
Using cardiovascular parameters and symptom severity to prescribe physical activity in women with fibromyalgia

B. Sañudo¹, D. Galiano²

¹Department of Physical Activity and Sport, University of Seville, Seville, Spain;

²Department of Physiology, Anatomy and Cellular Biology, University Pablo de Olavide, Seville, Spain.

Borja Sañudo, PhD
Delfín Galiano, PhD, MD

Please address correspondence and reprint requests to:

Dr Borja Sañudo Corrales,
Facultad de Ciencias de la Educación,
Departamento de Educación Física y Deporte Avda, Ciudad Jardín nº 22,
E-41005 Sevilla, Spain.
E-mail: bsancor@us.es

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ABSTRACT

Objective. This study has two main aims, firstly to define subgroups of women affected by fibromyalgia syndrome (FMS) based on symptoms and secondly to determine cardiovascular parameters in treadmill exercises in order to prescribe physical activity.

Methods. Thirty-two women (age = 53.26 ± 6.61 yr) were assigned to two different groups based on their functional capacity and symptoms as measured by the Fibromyalgia Impact Questionnaire and pain. Subjects were submitted twice to a maximum treadmill incremental test until participants achieved volitional exhaustion (VO_{2max}). Expired respiratory gases, ventilator parameters and heart rate (HR) were measured continuously through exercise, and rate perceived exertion (RPE) was assessed once a minute during the test.

Results. Peak VO_2 values for the moderately affected group (Group 1) were significantly different from those of severely affected group (Group 2) (26.2 ± 2.1 ml·kg⁻¹·min⁻¹ (Group 1) and 22.1 ± 2.5 ml·kg⁻¹·min⁻¹ (Group 2)). Additionally taking into account VO_2 at ventilatory threshold (VO_{2VT}), significant differences between groups were found in both tests. Some notable differences in all parameters evaluated were also found.

Conclusion. This study has demonstrated that the aerobic capacity of patients with FMS was different according to how severely affected they were by the condition; therefore, physical activity of the same intensity should not be prescribed for both groups. According to these results, health professionals could prescribe physical activity with confidence to this patient group.

Introduction

Fibromyalgia (FMS) is a condition characterised by widespread pain and pain at specific tender points (1). The prevalence of FMS in Spain is 2.7%,

affecting women much more frequently than men, with a ratio of 20:1 (2). Fibromyalgia may be a syndrome of dysfunctional central pain processing, and the neurologic mechanisms responsible for maintaining central pain states are now being studied, although the pathogenesis of widespread pain and FMS is unknown. Altered responses from the hypothalamus-pituitary-adrenal axis, changes in pain modulation in the central nervous system, sympathetic nervous system and muscular system have been suggested as being of importance (3). Several studies have evaluated exercises for the management of patients with FMS, the majority evaluating aerobic fitness by itself or combined with other modalities and, although treatment options for FMS are limited, a growing body of evidence suggests that exercise is beneficial (4-6).

While FMS is a chronic disease, some work has demonstrated symptomatic improvement in patients who practice regular physical exercise, as part of a prescribed rehabilitation programme (4-7). The acquisition of physical exercise as a coping strategy has been shown to be effective in improving pain and aerobic fitness (8). However, in order for the exercise to be effective, it has to be carefully prescribed and controlled. Exercise intensity has to be such that it can induce the effects of training but not so high as to increase symptoms. Getting patients with FMS to initiate and maintain an exercise programme remains challenging. In order to prescribe exercise to improve physical fitness, suitable frequency, duration and intensity are needed, among these, intensity is the most difficult to control (9). There are difficult problems when prescribing physical activity for women with FMS. Two women of the same age would have the same theoretical maximal heart rate (HR_{max}) according to traditional prescriptions based on the formula $220 - \text{age}$ supported by numer-

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ous authors (10-14). This can result in women with very different symptom profiles being prescribed similar exercise interventions, which may result in significantly different outcomes for patients who experience these similar interventions. Addressing these issues will assist clinicians design optimal therapeutic exercise training programs for patients.

Although 80% of patients with FMS are considered below normal level for maximum oxygen uptake (VO_{2max}), according to the American Heart Association (AHA) standards (15,16), no trials had been done so far to measure aerobic fitness, directly by a espiroergometric test and aerobic threshold, taking into account the different types of symptoms and capacities in patients.

The aim of this work was to identify changes in physiological parameters produced in patients with FMS while they exercise, while taking account of how severely affected they are by their condition. This paper assesses the nature and magnitude of differences in submaximal and maximal exercise capacity in women with FMS, assigned to two different groups according to their functional capacity and symptom presentation.

