Routledge
Taylor & Francis Group

Journal of Sports Sciences

ISSN: 0264-0414 (Print) 1466-447X (Online) Journal homepage: http://www.tandfonline.com/loi/rjsp20

Independent and joint associations of physical activity and fitness with fibromyalgia symptoms and severity: The al-Ándalus project

Víctor Segura-Jiménez, Alberto Soriano-Maldonado, Fernando Estévez-López, Inmaculada C. Álvarez-Gallardo, Manuel Delgado-Fernández, Jonatan R. Ruiz & Virginia A. Aparicio

To cite this article: Víctor Segura-Jiménez, Alberto Soriano-Maldonado, Fernando Estévez-López, Inmaculada C. Álvarez-Gallardo, Manuel Delgado-Fernández, Jonatan R. Ruiz & Virginia A. Aparicio (2017) Independent and joint associations of physical activity and fitness with fibromyalgia symptoms and severity: The al-Ándalus project, Journal of Sports Sciences, 35:15, 1565-1574, DOI: 10.1080/02640414.2016.1225971

To link to this article: https://doi.org/10.1080/02640414.2016.1225971

JOURNAL OF SPORTS SCIENCES, 2017
VOL. 35, NO. 15, 1565–1574
https://doi.org/10.1080/02640414.2016.1225971

Independent and joint associations of physical activity and fitness with fibromyalgia symptoms and severity: The al-Ándalus project

Víctor Segura-Jiménez [a,b], Alberto Soriano-Maldonado [b,c], Fernando Estévez-López [b,d], Inmaculada C. Álvarez-Gallardo [b], Manuel Delgado-Fernández [b], Jonatan R. Ruiz [e] and Virginia A. Aparicio [f]

[a]Department of Physical Education, Faculty of Education Sciences, University of Cádiz, Cádiz, Spain; [b]Department of Physical Education and Sport, Faculty of Sport Sciences, University of Granada, Granada, Spain; [c]Department of Education, Faculty of Education Science, University of Almería, Almería, Spain; [d]Department of Psychology, Faculty of Social and Behavioural Sciences, Utrecht University, Utrecht, The Netherlands; [e]PROFITH "PROmoting FITness and Health through physical activity" Research Group, Faculty of Sport Sciences, Department of Physical Education and Sport, University of Granada, Granada, Spain; [f]Department of Physiology, Faculty of Pharmacy, University of Granada, Granada, Spain

ABSTRACT

We examined independent and joint associations of objectively measured physical activity (PA) and physical fitness (PF) with pain, fatigue and the overall impact of fibromyalgia in 386 fibromyalgia women aged 51.2 ± 7.6 years. Levels of PA (light, moderate and vigorous) and PF were measured with triaxial accelerometry and the Senior Fitness Test, respectively. We used the Short-Form health survey-36 pain sub-scale and the Multidimensional Fatigue Inventory to assess pain and multiple dimensions of fatigue, respectively. The impact of fibromyalgia was studied with the Revised Fibromyalgia Impact Questionnaire (FIQR). Both, total PA and global PF were independently associated with pain pressure threshold, SF-36 pain, reduced activity, reduced motivation and FIQR total score (all, $P \leq 0.027$). The associations between total PA and symptoms were weaker than those observed between global PF and symptoms. Overall, unfit patients with low PA showed a worse profile that fit patients with high PA (all, $P \leq 0.001$). In summary, PA and PF are independently associated with pain, fatigue and the overall impact of fibromyalgia in women. Although PF presented greater associations with symptoms, the results suggest that both being physically active and keep adequate fitness levels might be convenient for fibromyalgia women.

ARTICLE HISTORY
Accepted 15 August 2016

KEYWORDS
GT3X+; counts per minute; physical function; cardio-respiratory fitness; muscle strength; flexibility

Introduction

Fibromyalgia is a complex disorder characterised by allodynia and hyperalgesia, together with several other important symptoms (Segura-Jiménez, Álvarez-Gallardo, Carbonell-Baeza et al., 2015; Segura-Jiménez, Aparicio et al., 2014; Wolfe, Brähler, Hinz, & Häuser, 2013). There is an increasing disability resulting from the burden of this prolonged chronic condition. Despite exercise training has shown to be a beneficial treatment therapy (Busch et al., 2011, 2013; Ellingson, Shields, Stegner, & Cook, 2012; Nuesch, Hauser, Bernardy, Barth, & Juni, 2012), fibromyalgia patients seem susceptible to an inactive lifestyle (Segura-Jiménez, Álvarez-Gallardo, Estévez-López et al., 2015), possibly because they think that physical activity (PA) might worsen their overall symptomatology.

PA is a leading factor associated with health markers (Booth, Roberts, & Laye, 2012; Eriksen, Curtis, Grønbæk, Helge, & Tolstrup, 2013). An active lifestyle has been associated with public health benefits (Ekelund et al., 2015). Higher PA levels have been associated with lower levels of fatigue in different populations and conditions (Puetz, 2006), such as fibromyalgia. Furthermore, fibromyalgia women who are physically active present increased ability to modulate their pain than women who are physically inactive (Ellingson, Shields et al., 2012). Another recent study suggests that increasing steps per day leads to improvements in physical function and pain in fibromyalgia patients (Kaleth, Slaven, & Ang, 2014). This highlights that fibromyalgia patients should be physically active, no matter the PA intensity.

There is a common reduction in PA and physical fitness (PF) levels in both men and women due to the ageing process (Milanovic, Jorgić, Trajković, & Pantelić, 2013). However, it seems that this process is premature in fibromyalgia. In fact, the reduction of PA in fibromyalgia women might determine a physical deconditioning. Physical fitness is so impaired in fibromyalgia population that is comparable with those of approximately 25 years older healthy individuals (Jones, Rakovski, Rutledge, & Gutierrez, 2014). In this context, the scientific literature shows that diverse conventional exercise interventions and complementary and alternative exercise programmes lead to symptoms improvement in fibromyalgia population (Rahman, Underwood, & Carnes, 2014). Importantly, not only cardiorespiratory fitness (Mannerkorpi, Svantesson, & Broberg, 2006), but also the improvement of other physical fitness components have shown to reduce the symptomatology in fibromyalgia patients (Assumpção, Sauer,

CONTACT Víctor Segura-Jiménez victor.segura@uca.es Department of Physical Education, Faculty of Education Sciences, University of Cádiz, Avenida República Saharaui s/n, 11519 Puerto Real, Cádiz, Spain

Mango, & Pascual Marques, 2010; Carbonell-Baeza et al., 2011; Mannerkorpi et al., 2006).

Due to the close link existing between PA and PF (Silva-Batista, Urso, Lima Silva, & Bertuzzi, 2013), and given the potentially beneficial effect of PA and PF for the general symptomatology in fibromyalgia, it is important to ascertain whether objectively assessed PA and PF are independently associated with fibromyalgia's key symptoms, such as pain and fatigue. In fibromyalgia, fatigue and pain are the hallmark, and they both are highly related to each other (Rongen-Van Dartel et al., 2014; Staud, 2012; Wolfe et al., 2013). Since PA has a significant role in maintaining PF (Milanovic et al., 2013), we hypothesised that both PA and PF are independently associated with pain, fatigue and the impact of fibromyalgia; and that there is a joint association of these symptoms and the overall impact of the disease. Therefore, we aimed to examine the independent and joint association of objectively measured PA and PF with pain, fatigue and the overall impact of the disease in fibromyalgia women.

Methods

Participants

We calculated the sample size needed to recruit a geographically representative sample of fibromyalgia patients (n = 300) from the South of Spain (Andalusia) by planning a province proportional recruitment. We contacted fibromyalgia women through fibromyalgia associations, internet advertisement, flyers and e-mail. A total of 616 fibromyalgia women were recruited from the eight provinces of Andalusia. Five hundred and sixty eight participants signed the written informed consent and agreed to wear an accelerometer during all required days. Patients had to be previously diagnosed by a rheumatologist (i.e., patients were requested to provide their medical records) and meet the 1990 American College of Rheumatology (ACR) fibromyalgia criteria (Wolfe et al., 1990), have neither acute or terminal illness nor severe cognitive impairment (Mini Mental State Examination (MMSE) score <10), and be ≤65 years old. The Ethics Committee of the *Hospital Virgen de Las Nieves* (Granada, Spain) reviewed and approved the study.

Measurements

PA

We used a triaxial accelerometer GT3X+ (Actigraph, Pensacola, FL, USA) to measure activity counts (rate of 30 Hz and stored at an epoch length of 60 s). Participants wore the device on the hip near to the centre of gravity, underneath clothing and secured with an elastic belt.

