Credit: Sheffield Teaching Hospitals NHS Foundation Trust

Key points

- Adults with fibromyalgia often present with reduced cardiorespiratory fitness.
- Reduced cardiorespiratory fitness might have an important impact on functional capacity and quality of life.
- Adults with fibromyalgia who have a secondary condition affecting their ventilatory anaerobic threshold and/or V'_{O_2peak}, for example chronic obstructive pulmonary disease, might present with a greater reduction of their cardiorespiratory fitness which may not be entirely related to their lung disease.

Educational aims

- To better understand the cardiorespiratory fitness results among adults with fibromyalgia in general, and when taking into account differences in assessment protocol (maximal *versus* submaximal testing protocol; cycle ergometer *versus* treadmill testing protocol) and symptom severity (fibromyalgia severity level).
- To better understand how cardiorespiratory fitness among adults with fibromyalgia could: 1) assist in exercise prescription; 2) minimise dropout rates from exercise/rehabilitation programmes; and 3) promote independence with activities of daily living.
- To learn why fibromyalgia might be important to consider in adults who have concurrent fibromyalgia and lung disease.

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Cardiorespiratory fitness among adults with fibromyalgia

This review presents and addresses the conflicting results on cardiorespiratory fitness among adults with fibromyalgia. The heterogeneity in study designs, symptom severity and the assessment protocols might partly explain these conflicting results. It also presents the possible relationship between cardiorespiratory fitness and exercise prescription, attrition from exercise/rehabilitation programmes and independence with activities of daily living.

Cardiorespiratory fitness might impact aerobic exercise and independence in daily activities of patients with fibromyalgia, which is often concomitantly diagnosed in patients with sleep disordered breathing, including patients with obstructive sleep apnoea. Therefore, cardiorespiratory fitness evaluation should be considered by general and respiratory physicians as well as physiotherapists who treat patients diagnosed with fibromyalgia for more accurate diagnosis, exercise prescription and monitoring of patients' status.

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Most studies indicate fibromyalgia decreases cardiorespiratory fitness, which might impact participants' capacity to complete certain activities; therefore, it is important to consider cardiorespiratory fitness in the management of this condition http://ow.ly/Uqqi30k1xvK

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Introduction

Fibromyalgia (FM) is characterised by widespread pain, fatigue and non-restorative sleep. In the USA, the prevalence of FM is roughly 2% of the adult population, with a ratio of approximately seven women to three men [1, 2]. Although chronic widespread pain is seen as the defining feature of FM, poor sleep and respiratory problems have also been reported and have even surpassed pain as the most prominent complaints. Decreased thoracoabdominal mobility, impaired respiratory muscle mechanics, dyspnoea and reduced cardiorespiratory fitness (CRF) have been observed for these patients [3, 4]. General practitioners and respiratory physicians and physiotherapists should be aware of these problems to propose optimal management for these patients. Unfortunately, CRF remains overlooked. Decreased CRF can cause dyspnoea on exertion and impact the patient's functional capacities and these problems need to be addressed in rehabilitation. Guidelines for FM management recommend a multidisciplinary approach involving physicians, physiotherapists and occupational therapists, where prescription of aerobic exercises represents a significant part of the rehabilitation [5–7].

However, the results on CRF seem to be controversial and this might explain the differences observed between clinical practice guidelines (*e.g.* Canadian Guidelines for the Diagnosis and Management of Fibromyalgia Syndrome and American College of Sports Medicine) regarding aerobic exercise prescription [5, 6]. These conflicting results could be explained by heterogeneity in protocols used to assess CRF (*e.g.* maximal *versus* submaximal testing protocol; cycle ergometer *versus* treadmill testing protocol). For clinicians involved in the management of FM patients, it is important to have a clear synthesis of the evidence on CRF results and on the evaluation protocols used to produce this knowledge. Although aerobic exercise training can help in the management of symptoms and may improve CRF and functional capacities, it can also cause an increase in symptoms such as pain and dyspnoea, potentially contributing to attrition from exercise programmes [8, 9]. Furthermore, an increase in symptoms might negatively affect self-management of the condition and subsequently have a negative impact on the level of participation in physical activities including exercise. This might cause deconditioning and lead to a decline in functional capacities. Furthermore, attrition from an exercise or rehabilitation programme would prevent progression toward maintenance or a return to work, which, in turn, might affect direct and indirect costs, particularly work-related costs.

The aim of this review is to synthesise the scientific evidence on CRF among women with FM to shed light on the controversies in clinical practice guidelines and provide some recommendations on the evaluation of CRF.

