For regression analyses, TUG was transformed (logarithm, base of 10) for normalisation. For multiple regressions, dependent variables were (y): Pain (VAS), TP and total score on the FIQ. Independent variables were TUG, FRT, 3FF, and MSI. The Pearson correlation test was first conducted followed by linear regression and the Best Subset Test for choosing the 15 best regression models, with adjusted R^2 as the best criteria. Finally, a multiple linear regression was performed for each of the models, and the predictive equation was calculated, with the dependent variable (y) as a function of independent variables (x_1, x_2, x_3, x_4). All non-normal models (Kolmogorov-Smirnov test) and those that did not pass the test of homogeneity of variance were eliminated. Models with higher R^2 were retained. Significance was established at 5%.

Analyses were performed using the SigmaStat 3.5 Software.

Results

Our sample consists of 55 women, with mean age of 46.5 years (SD 6.6) and mean body mass index (BMI) of 28.7 (SD 3.8) (kg/m^2). Most participants were married (84%) and 33% did not work for pay. Mean number of years of education was 8.9 (SD 3.6). Demographic data are presented in Table I.

Dolorimetry showed that pain thresholds were lower in all tender points (mean=1.72, SD=0.5) and subjects had high number of positive tender points (mean=16.05, SD=2.6). Mean VAS scores were 5.94 (SD 2.2) (Table II).

Clinical tests indirectly measured the dynamic balance (TUG, FRT), flexibility (3FF), muscular strength (MVIC) and muscle strength index (MSI) are described in Table III.

The dependent variables FIQ and PT were moderately and significantly correlated with the TUG, MSI and 3FF (p<0.05). The VAS was moderately and significantly correlated with TUG and MSI. No significance correlation was found between FR and VAS, PT or FIQ (Table IV).

The independent variables were not significantly correlated (<0.60) and therefore were all included for the regression models. Linear regression showed that, independent variables, alone, had little power to predict VAS, PT and FIQ (Table V).

For each of the dependent variables, the best multiple regression model was retained, based on the adjusted R^2 values. According to Table VI, the best predictive model for pain includes the TUG and MSI, explaining 12% of pain variability. For PT and total FM score (FIQ), most predictive variables are 3FF and MSI, responding for 30% of PT variability and 21% of the variability of the FIQ.

Table I. Demographic characteristics of participants.

Variable	Mean (SD) or n (%)
Age (years)	46.46 (6.60)
Weight (kg)	69.70 (10.20
Height (m)	1.56 (0.06)
BMI (kg/m^2)*	28.70 (3.82)
Years of education	8.90 (3.62)
Time suffering from pain (months)	91.09 (83.51)
Time since diagnosis (months)	29.04 (40.70)
Female gender	55 (100%)
Civil status	
Married	46 (84%)
Single	7 (13%)
Divorced	2 (4%)
Widowed	0 (0%)
Occupation	
Absence leave	11 (2%)
Working at home	18 (33%)
Others	26 (47%)

*BMI: body mass index.

Table II. Assessment of pain, pain threshold of the 18 tender points, overall pain threshold and tender point count.

Assessment	Mean (SD)
Pain (VAS)	5.94 (2.23)
Tender points[1]	
Suboccipital	1.70 (0.78)
Lower cervical	1.27 (0.60)
Trapezium	1.69 (0.71)
Supra-spinosus	1.81 (0.77)
2ª Costochondral	1.37 (0.68)
Lateral epicondyle	1.53 (0.58)
Right gluteus	2.07 (0.86)
Greater trochanter	2.16 (0.94)
Right knee	1.87 (0.82)
Pain threshold[2]	1.72 (0.54)
Tender point count	16.05 (2.62)

[1] mean for bilateral values; [2]mean of dolorimetry for the 18 tender points.

Table III. Clinical tests for the assessment of functional balance, flexibility, and muscular strength.

Clinical test	Mean (SD)
Time to get and go (seconds)	11.25 (3.60)
Functional Reach Test (FRT) (cm)	23.23 (5.69)
3rd finger to floor test (3FFT) (cm)	17.93 (11.34)
CIVM (RMS - kg)	
Extension of right knee	14.48 (7.18)
Flexion of right knee	4.26 (2.29)
Extension of right elbow	4.65 (2.42)
Flexion of left elbow	6.71 (3.11)
Muscular strength index (MSI) (%)	44.07 (19.23)

Table IV. Coefficient of correlation between independent (TUG, FR, MSI and 3FF), and dependent variables (VAS, PT and FIQ).

	VAS		Pain Threshold		Total score of FIQ	
	r	*p*	*r*	*p*	*r*	*p*
Time to get up and go[1] (TUG)	0.29	0.03*	-0.35	0.008*	0.38	0.004*
Functional reach Test (FRT)	-0.01	0.46	0.19	0.16	-0.17	0.22
3rd finger to floor (3FF)	0.25	0.70	-0.49	<0.001*	0.40	0.003*
Muscular strength index (MSI)	-0.29	0.03*	0.40	0.002*	-0.35	0.008*

[1] transformed variable; *statistically significant at $p \leq 0.05$.