PA was recorded up to 9 days, starting from the day the participants received the accelerometers until the day that they were instructed to return the devices. PA data from the first recorded day (to avoid reactivity) and last day (return back device) were excluded. A total of 7 continuous days with a minimum of 10 valid hours per day was the criteria for being included in the study analysis. Sleeping time (recorded through a sleep diary where patients reported the time they went to bed and the time they woke up) was excluded in order to obtain the accelerometer wear time. Bouts of 90 continuous minutes of 0 counts were excluded from the analysis, considered as non-wear periods (Choi, Ward, Schnelle, & Buchowski, 2012).

Light, moderate, vigorous and moderate-vigorous PA (MVPA) intensity levels were calculated based upon recommended PA vector magnitude cut points (Sasaki, John, & Freedson, 2011): 200–2689, 2690–6166, ≥6167and ≥2690 cpm, respectively, and were expressed as min · day^{-1}. Total PA (min · day^{-1}) was calculated as the sum of the time spent at the light and MVPA intensities. We used the manufacturer software (Actilife^{TM} 6 desktop) to download, clean and analyse data.

Physical fitness

The Functional Senior Fitness Test Battery assesses cardiorespiratory fitness, muscle strength, flexibility and motor agility (Carbonell-Baeza et al., 2015; Rikli & Jones, 1999). The tests are described in the following.

The *chair sit and reach* test was performed as measure of lower-body flexibility. The patients started in a sitting position with one leg extended, and slowly bended forward sliding the hands down the extended leg in an attempt to touch (or pass) the toes. The number of centimetres short of reaching the toe (negative score) or reaching beyond it (positive score) was recorded. The test was performed twice for each leg, and the average of the best score from each leg was used.

The *back scratch* test was used as measure of upper-body flexibility. It provides a measure of the overall shoulder range of motion, as the distance between (or overlap of) the middle fingers behind the back with a ruler. The participants performed the test twice, and the average of the best value from both hands was used.

The *30-s chair stand* test is a measure of lower-body muscle strength. It measures the number of times an individual can rise to a full stand, starting from a seated position, with the back straight and feet flat on the floor within 30 s.

The *arm curl* test was performed to assess upper-body muscle strength. It measures the number of times a hand weight (2.3 kg for women) can be curled through a full range of motion within 30 s. The test was performed once with each arm. The average number of repetitions was recorded.

The *8-ft-up-and-go* test is a measure of motor agility. It consists in standing up from a chair, walking 8 ft (2.44 m) to and around a cone, and returning to the chair in the shortest period of time. The best time from two trials was recorded.

The *6-min walk* test assesses cardiorespiratory fitness. This test measures the maximum distance (in metres) that the patient is able to walk in 6 min along a 45.7 m rectangular course.

To create a global PF variable, we calculated a standardised index (z-score) of each physical fitness test. The z-score is calculated as (value − mean)/standard deviation. The z-score values of the 8-ft-up-and-go test were inverted, since higher score indicates worse performance. Finally, we calculated the mean of all these z-scores together (global PF).

Fibromyalgia criteria

Fibromyalgia women had to meet the 1990 ACR fibromyalgia criteria (Wolfe et al., 1990). We used a standard pressure algometer (FPK 20; Wagner Instruments, Greenwich, CT, USA) to assess 18 tender points. We performed two alternative measurements at each tender point and used the mean. Tender points were positive if the patient noted pain at pressure ≤4 kg · cm^{-2}, and the total count of positive tender points was recorded for each participant. We recorded the sum of the minimum pain–pressure values obtained for each tender point (pressure pain threshold).

Clinical pain

We used the 36-item Short-Form health survey (SF-36) pain sub-scale (Alonso, Prieto, & Antó, 1995) to assess clinical pain. This questionnaire ranges from a minimum score of 0 and a maximum of 100 where higher score indicates lower pain.

Fatigue

Fatigue severity was measured with the Spanish version of the *Multidimensional Fatigue Inventory* (MFI-S) (Munguía-Izquierdo et al., 2012; Schwarz, Krauss, & Hinz, 2003). The five scales that compose this questionnaire are general fatigue, physical fatigue, reduced activity, reduced motivation and mental fatigue. Each subscale includes four items with five-point Likert scales. Scores on each subscale range from 4 to 20, with higher scores indicating greater fatigue.

The impact of fibromyalgia

The *Revised Fibromyalgia Impact Questionnaire* (FIQR) is a self-administered questionnaire, comprising 21 individual questions with a rating scale of 0–10 (Bennett et al., 2009). This questionnaire has been validated in Spanish fibromyalgia patients (Salgueiro et al., 2013). The FIQR total score range from 0 to 100, with a higher score indicating greater effect of the condition on the person's life.

Body fat

Total body fat percentage was estimated using a portable eight-polar tactile-electrode impedanciometer (InBody R20, Biospace, Seoul, South Korea). Following the manufacturer's recommendations, we asked them not to have a shower, not to practice intense PA and not to ingest large amounts of fluid and/or food in the 2 h before the measurement. Patients released from clothing and metal objects during the assessment. The validity and reliability of this instrument has been reported by Malavolti et al. (2003) and Segura-Jiménez et al. (2015).

Medication for pain and depression

We asked patients the following questions: Have you consumed pain painkillers (analgesics) in the past 2 weeks? Have you consumed antidepressants in the past 2 weeks? A yes/no answer was recorded for each question.

Statistical analysis

We used descriptive statistic [mean (standard deviation)] to describe the clinical characteristics of the group.

To test the independent associations of diverse PA intensity levels and PF components with pain, multi-dimensional fatigue and the impact of fibromyalgia, we conducted: (i) univariable linear regression (crude and adjusted); (ii) multivariable backward stepwise linear regression, where diverse PA intensity levels and PF components were introduced simultaneously as independent variables and (iii) multivariable linear regression, where total PA and global PF were introduced simultaneously as independent variables. When the residuals were not normally distributed, we used non-parametric (quantile regression) instead of parametric (linear regression) statistics. We included age, body fat percentage, pain medication, depression medication and accelerometry-wear time in the models in order to control for their effect.

To determine the presence of an interaction (joint effect) between total PA and global PF with the study outcomes, separate regression models were built with pain- and fatigue-related variables and the impact of fibromyalgia as dependent variables, and total PA, global PF and the interaction term (total PA × global PF) as independent variables. For a visual representation of the joint effect, we created four groups. We categorised the patients according to the median of the distribution of the data for total PA as performing "low PA" or "high PA". We also used the median of the distribution of the data for the global PF to categorise the patients as "unfit" or "fit". Then, we created a new variable with 4 categories: 1 = "unfit + low PA", 2 = "unfit + high PA", 3 = "fit+ low PA", 4 = "fit + high PA". To examine the differences between these 4 groups, we performed analysis of the covariance with age, body fat percentage, pain medication, depression medication and accelerometry-wear time as covariates. Post hoc analysis with the Bonferroni's correction checked the differences across groups.

We used stata version 12.0 (Stata Corp, College Station, TX, USA) and the statistical significance was set at $\alpha = 0.05$.

Results

Thirty-six fibromyalgia women were not previously diagnosed, 81 did not meet the 1990 ACR criteria, 1 had severe cognitive impairment and 11 were older than 65 years old. Accelerometer data from 3 patients presented malfunction when downloading data and 17 patients did not meet the accelerometer criteria. Furthermore, 33 women did not complete data in all the study variables. The final sample included in the analyses comprised 386 fibromyalgia women, whose clinical characteristics are shown in Table 1.

Overall, higher light and vigorous PA intensity levels were associated with lower pain, fatigue (except mental fatigue) and FIQR total score. Light PA and vigorous PA were the intensities that showed greater associations with the outcomes (see Table 2). Overall, higher PF was consistently associated with lower pain, fatigue and FIQR total score (see Table 2).

The stepwise regression model showed that diverse fitness components and light and vigorous PA were independently associated with the different measures of pain, fatigue and the impact of fibromyalgia (see Table 3 for further detail).

The independent association of total PA and global PF with pain, fatigue dimensions and the impact of fibromyalgia in women are shown in Table 4. Both, total PA and global PF

Table 1. Clinical characteristics of fibromyalgia women, n = 386.