Methods

Participants

Thirty-two women with FMS between 42 and 63 years old participated in the study. Participants were assigned, based on their symptom levels as defined by the Fibromyalgia Impact Questionnaire (FIQ). Subjects with a baseline FIQ below the overall baseline median of 54 were allocated in Group1 and those with baseline FIQ equal to or higher than 54 to Group 2 (Group1=52.75±5.99 yrs; Group 2=55.37±7.22 yrs); representing two natural groups according to Da Costa *et al.* (17). The exclusion criteria included the presence of inflammatory rheumatic diseases and subjects with respiratory or cardiovascular diseases that prevented physical exercise were also omitted. Finally, those women with FMS who attended a physical therapy during the last six months were excluded to avoid possible interactions with the present trial. The Committee

on Biomedical Ethics of the University of Seville (Spain) gave approval for the study.

Outcome measures

The primary outcome measures were physical fitness and symptoms as measured by the FIQ, visual analogue scale (VAS) for pain, Tender Points (TPs), and aerobic capacity.

Health related-quality of life and pain

All patients had to complete several questionnaires about their perceived functional ability and quality of life. The Spanish version of the FIQ, is a disease-specific measure of global health status developed and validated for use in patients with FMS (18). Total scores range from 0 to 100, with higher scores indicating more severe symptoms and disability. Pain intensity over the past week was assessed by using self-report using 10 cm VAS, 0=no pain and 10=severe pain (19). According to the protocol described by Wolfe *et al.* (1), the number of TPs were recorded.

Physiological parameters

Expired gas analysis was performed with a computerised metabolic system MetaMax 3B (CORTEZ Biophysik GMBH, Germany). From this analysis the following variables were evaluated: the rate at which gas enters/leaves the lung or ventilation per minute (VE), the volume of carbon dioxide expired from the lungs or carbonic gas output (VCO_2), the respiratory quotient (RQ) calculated from the ratio CO_2 eliminated/ O_2 consumed and ventilatory efficiency will be assessed using the ventilatory equivalents of CO2 and O2 (VE/VCO_2 and VE/VO_2).

The highest value obtained in the load was taken as peak oxygen uptake (VO_{2peak}). Heart rate (HR) was recorded via heart rate monitor (Polar; Seattle, WA). Rating of perceived exertion (RPE) was collected using the Borg 6-20 Scale, based on the physical sensations a person experiences during physical activity, including increased heart rate, increased respiration or breathing rate, increased sweating, and muscle fatigue were recorded in both trials.

The level of physical activity over the

previous seven days was assessed using a self-administered short form of the International Physical Activity Questionnaire (IPAQ). The questionnaire allows individuals to be classified into one of three groups including inactive, minimally active and active. Minutes of sitting, walking, moderate-intensity (walking not included), and vigorous-intensity activities were computed for the previous week.

Testing protocols

After informed written consent was obtained, subjects were submitted twice to a maximum treadmill incremental test to assess the reproducibility of the physiological outcome measures and testing protocols were performed approximately one week apart. The Bruce Protocol, modified by Kaminsky (20) was used. The protocol begins at 1.7 mph and at an incline of 10% and consists of increments in either speed and/or grade every 20 seconds. The speed and grade settings for the last 20 seconds of each 3-minute segment of the protocol are identical to those of the standard Bruce protocol (*e.g.* 3 minutes: 1.7 mph, 10% grade). During both treadmill bouts, expired gases were continuously collected breath by breath. HR was measured and recorded each five seconds during the exercise.

Once given anchors of RPE, each subject warmed up for 5 minutes before the test. The duration of each stage of the test was 3 min. Rate of Perceived Exertion was recorded every minute during exercise, and VE, RQ, HR and VO_2 were recorded every 5 seconds. Criteria for reaching VO_{2max} included two of the following: 1) respiratory exchange ratio=1.0, 2) HR_{max} =95% of age-predicted maximum, and 3) plateau or decrease of VO_2 ($2ml \cdot kg^{-1} \cdot min^{-1}$) during the final minute of the stage. Anaerobic threshold (VT) was defined by using the following criteria: nonlinear VE elevation, VE/VO_2 , VE/VCO_2 , and RQ curves inflection points.

Data were averaged every 30 seconds, and they were used to calculate VO_2 , RR, VE and RQ. Peak oxygen uptake was expressed in absolute values (VO_{2peak} , l/min) and relative to body weight ($ml \cdot kg^{-1} \cdot min^{-1}$).