Table V. Simple regression model, correlating the independent (TUG, FR, MSI and 3FF) and dependent variables (VAS, PT and FIQ).

	Constant	Coefficient	R^2	Adjusted R^2	*p*-value
Pain - VAS					
Time to get up and go	5.787	13.44	0.086	0.068	0.03*
Functional reach	6.874	-0.040	0.011	0.000	0.46
Third finger to floor	5.074	0.049	0.061	0.043	0.07
Muscular strength index	7.44	-0.034	0.086	0.068	0.03*
Pain Threshold					
Time to get up and go[1]	1.764	-3.93	0.125	0.109	0.008*
Functional reach	1.3	0.018	0.036	0.018	0.164
Third finger to floor	2.135	-0.023	0.239	0.225	<0.001*
Muscular strength index	0.011	0.011	0.162	0.14	0.002*
Total score of FIQ					
Time to get up and go[1]	68.865	105.036	0.146	0.13	0.004*
Functional reach	79.248	-0.0395	0.028	0.001	0.219
Third finger to floor	61.695	0.468	0.158	0.143	0.003*
Muscular strength index	80.871	-0.245	0.125	0.108	0.008*

[1] transformed variable; *statistically significant at $p \leq 0.05$; TUG: time to get up and go; FR: Functional Reach; 3FF: third finger to floor; MSI: muscular strength index.

Table VI. Multiple regression with best models correlating the independent (TUG, FR, MSI and 3FF) and dependent variables (VAS, PT and FIQ).

	Constant	Coefficient	R^2	Adjusted R^2	*p*-value
Pain – VAS					
Time to get up and go[1]	6.917	9.717	0.124	0.091	0.032*
Muscular strength index		-0.025			
Pain threshold					
Third finger to floor	1.729	-0.0189	0.302	0.275	<0.001*
Muscular strength index		0.007			
Total score of FIQ					
Third finger to floor	70.963	0.369	0.211	0.181	0.002*
Muscular strength index		-0.17			

[1] transformed variable; *statistically significant at $p \leq 0.05$; TUG: time to get up and go; FR: Functional Reach; 3FF: third finger to floor; MSI: muscular strength index.

Discussion

Some studies suggest that FM is not a musculoskeletal disorder (16, 17). However, it is a controversial topic that continues to be studied (18) with new reports (19). There is consensus that it is a disorder characterised by dysfunctional neuromodulation of pain (14). Nonetheless, physical exercise seems to improve symptoms of FM (30, 31), and a better comprehension of this topic is of scientific interest (28, 50).

Herein, we investigated the relationship between physical function (muscular strength, flexibility, and dynamic balance) with pain (VAS), pain threshold (dolorimetry), and total symptoms of fibromyalgia (FIQ), in patients with FM. Results supported the association among metrics of flexibility, muscular strength and dynamic balance with pain intensity, pain threshold and symptoms of FM in syndrome patients.

In the present study, the BMI mean was 28.7 (SD 3.8) (kg/m^2), which indicates being overweighed and almost obese. This condition is commonly reported by literature (51, 52, 53). According to Okifuji *et al.,* 50% of all subjects analysed were obese and 28% were overweighed (51). Neumman *et al*. (52) and Yunnus *et al*. (53) reported that this condition is related to increased disability and intensity of symptoms. In this way, this condition could interfere with physical function and symptoms assessed in this study. However, it seems to be a condition related to fibromyalgia (51) and to the Brazilian population (4), which is difficult to avoid in the screening process.

Several studies suggest that, as compared to controls, individuals with FM have reduced strength (23, 26, 27) and compromised muscular resistance (25). Indeed, muscular strength is decreased by 20 to 40%, and may potentially affect the superior and inferior members as well as the trunk (26, 27, 54). Because our study lacks a control group, is not possible to conclude if there was a decrease of muscle strength in this sample, as reported by Panton *et al*. (23), Maquet *et al*. (26) and Nørregaard *et al*. (24).

In addition to muscular strength, flexibility is an important muscular attribute, influencing torque and strength (55). Although stretching exercises are largely used in clinical practice and in physical activity programs, studies on the importance of stretching exercises in FM are scarce (30, 31). The same is observed in the assessment of muscular flexibility in FM patients. The results of the 3FF test are far from the ideal condition, but do not permit to affirm if it is related to FM conditions or to a common characteristic in other populations (36).

We also assessed the functional balance by using the FRT and TUG tests. Although the utility of these tests as direct measures of balance is still controversial (38, 39), they indirectly measure agility and capacity of maintaining balance when the centre of gravity is shifted (40). The balance study in FM patients is a new report by the scientific community. However, balance complaints are frequent in clinical practice (22) and it seems to increase the risk of falls (56). According to Shumway Cook *et al*. (43), normal TUG values for the elderly should be equal to or lower than 10 seconds; values between 10 and 20 seconds suggest good agility. Bohannon (44) suggests that, for those younger than 60 years, normal values are around 9 seconds. In our study, the mean value was 11.2 (3.6) seconds and, considering the age of our population, these values are worse than expected by literature. The absence of a control group does not permit us to confirm if it is a real lack of balance, if the compromise in balance is primary, or secondary to the presence of pain (57).