Variable	Mean	SD
Age	51.2	7.6
Fat percentage (%)	40.0	7.6
Tender points (11–18)	16.7	2.0
Pain pressure threshold (kg · cm^{-2})	43.2	13.3
SF-36 pain (0–100)	21.8	14.5
MFI-S		
General fatigue	18.0	2.6
Physical fatigue	16.6	3.0
Reduced activity	12.9	4.9
Reduced motivation	13.1	3.9
Mental fatigue	14.2	2.4
FIQR total score	63.9	16.7
Sedentary time (min · day^{-1})	459.0	103.3
Light PA (min · day^{-1})	419.9	91.9
Moderate PA (min · day^{-1})	44.5	29.4
Vigorous PA (min · day^{-1})	0.5	2.1
MVPA (min · day^{-1})	45.0	30.0
Chair sit and reach (cm)	−10.9	11.4
Back scratch (cm)	−13.8	11.9
Hand-grip (kg)	19.4	6.3
Chair stand (rep)	10.4	3.1
8-ft up and go (s)	6.8	1.7
Arm curl (rep)	14.4	4.9
6-min walk (m)	491.9	76.4

CI: confidence interval; FIQR: Revised Fibromyalgia Impact Questionnaire; MFI-S: Spanish version of the Multidimensional Fatigue Inventory; MVPA: moderate-vigorous physical activity; PA: physical activity; SD: standard deviation; SF-36: 36-item Short-Form health survey.

were independently associated with pain pressure threshold, SF-36 pain, reduced activity, reduced motivation and FIQR total score (all, $P \leq 0.027$).

There was a statistically significant interaction effect of total PA and global PF in relation to SF-36 pain ($P = 0.027$), general fatigue ($P < 0.001$) and FIQR total score ($P = 0.029$). The joint association of PA and PF on pain, fatigue and the impact of fibromyalgia are presented in Figure 1. All the analyses showed overall differences between groups (all, $P < 0.001$). In all the studied variables, unfit patients with low PA showed a worse profile than fit patients with high PA did (all, $P \leq 0.001$). Among unfit participants, the levels of pain, general fatigue and the impact of fibromyalgia did not differ between low and high physically active patients. Among fit participants, the levels of pain and general fatigue did not differ between low and high physically active patients, expect for FIQR total score. For this variable, fibromyalgia women with low PA showed higher FIQR total score (mean difference = 6.4; 95% confidence interval = 0.7, 12.1) than those with high PA ($P = 0.018$).

Discussion

The main finding from this study indicates an inverse and independent association of light and vigorous PA intensity levels and diverse PF components with pain, all fatigue-related dimensions (except mental fatigue), and the overall impact of fibromyalgia in women. Total PA and global PF were independently associated with the aforementioned variables. Although the overall strength of the associations was greater for the global PF, the results highlight the inclusion of total PA as a potential helpful behaviour in fibromyalgia. In fact, although reluctant to conclude on causality, fibromyalgia

Table 2. Individual association of physical activity (PA) intensity levels and physical fitness components with pain, diverse fatigue dimensions and overall impact of fibromyalgia women, n = 386.

	Unadjusted model			Adjusted model		
Variables	*B*	SE	*P*	*B*	SE	*P*
Pain pressure threshold						
Light PA (min · day^{-1})	0.025	0.008	0.002	0.027	0.008	0.001
Moderate PA (min · day^{-1})	0.023	0.023	0.331	0.025	0.024	0.304
Vigorous PA (min · day^{-1})	0.516	0.325	0.113	0.589	0.327	0.072
Moderate-to-vigorous PA (min · day^{-1})	0.025	0.023	0.278	0.027	0.023	0.247
Chair sit and reach (cm)	0.217	0.059	<0.001	0.230	0.061	<0.001
Back scratch (cm)	0.043	0.057	0.451	0.071	0.062	0.253
Chair stand (rep)	0.852	0.216	<0.001	0.934	0.223	<0.001
8-ft up and go (s)	−1.479	0.394	<0.001	−1.778	0.413	<0.001
Arm curl (repetitions)	0.614	0.134	<0.001	0.631	0.137	<0.001
6-min walk (m)	0.017	0.009	0.061	0.025	0.010	0.012
SF-36 pain						
Light PA (min · day^{-1})	0.036	0.009	<0.001	0.022	0.009	0.012
Moderate PA (min · day^{-1})	0.062	0.025	0.014	0.030	0.024	0.214
Vigorous PA (min · day^{-1})	1.069	0.349	0.002	0.921	0.332	0.006
Moderate-to-vigorous PA (min · day^{-1})	0.064	0.025	0.009	0.034	0.024	0.158
Chair sit and reach (cm)	0.346	0.062	<0.001	0.243	0.062	<0.001
Back scratch (cm)	0.311	0.060	<0.001	0.214	0.062	0.001
Chair stand (rep)	0.914	0.235	<0.001	0.634	0.231	0.006
8-ft up and go (s)	−1.180	0.431	0.006	−0.604	0.430	0.161
Arm curl (repetitions)	0.620	0.146	<0.001	0.481	0.142	0.001
6-min walk (m)	0.049	0.009	<0.001	0.035	0.010	<0.001
General fatigue						
Light PA (min · day^{-1})	−0.005	0.002	0.012	−0.002	0.001	0.085
Moderate PA (min · day^{-1})	−0.004	0.006	0.544	0.001	0.005	0.816
Vigorous PA (min · day^{-1})	−0.351	0.055	<0.001	−0.367	0.030	<0.001
Moderate-to-vigorous PA (min · day^{-1})	−0.004	0.006	0.536	−0.002	0.005	0.723
Chair sit and reach (cm)	−0.043	0.014	0.002	−0.033	0.012	0.005
Back scratch (cm)	−0.027	0.014	0.049	−0.021	0.010	0.047
Chair stand (rep)	−0.143	0.046	0.002	−0.137	0.043	0.002
8-ft up and go (s)	0.137	0.072	0.057	0.185	0.073	0.012
Arm curl (repetitions)	−0.103	0.031	0.001	−0.076	0.022	0.001
6-min walk (m)	−0.005	0.002	0.027	−0.005	0.002	0.032
Physical fatigue						
Light PA (min · day^{-1})	−0.009	0.002	<0.001	−0.005	0.002	0.046
Moderate PA (min · day^{-1})	−0.013	0.008	0.125	−0.012	0.008	0.109
Vigorous PA (min · day^{-1})	−0.271	0.075	<0.001	−0.293	0.075	<0.001
Moderate-to-vigorous PA (min · day^{-1})	−0.014	0.008	0.088	−0.013	0.008	0.109
Chair sit and reach (cm)	−0.072	0.017	<0.001	−0.052	0.017	0.002
Back scratch (cm)	−0.088	0.019	<0.001	−0.066	0.019	<0.001
Chair stand (rep)	−0.200	0.085	0.019	−0.216	0.067	0.001
8-ft up and go (s)	0.421	0.139	0.003	0.309	0.128	0.016
Arm curl (repetitions)	−0.087	0.058	0.134	−0.141	0.034	<0.001
6-min walk (m)	−0.012	0.003	<0.001	−0.007	0.003	0.005
Reduced activity						
Light PA (min · day^{-1})	−0.022	0.005	<0.001	−0.021	0.005	<0.001
Moderate PA (min · day^{-1})	−0.045	0.016	0.004	−0.036	0.011	0.001
Vigorous PA (min · day^{-1})	−0.273	0.128	0.034	−0.287	0.105	0.006
Moderate-to-vigorous PA (min · day^{-1})	−0.045	0.015	0.003	−0.036	0.009	<0.001
Chair sit and reach (cm)	−0.116	0.037	0.002	−0.054	0.029	0.065
Back scratch (cm)	−0.103	0.038	0.007	−0.034	0.030	0.251
Chair stand (rep)	−0.500	0.127	<0.001	−0.273	0.122	0.026
8-ft up and go (s)	0.820	0.237	0.001	0.478	0.176	0.007
Arm curl (repetitions)	−0.129	0.086	0.133	−0.103	0.068	0.131
6-min walk (m)	−0.021	0.005	<0.001	−0.014	0.006	0.030
Reduced motivation						
Light PA (min · day^{-1})	−0.010	0.002	<0.001	−0.008	0.002	0.001
Moderate PA (min · day^{-1})	−0.011	0.007	0.113	−0.006	0.007	0.349
Vigorous PA (min · day^{-1})	−0.254	0.092	0.006	−0.239	0.091	0.009
Moderate-to-vigorous PA (min · day^{-1})	−0.011	0.007	0.082	−0.007	0.007	0.273
Chair sit and reach (cm)	−0.071	0.017	<0.001	−0.051	0.017	0.003
Back scratch (cm)	−0.059	0.016	<0.001	−0.047	0.017	0.007
Chair stand (rep)	−0.237	0.063	<0.001	−0.197	0.064	0.002
8-ft up and go (s)	0.474	0.114	<0.001	0.420	0.117	<0.001
Arm curl (repetitions)	−0.118	0.039	0.003	−0.089	0.039	0.025
6-min walk (m)	−0.010	0.003	<0.001	−0.008	0.003	0.004

(*Continued*)

Table 2. (Continued).