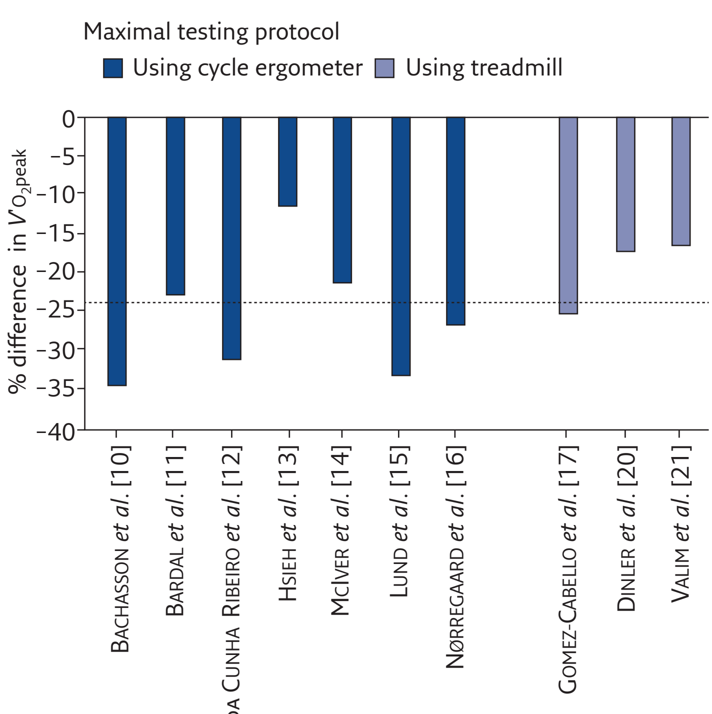

Figure 1 *Percentage difference in V'_{O_2}peak between the FM and control groups in studies showing a significant difference between study groups. The dotted line represents the mean percentage difference.*

Cardiorespiratory fitness level

Studies showing a significantly lower CRF in participants with FM

12 studies showed a lower CRF in women with FM [10–21] compared with a control group or normative values. These studies were published between 1994 and 2015, and used a maximal exercise test protocol on either a cycle ergometer (n=7) or treadmill (n=5).

Altogether, the 12 studies showed that participants with FM have a significantly lower peak oxygen uptake (V'_{O_2}peak) compared with a control group, or were at or below the 35th percentile compared with normative values. Two studies compared their results to normative values instead of a control group without FM [18, 19]. The study by Sañudo and Galiano [19] evaluated two groups of participants with FM: a severely affected group (n=16) and a moderately affected group (n=16), on two separate occasions, approximately 1 week apart. The Fibromyalgia Impact Questionnaire (FIQ) was used to classify the participants (moderately affected and severely affected participants), using a cut-off point of 54 on the total FIQ score (<54 *versus* ≥54). The study found that the average V'_{O_2}peak of the severely affected participants was significantly lower than the moderately affected participants for both tests. When compared to American College of Sports Medicine (ACSM) normative values, the average V'_{O_2}peak of the moderately affected participants were at the 35th percentile, whereas the severely affected participants were under the 10th percentile [19]. For its part, the study by Soriano-Maldonado *et al.* [18] reported an average V'_{O_2}peak below the 10th percentile for an American population of the same sex and age.

Figure 1 shows percentage differences in V'_{O_2}peak between control and FM groups [8–15, 18, 19]. This difference ranges from –11.4% to –34.3%, with lower V'_{O_2}peak results in all the FM groups with a mean of –24.1%.

Four of the studies [11, 13, 15, 21] identified oxygen uptake at the ventilatory anaerobic threshold (V'_{O_2}VAT) between the FM and control group, and one study [19] compared V'_{O_2}VAT between severely and moderately affected participants with FM. The four studies showed a significantly lower V'_{O_2}VAT in the FM group compared with the control group [11, 13, 15, 21] and the other study showed a significant difference in V'_{O_2}VAT between severely and moderately affected participants during the second trial only [19]. Figure 2 shows the percentage difference in V'_{O_2}VAT between the FM and control groups across the four studies [11, 13, 15, 21]. The percentage difference ranges from –12.8% to –37.0%, with a mean difference of –22.9%.