Table I. Subjects' characteristics.

	Group 1		Group 2	
	Mean	SD	Mean	SD
Age (years)	54.12	5.94	55.38	7.37
BMI (kg/m ²)	28.29	4.49	29.04	4.98
VAS pain (0-10)	5.6	1.9	6.4	2.3
FIQ (0-100)	51.56	12.46	70.21	5.75
TP	11.71	4.61	14.88	3.36

Group 1: moderately affected; Group 2: severely affected.

BMI: body mass index; FIQ: Fibromyalgia Impact Questionnaire; TP: tender points count.

Statistical analysis

Descriptive data for perceptual and physiological variables were calculated as mean±SD. All variables were compared in both groups using independent *t*-test. Data were tested for normal distribution (Kolmogorov-Smirnov non-parametric test). In all tests the significance level was set at *p*<0.05. Analyses were performed using SPSS 15.0 for windows (SPSS Inc, Chicago, IL, USA).

Results

The main personal features of patients in both groups are presented in Table I. According to the IPAQ scoring mechanism 68.75% of patients in group one and 93.75% of the patients allocated in group two were considered as inactive (do not meet 3 or more days of vigorous activity of at least 20 minutes per day, or 5 or more days of moderate-intensity

activity or walking of at least 30 minutes per day), and just 31.25% in group one and 6.25% in group two reported to walk of at least 30 minutes per day and therefore were considered as moderate active. Both groups (allocation based on their level of FMS severity) showed significant differences related to their symptoms, functional ability (FIQ and VAS) and TPs.

Sixty-three percent of participants in Group 1 and only 40% in Group 2 reached VO_{2max}. All patients in both groups reached anaerobic threshold load (VO_{2VT}). VO_{2max} and VO_{2VT} were lower in Group 2, when compared to Group 1. Oxygen utilisation percentage at anaerobic threshold in relation to maximum uptake (%VT) was higher in Group 2 (Table II).

Peak VO₂ values for Group1 were significantly higher from those reached in Group 2 (26.2±2.1 ml·kg⁻¹·min⁻¹ (Gr1)

and 22.1±2.5 ml·kg⁻¹·min⁻¹(Gr2)). On the other hand, taking into account VO_{2VT}, significant differences between groups were found only in the second trial. Another finding is that achieved HR_{max}, VE and RPE were all lower in group 2, *i.e.* those who had the worst symptoms. Finally, significant differences in test duration (815 seconds in Group 1, and 627 seconds in Group 2) were found.

Discussion

According to Thieme *et al.* (21), many studies in FMS report negative finding without considering sub-groups in FMS. The consequences of this may be that positive treatment intervention may be overlooked. The aim of this study was to use cardiovascular parameters and symptom severity to prescribe physical activity in women with FMS. In the present study those participants with more severe symptoms had lower VO₂ and higher HR, than patients with less severe symptoms. In order to determine whether a VO_{2max} value is abnormally low, reference values are required. This allows those values to be compared with that published by ACSM (22). Participants in Group 1 scored in the 35th percentile (26.13 ml.kg⁻¹.min⁻¹); by contrast Group 2 patients were under 10% (22.33 ml.kg⁻¹.min⁻¹). This study has demonstrated that there were significant statistical differences between

Table II. Physiological parameters mean ± standard deviation.

Variables	Trial 1			Trial 2		
	Group 1	Group 2	<i>p</i> -values	Group 1	Group 2	<i>p</i> -values
RR	27.95 ± 5.50	26.68 ± 6.75	0.372	25.32 ± 5.16	26.16 ± 8.21	0.748
VE	36.58 ± 5.55	35.61 ± 5.15	0.598	34.29 ± 5.93	32.22 ± 7.07	0.291
VO ₂ (l/min)	1.31 ± 0.19	1.28 ± 0.21	0.825	1.27 ± 0.06	1.23 ± 0.27	0.453
VO ₂ (ml·kg ⁻¹ ·min ⁻¹)	20.72 ± 2.15	16.08 ± 1.55	<0.001*	19.98 ± 1.72	15.17 ± 1.46	<0.001*
VO _{2peak}	26.17 ± 3.62	22.13 ± 2.50	<0.001*	23.59 ± 2.83	20.89 ± 1.62	<0.001*
VO _{2VT}	20.28 ± 2.70	19.21 ± 2.22	0.163	20.29 ± 3.04	18.55 ± 1.67	0.019*
RQ	0.91 ± 0.01	0.91 ± 0.01	NS	0.89 ± 0.10	0.89 ± 0.05	NS
HR _{mean}	130.82 ± 12.34	126.03 ± 16.81	0.311	129.91 ± 13.26	123.21 ± 15.98	0.135
HR _{max}	158.17 ± 12.37	144.01 ± 21.33	0.015*	153.88 ± 10.76	145.11 ± 19.92	0.086
HR _{VT}	140.33 ± 16.62	131.64 ± 22.76	0.177	138.35 ± 11.84	133.11 ± 16.39	0.243
RPE	13.6 ± 0.87	14.22 ± 1.20	0.049*	13.42 ± 0.63	14.31 ± 0.71	<0.001*
Duration (s)	815 ± 23	627 ± 16	<0.001*	818 ± 6	621 ± 9	<0.001*