Variables	Unadjusted model			Adjusted model		
	B	SE	P	B	SE	P
Mental fatigue						
Light PA (min · day^{-1})	−0.006	0.002	0.002	−0.002	0.002	0.197
Moderate PA (min · day^{-1})	−0.007	0.008	0.427	0.000	0.006	0.938
Vigorous PA (min · day^{-1})	−0.083	0.080	0.299	−0.095	0.042	0.024
Moderate-to-vigorous PA (min · day^{-1})	−0.007	0.008	0.416	0.000	0.006	0.972
Chair sit and reach (cm)	−0.050	0.016	0.002	−0.017	0.016	0.266
Back scratch (cm)	−0.037	0.013	0.004	0.000	0.025	1.000
Chair stand (rep)	−0.167	0.069	0.016	−0.167	0.032	<0.001
8-ft up and go (s)	0.284	0.126	0.024	0.131	0.071	0.064
Arm curl (repetitions)	−0.091	0.034	0.008	−0.049	0.039	0.209
6-min walk (m)	−0.007	0.002	0.004	−0.004	0.002	0.046
FIQR total score						
Light PA (min · day^{-1})	−0.054	0.010	<0.001	−0.039	0.009	<0.001
Moderate PA (min · day^{-1})	−0.095	0.028	0.001	−0.064	0.027	0.019
Vigorous PA (min · day^{-1})	−1.281	0.398	0.001	−1.090	0.372	0.004
Moderate-to-vigorous PA (min · day^{-1})	−0.098	0.028	<0.001	−0.067	0.027	0.012
Chair sit and reach (cm)	−0.451	0.071	<0.001	−0.307	0.070	<0.001
Back scratch (cm)	−0.420	0.068	<0.001	−0.316	0.070	<0.001
Chair stand (rep)	−1.650	0.263	<0.001	−1.342	0.255	<0.001
8-ft up and go (s)	2.460	0.487	<0.001	1.841	0.480	<0.001
Arm curl (repetitions)	−0.977	0.166	<0.001	−0.769	0.158	<0.001
6-min walk (m)	−0.072	0.011	<0.001	−0.056	0.011	<0.001

Unadjusted and adjusted models are controlled for accelerometry-wear time when physical activity variables are included. In addition, adjusted model is controlled for age, fat percentage, pain medication and depression medication. FIQR, Revised Fibromyalgia Impact Questionnaire; SE, standard error; SF-36, short-form health survey 36. Non-parametric statistic used with the variables: general fatigue, physical fatigue, reduced activity and mental fatigue.

Table 3. Independent association of physical activity (PA) intensity levels and physical fitness components with pain, fatigue dimensions and overall impact of fibromyalgia women, n = 386.

	B	SE	P	R_1^2	R_2^2
Pain pressure threshold				0.02	0.11
Arm curl (repetitions)	0.440	0.159	0.006		
Light PA (min · day^{-1})	0.024	0.008	0.003		
8-ft up and go (s)	−1.004	0.478	0.036		
SF-36 pain				0.13	0.21
Chair sit and reach (cm)	0.186	0.064	0.004		
Vigorous PA (min · day^{-1})	0.819	0.323	0.012		
Back scratch (cm)	0.166	0.063	0.009		
Light PA (min · day^{-1})	0.020	0.008	0.019		
General fatigue				0.04	0.08
Vigorous PA (min · day^{-1})	−0.346	0.031	<0.001		
Chair sit and reach (cm)	−0.130	0.034	<0.001		
Physical fatigue				0.08	0.12
Back scratch (cm)	−0.088	0.043	0.042		
Vigorous PA (min · day^{-1})	−0.277	0.063	<0.001		
Chair stand (rep.)	−0.051	0.019	0.007		
Reduced activity				0.07	0.12
Light PA (min · day^{-1})	−0.021	0.004	<0.001		
6-min walk test (m)	−0.068	0.033	0.039		
Chair stand (repetitions)	−0.256	0.120	0.034		
Reduced motivation				0.09	0.15
8-ft up and go (s)	−0.007	0.002	0.003		
Light PA (min · day^{-1})	0.358	0.116	0.002		
Vigorous PA (min · day^{-1})	−0.220	0.089	0.014		
Mental fatigue				0.04	0.06
Chair stand (repetitions)	−0.160	0.049	0.001		
FIQR total score				0.18	0.29
Chair sit and reach (cm)	−0.961	0.253	<0.001		
Light PA (min · day^{-1})	−0.035	0.009	<0.001		
Back scratch (cm)	−0.244	0.068	<0.001		
Vigorous PA (min · day^{-1})	−0.858	0.353	0.015		

Backward stepwise regression controlled for age, fat percentage, pain medication, depression medication and accelerometry-wear time. Only significant results are shown. FIQR, Revised Fibromyalgia Impact Questionnaire; SE, standard error; SF-36, 36-item Short-Form health survey. R_1^2, represents the R^2 when the covariates are the only variables included in the model, whereas R_2^2 represents the full model. Non-parametric statistic used with the variables: general fatigue, physical fatigue, reduced activity and mental fatigue.

women might avoid the deleterious impact of being unfit in their overall symptomatology and impact of the disease by being physically active.

Regularly, PA and PF are used interchangeably. However, it is noteworthy that these concepts cover different constructs. PA is defined as “any bodily movement produced by skeletal muscles that results in energy expenditure” (Caspersen, Powell, & Christenson, 1985), whereas physical fitness is “a set of attributes that people have or achieve that relates to the ability to perform physical activity” (Caspersen et al., 1985). Conceptualising these constructs is important since PA is a behaviour, whereas PF is the product of a combination of PA behaviours, genetics and functional health (Carnethon et al., 2010; Leskinen et al., 2009; Stubbe et al., 2006). Usually, engagement in PA leads to improvements in PF; however, high intensity seems to be the main characteristic of PA determining its effect on cardiorespiratory and muscular PF. For instance, cardiorespiratory fitness has shown to be more a function of PA intensity than PA volume in middle-aged women (Nokes, 2009).

The evidence regarding the preventive effect of regular PA on cardiovascular disease, mortality and morbidity in the general population has grown (Carnethon et al., 2010; Sassen et al., 2009). It is suggested that the protective effect of PA is only present if intensity levels are moderate-vigorous (Carnethon et al., 2010). However, these studies have overall focused on cardiovascular disease factors and metabolic abnormalities. The study of the association of PA with other health-related factors such as pain and fatigue are scarce. A recent study has shown that meeting PA recommendations is associated with higher levels of energy and lower levels of fatigue in adult women (Ellingson, Kuffel, Vack, & Cook, 2014). Similarly, vigorous PA was the only PA intensity level associated with pain in adult women (Ellingson, Colbert, & Cook, 2012). Given that vigorous PA is often painful (Cook, O’Connor, Eubanks, Smith, & Lee, 1997), traditionally this PA intensity level has been discouraged in patients with fibromyalgia. Moreover, fibromyalgia is a population less physically active than controls (Segura-Jiménez, Álvarez-Gallardo, Estévez-López et al., 2015), thus lighter intensity levels might be more appropriate for these patients. However, our results showed that higher vigorous PA was independently associated with lower pain. A hypothesis might be that regular engagement in vigorous PA might trigger an adaptation to repeated muscle pain exposure and decrease the unpleasant property of the stimulus (Ellingson, Colbert et al., 2012). Nonetheless, pain modulation has been also associated with both light and moderate PA in fibromyalgia patients (Ellingson, Shields et al., 2012). It is interesting that accumulating 30 min · day^{-1} of self-selected lifestyle PA produced clinically relevant changes in perceived physical function and pain in this population (Fontaine, Conn, & Clauw, 2010). This is in agreement with the results of this study, which showed an independent association of light PA with pain in fibromyalgia

Table 4. Independent association of total physical activity (PA) and global physical fitness (PF) with pain, diverse fatigue dimensions and overall impact of fibromyalgia in women, n = 386.