More specifically, seven studies [10–16] used a maximal exercise protocol on a cycle ergometer. Bachasson *et al.* [10] showed a significantly lower V'_{O_2}peak ($p<0.01$) in the FM group (n=11) compared with the healthy sedentary age-, sex- and body mass index (BMI)-matched control group (n=11) (FM: 23.7±2.7 mL O_2·min⁻¹·kg⁻¹; control: 36.1±6.3 mL O_2·min⁻¹·kg⁻¹). No data on V'_{O_2}VAT were reported. Bardal *et al*. [11] compared the FM group (n=12; except for V'_{O_2peak} values, n=11) to a healthy sex- and age-matched control group (n=12). V'_{O_2peak} and V'_{O_2}VAT were significantly lower in the FM group than in the control group (V'_{O_2peak}: 1.7±0.3 *versus* 2.2±0.5 L O_2·min⁻¹, p=0.007; V'_{O_2}VAT: 1.3±0.3 *versus* 1.7±0.4 L O_2·min⁻¹, p=0.011). da Cunha Ribeiro *et al*. [12] also reported significantly lower V'_{O_2peak} in FM participants compared with sex-, age- and BMI-matched healthy controls (FM: 22±1 mL O_2·min⁻¹·kg⁻¹ *versus* control: 32±2 mL O_2·min⁻¹·kg⁻¹; p<0.01). Hsieh *et al*. [13] recruited 31 Chinese women with FM, as well as 31 gender-, body weight-, daily activity level- and exercise habit-matched healthy women for the control group. The V'_{O_2peak} and V'_{O_2}VAT values for the FM group were 18.6±3.7 and 10.7±2.3 mL O_2·min⁻¹·kg⁻¹, and for the control group were 21.0±3.2 and 13.1±2.9 mL O_2·min⁻¹·kg⁻¹, presenting a significant difference between both groups (V'_{O_2peak}: p=0.009; V'_{O_2}VAT: p=0.001). The authors mention that eight women with FM and 25 women from the control group met the maximal oxygen uptake (V'_{O_2max}) criterion. The research study by McIver *et al*. [14] selected eight women with FM and eight healthy controls matched for age and exercise training status. There was no significant difference in BMI between the groups. Criteria for achievement of V'_{O_2max} were listed and all the participants met at least two of the four criteria. V'_{O_2max} was 16.9±1.32 mL O_2·min⁻¹·kg⁻¹ for the FM group and 21.5±1.44 mL O_2·min⁻¹·kg⁻¹ for the control group, with a significant difference between both groups (p=0.035). Lund *et al*. [15] recruited nine women for the FM group and nine matched women for the control group, with similar age, height and weight, and did not include any trained athletes. The median (range) V'_{O_2peak} was 24 (21–39) mL O_2·min⁻¹·kg⁻¹ for the FM group and 36 (28–46) mL O_2·min⁻¹·kg⁻¹ for the control group with a significant difference between both groups (p<0.01). The ventilatory anaerobic threshold was reached at a lower absolute and relative work level in the FM group compared with the control group, with a median (range) V'_{O_2peak} of 17 (11–24) mL O_2·min⁻¹·kg⁻¹ for the FM group and 27 (20–34) mL O_2·min⁻¹·kg⁻¹ for the control group with a p-value of <0.001 between both groups. Nørregaard *et al*. [16] also used a maximal exercise protocol on a cycle ergometer, but without measuring gas exchange. Therefore, V'_{O_2max} was estimated using the following formula: V'_{O_2max} (mL O_2·min⁻¹·kg⁻¹)=3.5+(maximal performance (W)×13/weight (kg)). Using the median maximal workload obtained, the equivalent oxygen uptake was 22 mL O_2·min⁻¹·kg⁻¹ (range: 20–27) for the FM group and 30 mL O_2·min⁻¹·kg⁻¹ (range: 25–31) for the control group (p=0.012).

The remaining five studies [17–21] used a maximal exercise test on a treadmill instead of a cycle ergometer. The first study [17] included 28 women with FM and 22 age-matched women without FM as the control group. There was no significant difference between the groups for height but there was a significant difference for BMI (FM: 28.6±6.5 kg·m⁻² *versus* control: 23.5±28.6 kg·m⁻²; p=0.001). V'_{O_2peak} was significantly lower in the FM group than in the control group (FM: 21.4±4.9 mL O_2·min⁻¹·kg⁻¹ *versus* control: 28.8±5.4 mL O_2·min⁻¹·kg⁻¹; p<0.001). In the second study [18], 31 women with FM were included in cardiorespiratory data analysis. There was no control group. V'_{O_2peak} was 19.5±3.4 mL O_2·min⁻¹·kg⁻¹. Compared to normative values, the findings indicated that CRF was severely impaired with an average V'_{O_2peak} below the 10th percentile compared with American women of the same age [22]. As mentioned previously, the study by Sañudo and Galiano [19] compared two groups of women with FM: a moderately affected group and a severely affected group. Each group included 16 women between the ages of 42 and 63 years. The authors compared physiological parameters such as V'_{O_2peak} and V'_{O_2}VAT between the moderately and severely affected participants during a first trial (T1) and a second trial (T2) approximately 1 week apart. V'_{O_2peak} and V'_{O_2}VAT at T1 were 26.17±3.62 mL O_2·min⁻¹·kg⁻¹ and 20.28±2.70 mL O_2·min⁻¹·kg⁻¹ for the moderately affected participants and 22.13±2.50 mL O_2·min⁻¹·kg⁻¹ and 19.21±2.22 mL O_2·min⁻¹·kg⁻¹ for the severely affected participants, with a respective p-value of <0.001 for V'_{O_2peak} and 0.163 for V'_{O_2}VAT. Therefore, there was no significant difference in V'_{O_2}VAT between both groups at T1. At T2, V'_{O_2peak} and V'_{O_2}VAT were 23.59±2.83 mL O_2·min⁻¹·kg⁻¹ and