As for the FRT test, mean values obtained in our study were 23.2 (SD 5.7) cm. The mean was similar to what would have been expected, according to literature, in individuals from 70 to 87 years – 27.1 (SD 2.8) cm – but neither for 20 to 40 years women – 34.7cm nor for 41 to 69 women – 28.5 cm (37). Although this data could not be confirm without a control group, these findings are of clinical importance, since they may reflect difficulty in reacting to routine balances, with increased predisposition to falls (56).

The influences of strength, flexibility and balance on the burden of FM are still poorly explored. In our study we assessed these parameters by respectively using the VAS, dolorimetry, and FIQ – instruments that are largely used and well validated (34, 35). Associations were explored using correlation analyses and regression. We found moderate but significant association between symptoms (pain, PT, and symptoms of FM) and physical variables (TUG, 3FF, and MSI). FRT was not associated with the studied variables. For pain, 8% of the variability was explained by the TUG and MSI. For PT and FIQ, TUG, MSI and 3FF are of importance. For PT, flexibility may explain 24% of the variance; for the FIQ, flexibility responds by 15.8% of the variability.

Pain imposes sensorial and emotional unpleasant experiences (32). In FM, the psychological component of pain should not be neglected (58). Accordingly, it should not be expected that pain could be totally explained by physical variables (muscular strength, flexibility and balance). Similar results were described by Mannerkorpi *et al.,* (59) who reported weak correlation between pain and physical performance. Nonetheless, we observed that 12% of the variance of the VAS in FM patients was explained by the model that included TUG and MSI, suggesting that dynamic balance and muscular strength are relevant for pain. Clinically, we propose that approaches addressing theses aspects may potentially improve pain by around 10%, which is relevant according to Dworkin *et al*. (60).

FM is characterised by low pain threshold, which can be explained by sensitisation of the central nervous system (14). This sensitisation is inherent in FM but, in the present study, we found that 30% of the variability in the pain threshold could be explained by strength and flexibility in our sample. This association between tender points and muscle condition was previously reported by Henriksen *et al*. (50) who observed that 5.1% of the variance in the number of tender points was explained by muscular strength of the knees. Our variables presented a greater association between pain threshold and muscle strength and flexibility. This data suggest that the improvement in muscular condition should positively affect the pain threshold on the tender points.

Accordingly, for the treatment of FM, the relevance of multiple symptoms and their interaction should not be neglected (2). The FIQ properly measures the burden of this syndrome (35). Although FM symptoms result not only in physical compromise, our data suggest that 21% of the variance of the FIQ could be explained by flexibility and muscular strength. Although correlation was not strong, it is still relevant that symptoms of FM can be partially predicted by musculoskeletal aspects in FM patients. Considering only the physical assessments of the FIQ, Mannerkorpi *et al*. (54) reported that 24% of the variability could be predicted by the 6-minute walking test and by the endurance of the shoulder muscles. Additionally Henrikson *et al*. (50) suggest that 5.1% of the physical function and 4.6% of the FIQ are explained by isokinetic strength of the knees. Although few studies explored these associations, the relationship seems to be relevant.

Our data support the hypothesis that FM symptoms are predisposed to inactivity, which in turn, contributes and reinforces the FM impact (25, 50). In other words, even without specific musculoskeletal changes, symptoms of FM compromise physical activity, limiting daily function and leading to progressive de-conditioning in FM individuals which then predispose them to sedentary lifestyles, with further reductions in physical capacity (50). Severity of pain, reduced pain threshold, as well as symptoms of FM, may be partially explained by decreased muscular strength, reduced flexibility, and impaired balance, in our study. Rutledge *et al*. (28) suggest that physical function in patients with FM may be predicted by fatigue, imbalance, and aerobic fitness, among others, suggesting an important relation between FM symptoms and physical function. After the syndrome is established and symptoms are perpetuated, it becomes unclear which aspects are more relevant for the incapacity: the symptoms or the secondary lack of physical condition.

In summary, our data support the hypothesis that pain and symptoms of FM can be partially explained by muscle condition (flexibility and strength) and dynamic balance in FM patients. Clinically, these results suggest that treatments including these modalities can improve FM impact around 10% to 30% by themselves.

Some limitations of our study should be acknowledged and limit the conclusions. The sample does not have a control groups to confirm the decreased physical function and is not large enough to yield more robust analyses. Additionally, the inclusion of tests of physical performance, such as the 6-minute walking test, could better explore the relationship between musculoskeletal changes and symptoms of FM.

Conclusion

Our results suggest the association between intensity of pain, pain threshold, and symptoms of FM, with muscular strength, flexibility and dynamic balance in FM patients. Intensity of pain may be at least partially explained by muscular strength and dynamic balance; changes in the pain threshold and symptoms of FM may be explained by muscle strength and flexibility. These data suggest that improving muscle strength, flexibility and dynamic balance can positively impact on pain, pain threshold and FM symptoms in patients with the syndrome.

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