	B	SE	P	R_1^2	R_2^2
Pain pressure threshold				0.02	0.10
Total PA (min · day^{-1})	0.019	0.007	0.007		
Global PF (z-score)	0.733	0.162	<0.001		
SF-36 pain				0.13	0.18
Total PA (min · day^{-1})	0.016	0.007	0.027		
Global PF (z-score)	0.672	0.167	<0.001		
General fatigue				0.04	0.06
Total PA (min · day^{-1})	−0.001	0.001	0.565		
Global PF (z-score)	−0.100	0.028	<0.001		
Physical fatigue				0.08	0.11
Total PA (min · day^{-1})	−0.002	0.002	0.399		
Global PF (z-score)	−0.178	0.051	0.001		
Reduced activity				0.07	0.13
Total PA (min · day^{-1})	−0.019	0.004	<0.001		
Global PF (z-score)	−0.265	0.091	0.004		
Reduced motivation				0.09	0.12
Total PA (min · day^{-1})	−0.006	0.002	0.005		
Global PF (z-score)	−0.156	0.046	0.001		
Reduced motivation				0.04	0.05
Total PA (min · day^{-1})	−0.001	0.002	0.487		
Global PF (z-score)	−0.062	0.047	0.185		
FIQR total score				0.18	0.29
Total PA (min · day^{-1})	−0.030	0.008	<0.001		
Global PF (z-score)	−1.082	0.181	<0.001		

Analyses controlled for age, fat percentage, pain medication depression medication and accelerometry-wear time. CI, confidence interval; FIQR, Revised Fibromyalgia Impact Questionnaire; SE, standard error; SF-36, 36-item Short-Form health survey. R_1^2, represents the R^2 when the covariates are the only variables included in the model, whereas R_2^2 represents the full model. Non-parametric statistic used with the variables: general fatigue, physical fatigue and reduced activity.

women, regardless of vigorous PA and some PF components. Other studies in the general population and other conditions (Rongen-Van Dartel et al., 2014) found that PA is associated with overall fatigue, which agrees with our findings regarding general and physical-related fatigue, and reduced activity and motivation. Fatigue is a key fibromyalgia symptom highly related with pain and seems to contribute as much to these patients' dysfunction as pain itself (Staud, 2012). Thus, obtaining similar findings in the associations of PA with pain and fatigue was expected in our sample. Our results reinforce the inclusion of regular PA in this population, no matter the PA intensity level.

We observed an overall inverse association of diverse PF components with pain, fatigue and the impact of fibromyalgia. The link between PF components and fibromyalgia symptoms has been previously described. Cardiorespiratory fitness (Córdoba-Torrecilla et al., 2015; Estévez-López et al., 2015; Mannerkorpi et al., 2006; Soriano-Maldonado, Estévez-López et al., 2015; Soriano-Maldonado, Henriksen et al., 2015; Soriano-Maldonado, Ruiz et al., 2015), muscular strength (Carbonell-Baeza et al., 2011; Córdoba-Torrecilla et al., 2015; Estévez-López et al., 2015; Soriano-Maldonado, Estévez-López et al., 2015; Soriano-Maldonado, Henriksen et al., 2015; Soriano-Maldonado, Ruiz et al., 2015) and flexibility (Assumpção et al., 2010; Córdoba-Torrecilla et al., 2015; Estévez-López et al., 2015; Mannerkorpi et al., 2006; Soriano-Maldonado, Estévez-López et al., 2015; Soriano-Maldonado, Henriksen et al., 2015; Soriano-Maldonado, Ruiz et al., 2015) are associated with fibromyalgia symptoms and the severity of the disease. Since regular PA is a way to promote

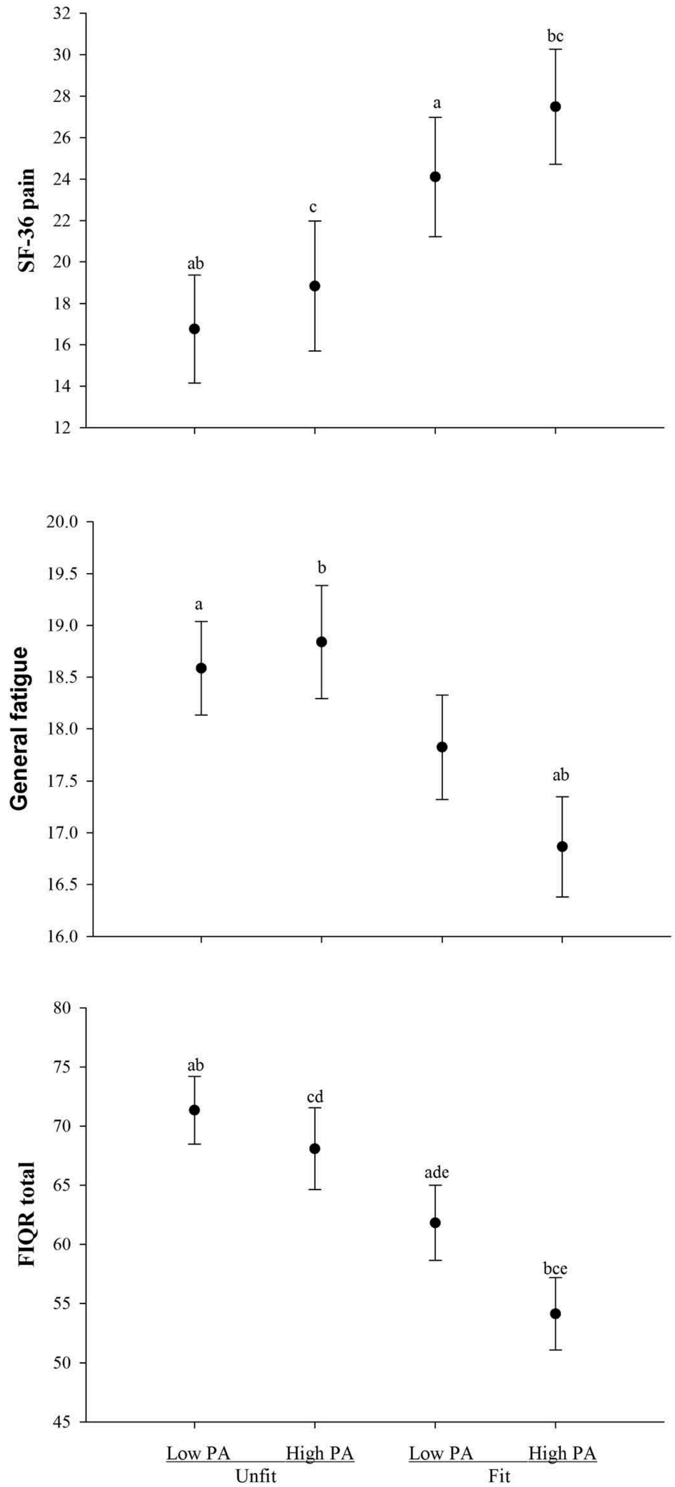

Figure 1. Joint effect of physical activity (PA) and global physical fitness on pain, general fatigue and the overall impact of fibromyalgia in women. Estimated mean (dots) and 95% confidence intervals (error bars) represent values after adjustment for age, total body fat percentage, medication for pain and accelerometry-wear time (analysis of the covariance was used to test the group differences). Common superscripts indicate significant (P < 0.05) differences between the groups with the same letter after Bonferroni's correction. From left to right n = 115, 78, 90 and 103, respectively. FIQR, Revised Fibromyalgia Impact Questionnaire; SF-36, 36-item Short-Form health survey.

improvement in different PF components, our results seem to encourage exercise as a common key component in the management of fibromyalgia. Although the association between individual PF components and pain, multi-dimensional fatigue and the severity of fibromyalgia was overall low, these were consistent with the magnitude of the associations found in previous research (Assumpção et al., 2010; Carbonell-Baeza, Ruiz, Aparicio, Ortega, & Delgado-Fernández, 2013; Carbonell-Baeza et al., 2011; Mannerkorpi et al., 2006). In fact, the effect of different types of exercise programmes in fibromyalgia present generally low effect sizes, although this weak effect seems even greater than that of pharmacologic treatment (Rahman et al., 2014).

To our knowledge, we showed for the first time, that there is an independent association of total PA and global PF with pain, general and physical fatigue, reduced activity and motivation, and the severity of the disease. In the general population, both PA and PF have shown an inverse association with metabolic abnormalities and cardiovascular disease risk factors (Carnethon et al., 2010; Sassen et al., 2009). Yet, low PF demonstrated a more robust association with the development of hypertension than low self-reported PA (Carnethon et al., 2010). Our results are generally in agreement with the general literature, since the association of PF with pain, fatigue and the impact of fibromyalgia was more robust than those of PA. Nonetheless, both PA and PF seem to be important for fibromyalgia management, since patients with both low PA and low PF presented the greatest impact of the disease, which is a deep marker of self-perceived health-related quality of life. This is consistent with a previous study showing that high levels of MVPA and cardiorespiratory fitness were associated with 12 times higher self-rated health compared with sedentary participants with low cardiorespiratory fitness (Eriksen et al., 2013). However, as PF is more consistently associated with fibromyalgia's key symptoms, in daily practice PA should preferably increase PF to achieve even better benefits for this population.