Group1: moderately affected group; Group 2: severely affected group. RR: respiratory rate; VE: ventilation per minute; RQ: respiratory quotient; VO_{2peak}: maximum oxygen uptake reached on the test; VO_{2VT}: oxygen uptake at ventilatory threshold; HR: Heart rate; HRVT: heart rate at ventilatory threshold; RPE: rating of perceived exertion. *p*<0.05.

patients with FMS in VO_{2max} based on their symptoms. This confirms low cardiorespiratory fitness level in patients with the worst symptoms as previously described (16, 23, 24).

This study has also shown that FMS patients had greater perceived exertion, which can be due to prolonged inactivity in these patients (25). In contrast to healthy subjects, women with FMS perceive modest muscular work as painful, which may be caused by altered pain processing mechanisms (26). Some patients can exercise at moderate intensity, while for others this intensity can increase their pain (10). It has been demonstrated that pain intensity in those with chronic pain is not constant, particularly in those with FMS whose symptoms are highly variable (27). This emphasises the need to assess individual capacity before starting any exercise program in those with FMS. A significant association between perceived exertion and pain was found, which could indicate that it is difficult to distinguish between pain and perceived exertion during this type of exercise. Sensitisation of ergoreceptors and nociceptors in the muscles has been suggested as an explanation of both higher perceived exertion and pain in FMS compared with controls at similar workloads (28). The attenuated hormonal response to exercise in FMS patients may indicate lower sympathetic activity during exercise which is related with pain sensation. However, aerobic capacity is a known confounder of sympathoadrenal responses and differences in exercise intensity may affect the catecholamine release (3). Reduction in the release of several neurotransmitters is thought to play a role in pain processing in FMS patients and both pain and exercise appear to modify the corticomotor pathway; although the relation between activation of the corticomotor pathway and exercise-induced analgesia is not known (29). One potential mechanism is the activation of the opioid system, which is frequently assessed in relation to exercise-induced analgesia and activated with exercise, when physical fitness is high circulating beta-endorphin is increased (30).

Sietsema (23) found no differences between those with FMS and sedentary

control individuals by using VO_{2peak} and VO_{2VT} . However, Valim *et al.* (16), showed lower VO_{2max} and VO_{2VT} values in FMS patients compared to controls. VO_2 values were slightly lower in Group 1, than VO_2 values previously reported for sedentary women (31), although VO_{2VT} values were within normal range for sedentary subjects. By contrast, VO_2 for Group 2 patients showed significant differences, similar to that reached in other diseases (32).

A notable finding in the present study was the difficulty in obtaining a true maximal exercise test in some of those with FMS; however all patients in both groups reached the anaerobic threshold load. Thus, VT can be considered a more reliable index than maximum uptake in patients with FMS (15). In this sense, VT can be used directly and accurately as a cardiorespiratory fitness measure (33), and is also a useful means to evaluate training effect in low to moderate intensity physical exercise (34) as recommended in these patients (6). The exercise intensity is important for the safety and effectiveness of programs in subjects with FMS (35). However, the patient must be aware that at short term could increase the pain and fatigue. Heartbeat at VT indicates a training intensity suitable to gain cardio-respiratory fitness, with a lower risk of injury and higher adherence (36).

In summary, results confirmed the necessity of establishing sub-groups in FMS patients based on symptoms and cardiovascular parameters in order to prescribe physical activity. This study also demonstrated that aerobic capacity of FMS patients is different according to how severe the condition is. This information may be used for prescription and control of physical activity in these populations. Prescription of aerobic exercise based on anaerobic threshold may be recommend in FMS patients instead of VO_{2max} .

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