It has been suggested that combined aerobic and resistance exercise might effectively combat the primary muscle physiologic deficits in fibromyalgia (Srikuea et al., 2013). These deficits include peripheral abnormalities such as alterations in shape, volume, orientation, distribution and functioning of mitochondria (Castro-Marrero et al., 2013). Capillary density, permeability and structural changes in the capillary endothelium have been described as well (Srikuea et al., 2013). Muscle oxidative capacity associated with decreased capillary density contributes to exercise-induced fatigue and malaise in fibromyalgia. These abnormalities suggest an altered microcirculation which might lead to oxygen delivery and waste product clearance, contributing directly to pain and fatigue in fibromyalgia (Srikuea et al., 2013). In this context, PA and PF might promote angiogenesis and increase muscle vascular density in fibromyalgia, which in turns might reduce muscle pain and fatigue, and consequently the impact of the disease (Srikuea et al., 2013). Exercise-related changes in the structure of muscles might determine an increased tissue oxygenation, which could diminish peripheral sensitisation (Elvin, Siösteen, Nilsson, & Kosek, 2006). Furthermore, exercise might also improve fibromyalgia's central sensitisation by triggering an exercise-induced analgesic effect of the endogenous opioid activity in the central nervous system. Aerobic training improves physical function and fitness indices in patients with fibromyalgia (Carbonell-Baeza et al., 2011). Thus, we hypothesise that exercise training incorporating multiple resistance exercise combined with concurrent aerobic exercise would be most effective in improving both muscular strength and endurance deficits observed in fibromyalgia women (Srikuea et al., 2013). We recommend increase PA levels in fibromyalgia women, as well as is currently highly recommended in other pain syndromes, such as rheumatoid arthritis (Eurenius & Stenström, 2005). In this context, even brief self-regulation PA intervention has significant post-treatment beneficial effects upon fatigue severity, PA and health-related quality of life in chronic fatigue patients (Marques, De Gucht, Leal, & Maes, 2015). Broadly, motivating women with fibromyalgia to become more physically active, still represents a challenge to society and health professionals.

Limitations and strengths

We cannot establish causality relationships, although it has been suggested that a vicious cycle might exist, whereby symptoms may lead to inactivity, and inactivity leads to increased symptoms (Kop et al., 2005). For instance, physical inactivity and low PF might lead to fatigue and pain, but equally, myalgia could accentuate fatigue and have detrimental effects on aerobic and muscle performance (Mastaglia, 2012). Furthermore, it is likely that fibromyalgia women with lesser symptoms are able to be active and, consequently, they are fitter than those with greater symptoms are. Therefore, the results can be highly influenced by residual confounding and future studies should further study these complex relationships. Intervention studies with different patients' groups (low symptoms vs. high symptoms or low fitness vs. high fitness) might be a way to avoid this potential confounding effect. In addition, follow-up studies might help us to know the true direction of the relationships found in the present study. Traditionally, PA has been collected through subjective measures such as PA questionnaires. However, the recall of PA by means of self-reported questionnaires has been questioned since the use of self-reports of PA have shown to provide misleading information in fibromyalgia population (Segura-Jiménez, Álvarez-Gallardo et al., 2014, Segura-Jiménez et al., 2013). Therefore, strength of the present study was the use of an objective, feasible, valid and reliable measure of PA. Similarly, we measured PF objectively with a valid and reliable fitness test battery, which is commonly used in fibromyalgia patients. Additionally, we controlled all the analyses for body fat since it has shown to be associated with PF (Nokes, 2009) and fibromyalgia severity (Aparicio et al., 2014). Finally, we assessed a relatively large sample size of fibromyalgia women representative from Andalusia (southern Spain) (Segura-Jiménez, Álvarez-Gallardo, Carbonell-Baeza et al., 2015).

Conclusions

In conclusion, we showed that higher light and vigorous PA and diverse PF components are independently associated with lower pain, fatigue, and the overall impact of the disease in fibromyalgia women. The independent associations between total PA with pain, fatigue and the impact of fibromyalgia were overall weaker than those observed with global PF, indicating that being fit might be relevant for this condition. We also observed that fibromyalgia women who were fit and physically active consistently displayed a better profile than those unfit and physically inactive. Furthermore, unfit patients should be at least physically active, in order to avoid a greater deleterious impact. This study adds greater support in the inclusion of regular PA as a major component of fibromyalgia women's lifestyle.

Acknowledgements

We gratefully acknowledge all the study participants for their collaboration. We thank all the members from the al-Ándalus research group involved in the fieldwork.

Disclosure statement

None of the authors had any conflict of interests.

Funding

This study was supported by the Spanish Ministry of Economy and Competitiveness [I + D + I DEP2010-15639; BES-2014-067612; RYC-2010-05957]; the Consejeria de Turismo, Comercio y Deporte [CTCD-201000019242-TRA]; Granada Research of Excellence Initiative on Biohealth (GREIB), Campus BioTic, University of Granada; and the European University of Madrid, Escuela de Estudios Universitarios Real Madrid [2010/04RM]. VAA was supported by the Andalucía Talent Hub Program launched by the Andalusian Knowledge Agency, co-funded by the European Union's Seventh Framework Program, Marie Skłodowska-Curie actions (COFUND – Grant Agreement nº 291780) and the Ministry of Economy, Innovation, Science and Employment of the Junta de Andalucía, Spain.

ORCID

Víctor Segura-Jiménez http://orcid.org/0000-0001-8655-9857
Alberto Soriano-Maldonado http://orcid.org/0000-0002-4626-420X
Fernando Estévez-López http://orcid.org/0000-0003-2960-4142
Inmaculada C. Álvarez-Gallardo http://orcid.org/0000-0002-1062-8251
Manuel Delgado-Fernández http://orcid.org/0000-0003-0636-9258
Jonatan R. Ruiz http://orcid.org/0000-0002-7548-7138
Virginia A. Aparicio http://orcid.org/0000-0002-2867-378X

References

Alonso, J., Prieto, L., & Antó, J. M. (1995). The Spanish version of the SF-36 health survey (the SF-36 health questionnaire): An instrument for measuring clinical results. *Medicina Clinica*, *104*(20), 771–776. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/7783470

Aparicio, V. A., Segura-Jiménez, V., Álvarez-Gallardo, I. C., Estévez-López, F., Camiletti-Moirón, D., Latorre-Román, P. A., … Carbonell-Baeza, A. (2014). Are there differences in quality of life, symptomatology and functional capacity among different obesity classes in women with fibromyalgia? The al-Ándalus project. *Rheumatology International*, *34*(6), 811–821. doi:10.1007/s00296-013-2908-8

Assumpção, A., Sauer, J. F., Mango, P. C., & Pascual Marques, A. (2010). Physical function interfering with pain and symptoms in fibromyalgia patients. *Clinical and Experimental Rheumatology*, *28*(6Suppl 63), S57–63. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/21176422

Bennett, R. M., Friend, R., Jones, K. D., Ward, R., Han, B. K., & Ross, R. L. (2009). The Revised Fibromyalgia Impact Questionnaire (FIQR): Validation and psychometric properties. *Arthritis Research & Therapy*, *11*(4), R120. doi:10.1186/ar2783

Booth, F. W., Roberts, C. K., & Laye, M. J. (2012). Lack of exercise is a major cause of chronic diseases. *Comprehensive Physiology*, *2*(2), 1143–1211. doi:10.1002/cphy.c110025

Busch, A. J., Webber, S. C., Brachaniec, M., Bidonde, J., Bello-Haas, V. D., Danyliw, A. D., … Schachter, C. L. (2011). Exercise therapy for fibromyalgia. *Current Pain and Headache Reports*, *15*(5), 358–367. doi:10.1007/s11916-011-0214-2

Busch, A. J., Webber, S. C., Richards, R. S., Bidonde, J., Schachter, C. L., Schafer, L. A., … Overend, T. J. (2013). Resistance exercise training for fibromyalgia. *The Cochrane Database of Systematic Reviews*, *12*(12), CD010884. doi:10.1002/14651858.CD010884

Carbonell-Baeza, A., Álvarez-Gallardo, I. C., Segura-Jiménez, V., Castro-Piñero, J., Ruiz, J. R., Delgado-Fernández, M., & Aparicio, V. A. (2015). Reliability and feasibility of physical fitness tests in female fibromyalgia patients. *International Journal of Sports Medicine*, *36*, 157–162. doi:10.1055/s-0034-1390497

Carbonell-Baeza, A., Aparicio, V. A., Ortega, F. B., Cuevas, A. M., Álvarez-Gallardo, I. C., Ruiz, J. R., & Delgado-Fernández, M. (2011). Does a 3-month multidisciplinary intervention improve pain, body composition and physical fitness in women with fibromyalgia? *British Journal of Sports Medicine*, *45*(15), 1189–1195. doi:10.1136/bjsm.2009.070896

Carbonell-Baeza, A., Ruiz, J. R., Aparicio, V. A., Ortega, F. B., & Delgado-Fernández, M. (2013). The 6-minute walk test in female fibromyalgia patients: Relationship with tenderness, symptomatology, quality of life, and coping strategies. *Pain Management Nursing: Official Journal of the American Society of Pain Management Nurses*, *14*(4), 193–199. doi:10.1016/j.pmn.2011.01.002

Carnethon, M. R., Evans, N. S., Church, T. S., Lewis, C. E., Schreiner, P. J., Jacobs, D. R., … Sidney, S. (2010). Joint Associations of Physical Activity and Aerobic Fitness on the development of incident hypertension: Coronary artery risk development in young adults. *Hypertension*, *56*(1), 49–55. doi:10.1161/HYPERTENSIONAHA.109.147603

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports (Washington, D.C.: 1974)*, *100*(2), 126–131. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1424733&tool=pmcentrez&rendertype=abstract

Castro-Marrero, J., Cordero, M. D., Sáez-Francas, N., Jimenez-Gutierrez, C., Aguilar-Montilla, F. J., Aliste, L., & Alegre-Martin, J. (2013). Could mitochondrial dysfunction be a differentiating marker between chronic fatigue syndrome and fibromyalgia? *Antioxidants & Redox Signaling*, *19*(15), 1855–1860. doi:10.1089/ars.2013.5346

Choi, L., Ward, S. C., Schnelle, J. F., & Buchowski, M. S. (2012). Assessment of wear/nonwear time classification algorithms for triaxial accelerometer. *Medicine & Science in Sports & Exercise*, *44*(10), 2009–2016. doi:10.1249/MSS.0b013e318258cb36

Cook, D. B., O'Connor, P. J., Eubanks, S. A., Smith, J. C., & Lee, M. (1997). Naturally occurring muscle pain during exercise: Assessment and experimental evidence. *Medicine and Science in Sports and Exercise*, *29*(8), 999–1012. doi:10.1097/00005768-199708000-00004

Córdoba-Torrecilla, S., Aparicio, V. A., Soriano-Maldonado, A., Estévez-López, F., Segura-Jiménez, V., Álvarez-Gallardo, I., … Delgado-Fernández, M. (2015). Physical fitness is associated with anxiety levels in women with fibromyalgia: The al-Ándalus project. *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation*. doi:10.1007/s11136-015-1128-y

Ekelund, U., Ward, H. A., Norat, T., Luan, J., May, A. M., Weiderpass, E., … Riboli, E. (2015). Physical activity and all-cause mortality across levels of overall and abdominal adiposity in European men and women: The European Prospective Investigation into Cancer and nutrition study (EPIC). *American Journal of Clinical Nutrition*, *101*(3), 613–621. doi:10.3945/ajcn.114.100065

Ellingson, L. D., Colbert, L. H., & Cook, D. B. (2012). Physical activity is related to pain sensitivity in healthy women. *Medicine & Science in Sports & Exercise*, *44*(7), 1401–1406. doi:10.1249/MSS.0b013e318248f648

Ellingson, L. D., Kuffel, A. E., Vack, N. J., & Cook, D. B. (2014). Active and sedentary behaviors influence feelings of energy and fatigue in women.

Medicine & Science in Sports & Exercise, *46*(1), 192–200. doi:10.1249/MSS.0b013e3182a036ab

Ellingson, L. D., Shields, M. R., Stegner, A. J., & Cook, D. B. (2012). Physical activity, sustained sedentary behavior, and pain modulation in women with fibromyalgia. *The Journal of Pain*, *13*(2), 195–206. doi:10.1016/j.jpain.2011.11.001

Elvin, A., Siösteen, A.-K., Nilsson, A., & Kosek, E. (2006). Decreased muscle blood flow in fibromyalgia patients during standardised muscle exercise: A contrast media enhanced colour doppler study. *European Journal of Pain*, *10*(2), 137–144. doi:10.1016/j.ejpain.2005.02.001

Eriksen, L., Curtis, T., Grønbæk, M., Helge, J. W., & Tolstrup, J. S. (2013). The association between physical activity, cardiorespiratory fitness and self-rated health. *Preventive Medicine*, *57*(6), 900–902. doi:10.1016/j.ypmed.2013.09.024

Estévez-López, F., Gray, C. M., Segura-Jiménez, V., Soriano-Maldonado, A., Álvarez-Gallardo, I. C., Arrayás-Grajera, M. J., … Pulido-Martos, M. (2015). Independent and combined association of overall physical fitness and subjective well-being with fibromyalgia severity: The al-Ándalus project. *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation*, *24*, 1865–1873. doi:10.1007/s11136-015-0917-7

Eurenius, E., & Stenström, C. H. (2005). Physical activity, physical fitness, and general health perception among individuals with rheumatoid arthritis. *Arthritis Care & Research*, *53*(1), 48–55. doi:10.1002/art.20924

Fontaine, K. R., Conn, L., & Clauw, D. J. (2010). Effects of lifestyle physical activity on perceived symptoms and physical function in adults with fibromyalgia: Results of a randomized trial. *Arthritis Research & Therapy*, *12*(2), R55. doi:10.1186/ar2967

Jones, C. J., Rakovski, C., Rutledge, D., & Gutierrez, A. (2014). A comparison of women with fibromyalgia syndrome to criterion fitness standards: A pilot study. *Journal of Aging and Physical Activity*, *23*(1), 103–111. doi:10.1123/japa.2013-0159

Kaleth, A. S., Slaven, J. E., & Ang, D. C. (2014). Does increasing steps per day predict improvement in physical function and pain interference in adults with fibromyalgia? *Arthritis Care & Research*, *66*(12), 1887–1894. doi:10.1002/acr.22398

Kop, W. J., Lyden, A., Berlin, A. A., Ambrose, K., Olsen, C., Gracely, R. H., … Clauw, D. J. (2005). Ambulatory monitoring of physical activity and symptoms in fibromyalgia and chronic fatigue syndrome. *Arthritis & Rheumatism*, *52*(1), 296–303. doi:10.1002/art.20779

Leskinen, T., Waller, K., Mutikainen, S., Aaltonen, S., Ronkainen, P. H. A., Alén, M., … Kujala, U. M. (2009). Effects of 32-year leisure time physical activity discordance in twin pairs on health (TWINACTIVE study): Aims, design and results for physical fitness. *Twin Research and Human Genetics: The Official Journal of the International Society for Twin Studies*, *12*(1), 108–117. doi:10.1375/twin.12.1.108

Malavolti, M., Mussi, C., Poli, M., Fantuzzi, A. L., Salvioli, G., Battistini, N., & Bedogni, G. (2003). Cross-calibration of eight-polar bioelectrical impedance analysis versus dual-energy X-ray absorptiometry for the assessment of total and appendicular body composition in healthy subjects aged 21-82 years. *Annals of Human Biology*, *30*(4), 380–391. doi:10.1080/0301446031000095211

Mannerkorpi, K., Svantesson, U., & Broberg, C. (2006). Relationships between performance-based tests and patients' ratings of activity limitations, self-efficacy, and pain in fibromyalgia. *Archives of Physical Medicine and Rehabilitation*, *87*(2), 259–264. doi:10.1016/j.apmr.2005.10.013

Marques, M., De Gucht, V., Leal, I., & Maes, S. (2015). Effects of a self-regulation based physical activity program (The "4-STEPS") for unexplained chronic fatigue: A randomized controlled trial. *International Journal of Behavioral Medicine*, *22*(2), 187–196. doi:10.1007/s12529-014-9432-4

Mastaglia, F. L. (2012). The relationship between muscle pain and fatigue. *Neuromuscular Disorders: NMD*, *22*(Suppl 3), S178–S180. doi:10.1016/j.nmd.2012.10.003

Milanovic, Z., Jorgić, B., Trajković, N., & Pantelić, S. (2013). Age-related decrease in physical activity and functional fitness among elderly men and women. *Clinical Interventions in Aging*, *8*, 549. doi:10.2147/CIA.S44112

Munguía-Izquierdo, D., Segura-Jiménez, V., Camiletti-Moirón, D., Pulido-Martos, M., Álvarez-Gallardo, I. C., Romero-Zurita, A., … Delgado-Fernández, M. (2012). Multidimensional fatigue inventory: Spanish adaptation and psychometric properties for fibromyalgia patients. The al-Andalus study. *Clinical and Experimental Rheumatology*, *30*(6Suppl 74), 94–102. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/23261007

Nokes, N. (2009). Relationship between physical activity and aerobic fitness. *The Journal of Sports Medicine and Physical Fitness*, *49*(2), 136–141. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/19528890

Nuesch, E., Hauser, W., Bernardy, K., Barth, J., & Juni, P. (2012). Comparative efficacy of pharmacological and non-pharmacological interventions in fibromyalgia syndrome: Network meta-analysis. *Annals of the Rheumatic Diseases*, December 2011, 955–962.doi:10.1136/annrheumdis-2011-201249

Puetz, T. W. (2006). Physical activity and feelings of energy and fatigue: Epidemiological evidence. *Sports Medicine*, *36*(9), 767–780. doi:10.2165/00007256-200636090-00004

Rahman, A., Underwood, M., & Carnes, D. (2014). Fibromyalgia. *BMJ (Clinical Research Ed.)*, *348*, g1224. doi:10.1136/bmj.g1224

Rikli, R., & Jones, C. (1999). Development and validation of a functional fitness test for community-residing older adults. *Journal of Aging and Physical Activity*, *7*(2), 129–161. doi:10.1123/japa.7.2.129

Rongen-Van Dartel, S. A. A., Repping-Wuts, H., Van Hoogmoed, D., Knoop, H., Bleijenberg, G., Van Riel, P. L. C. M., & Fransen, J. (2014). Relationship between objectively assessed physical activity and fatigue in patients with rheumatoid arthritis: Inverse correlation of activity and fatigue. *Arthritis Care & Research*, *66*(6), 852–860. doi:10.1002/acr.22251

Salgueiro, M., García-Leiva, J. M., Ballesteros, J., Hidalgo, J., Molina, R., & Calandre, E. P. (2013). Validation of a Spanish version of the Revised Fibromyalgia Impact Questionnaire (FIQR). 1–8. doi:10.1186/1477-7525-11-132

Sasaki, J. E., John, D., & Freedson, P. S. (2011). Validation and comparison of ActiGraph activity monitors. *Journal of Science and Medicine in Sport*, *14*(5), 411–416. doi:10.1016/j.jsams.2011.04.003

Sassen, B., Cornelissen, V. A., Kiers, H., Wittink, H., Kok, G., & Vanhees, L. (2009). Physical fitness matters more than physical activity in controlling cardiovascular disease risk factors. *European Journal of Cardiovascular Prevention and Rehabilitation: Official Journal of the European Society of Cardiology, Working Groups on Epidemiology & Prevention and Cardiac Rehabilitation and Exercise Physiology*, *16*(6), 677–683. doi:10.1097/HJR.0b013e3283312e94

Schwarz, R., Krauss, O., & Hinz, A. (2003). Fatigue in the general population. *Onkologie*, *26*(2), 140–144. doi:10.1159/000069834

Segura-Jiménez, V., Álvarez-Gallardo, I. C., Carbonell-Baeza, A., Aparicio, V. A., Ortega, F. B., Casimiro, A. J., & Delgado-Fernández, M. (2015). Fibromyalgia has a larger impact on physical health than on psychological health, yet both are markedly affected: The al-Ándalus project. *Seminars in Arthritis and Rheumatism*, *44*(5), 563–570. doi:10.1016/j.semarthrit.2014.09.010

Segura-Jiménez, V., Álvarez-Gallardo, I. C., Estévez-López, F., Soriano-Maldonado, A., Delgado-Fernández, M., Ortega, F. B., … Ruiz, J. R. (2015). Differences in sedentary time and physical activity between female patients with fibromyalgia and healthy controls: The al-Ándalus project. *Arthritis & Rheumatology*, *67*(11), 3047–3057. doi:10.1002/art.39252

Segura-Jiménez, V., Álvarez-Gallardo, I. C., Romero-Zurita, A., Camiletti-Moirón, D., Munguía-Izquierdo, D., Carbonell-Baeza, A., & Ruiz, J. R. (2014). Comparison of physical activity using questionnaires (LTPAI and PAHWI) and accelerometry in fibromyalgia patients: The al-Ándalus project. *Archives of Physical Medicine and Rehabilitation*, *95*(10), 1903–1911.e2. doi:10.1016/j.apmr.2014.05.015

Segura-Jiménez, V., Aparicio, V. A., Álvarez-Gallardo, I. C., Carbonell-Baeza, A., Tornero-Quinones, I., & Delgado-Fernández, M. (2015). Does body composition differ between fibromyalgia patients and controls? The al-Andalus project. *Clinical and Experimental Rheumatology*, *33*(1Suppl 88), 25–32. Retrieved from http://www.clinexprheumatol.org/abstract.asp?a=8376

Segura-Jiménez, V., Aparicio, V. A., Álvarez-Gallardo, I. C., Soriano-Maldonado, A., Estévez-López, F., Delgado-Fernández, M., & Carbonell-Baeza, A. (2014). Validation of the modified 2010 American College of Rheumatology diagnostic criteria for fibromyalgia in a Spanish population. *Rheumatology (Oxford, England)*, *53*(10), 1803–1811. doi:10.1093/rheumatology/keu169

Segura-Jiménez, V., Munguía-Izquierdo, D., Camiletti-Moirón, D., Álvarez-Gallardo, I. C., Ortega, F. B., Ruiz, J. R., & Delgado-Fernández, M. (2013). Comparison of the International Physical Activity Questionnaire (IPAQ) with a multi-sensor armband accelerometer in women with fibromyalgia: The al-Ándalus project. *Clinical and Experimental Rheumatology*, *31* (6Suppl 79), S94–101. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/24373367

Silva-Batista, C., Urso, R. P., Lima Silva, A. E., & Bertuzzi, R. (2013). Associations between fitness tests and the international physical activity questionnaire-short form in healthy men. *Journal of Strength and Conditioning Research /National Strength & Conditioning Association*, *27* (12), 3481–3487. doi:10.1519/JSC.0b013e31828f1efa

Soriano-Maldonado, A., Estévez-López, F., Segura-Jiménez, V., Aparicio, V. A., Álvarez-Gallardo, I. C., Herrador-Colmenero, M., … Delgado-Fernández, M. (2015). Association of physical fitness with depression in women with fibromyalgia. *Pain Medicine*, pnv036. doi:10.1093/pm/pnv036

Soriano-Maldonado, A., Henriksen, M., Segura-Jiménez, V., Aparicio, V. A., Carbonell-Baeza, A., Delgado-Fernández, M., … Ruiz, J. R. (2015). Association of physical fitness with fibromyalgia severity in women: The al-Ándalus project. *Archives of Physical Medicine and Rehabilitation*, *96*(9), 1599–1605. doi:10.1016/j.apmr.2015.03.015

Soriano-Maldonado, A., Ruiz, J. R., Aparicio, V. A., Estévez-López, F., Segura-Jiménez, V., Álvarez-Gallardo, I. C., … Ortega, F. B. (2015). Association of physical fitness with pain in women with fibromyalgia: The al-Ándalus project. *Arthritis Care & Research*, *67*(11), 1561–1570. doi:10.1002/acr.22610

Srikuea, R., Symons, T. B., Long, D. E., Lee, J. D., Shang, Y., Chomentowski, P. J., … Peterson, C. A. (2013). Association of fibromyalgia with altered skeletal muscle characteristics which may contribute to postexertional fatigue in postmenopausal women. *Arthritis & Rheumatism*, *65*(2), 519–528. doi:10.1002/art.37763

Staud, R. (2012). Peripheral and central mechanisms of fatigue in inflammatory and noninflammatory rheumatic diseases. *Current Rheumatology Reports*, *14*(6), 539–548. doi:10.1007/s11926-012-0277-z

Stubbe, J. H., Boomsma, D. I., Vink, J. M., Cornes, B. K., Martin, N. G., Skytthe, A., … Feldman, M. (2006). Genetic influences on exercise participation in 37,051 twin pairs from seven countries. *PloS One*, *1*, e22. doi:10.1371/journal.pone.0000022

Wolfe, F., Brähler, E., Hinz, A., & Häuser, W. (2013). Fibromyalgia prevalence, somatic symptom reporting, and the dimensionality of polysymptomatic distress: Results from a survey of the general population. *Arthritis Care & Research*, *65*(5), 777–785. doi:10.1002/acr.21931

Wolfe, F., Smythe, H. A., Yunus, M. B., Bennett, R. M., Bombardier, C., Goldenberg, D. L., … Sheon, R. P. (1990). The American College of Rheumatology 1990 criteria for the classification of fibromyalgia. *Arthritis & Rheumatism*, *33*(2), 160–172. doi:10.1002/art.1780330203