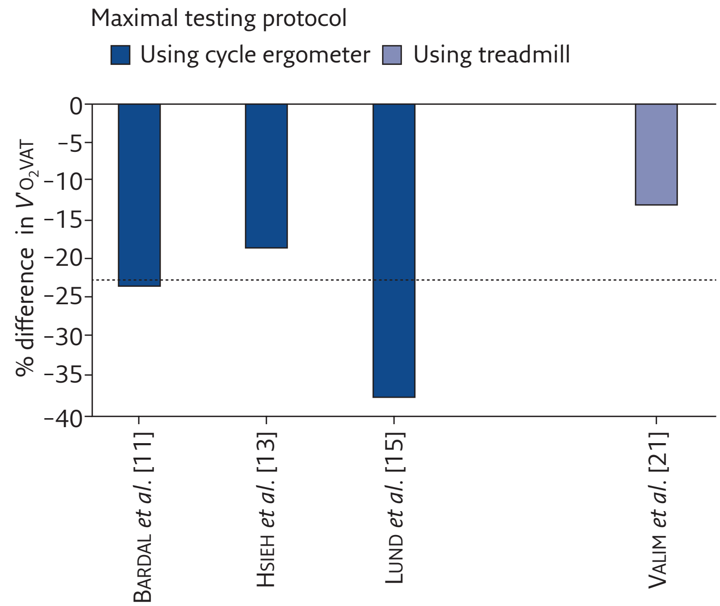

Figure 2 *Percentage difference in V′O₂VAT between the FM and control groups in studies showing a significantly lower CRF in participants with FM. The dotted line represents the mean percentage difference.*

20.29±3.04 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$ for the moderately affected group and 20.89±1.62 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$ and 18.55±1.67 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$ for the severely affected group, with a significant difference in V'_{O_2peak} (p=<0.001) and V'_{O_2VAT} (p=0.019) between both groups. Therefore, there was a significant difference in V'_{O_2VAT} between both groups at T2 but not at T1. Furthermore, 63% of participants in the moderately affected group and 40% in the severely affected group achieved the V'_{O_2max} criterion. The fourth study [20], using a maximal exercise protocol on a treadmill, showed a lower V'_{O_2peak} by an average of 21.2% in the FM group (n=18; V'_{O_2peak}=22.66±3.18 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$) compared with the control group (n=15; 27.46±4.68 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$; p=0.001). The last study by Valim *et al*. [21] compared 50 women with FM to 50 healthy sedentary women matched for age, weight and BMI. The results showed a significantly lower V'_{O_2peak} and V'_{O_2VAT} in the FM group (V'_{O_2peak}: 25.64±5.21 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$; V'_{O_2VAT}: 16.35±2.94 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$) compared with the control group (V'_{O_2peak}: 30.77±5.56 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$; V'_{O_2VAT}: 18.74±3.86 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$) ($V'_{O_2peak}$ p=0.000001; V'_{O_2VAT} p=0.001).

Studies not showing a significant reduction in CRF in participants with FM

Six studies did not demonstrate a lower CRF in women with FM when compared with matched control participants [23–28]. These studies were published between 1994 and 2016, and all used a cycle ergometer to evaluate CRF. Three studies used a submaximal exercise test protocol [24–26] and three studies used a maximal exercise test protocol [23, 27, 28]. None of the studies evaluated V'_{O_2VAT}. Therefore, the fact that these studies did not demonstrate a significantly lower CRF is based solely on V'_{O_2peak}.

The study by Vincent *et al*. [23] recruited 30 women with FM (age: 47.0±10.4 years; BMI: 25.8±4.6 $kg \cdot m^{-2}$) and 30 healthy pain- and fatigue-free women (age: 41.1±8.4 years; BMI: 26.0±4.0 $kg \cdot m^{-2}$). There was no significant difference in BMI between the groups, but there was a significant difference between the groups with regard to age (p=0.019). Therefore, they included age as a covariate in all consecutive analyses [23]. The maximal testing protocol on the cycle ergometer was not explained in detail, only that the workload was increased in increments until participants achieved V'_{O_2max} or exhaustion. There was no significant difference between the V'_{O_2peak} of the FM group and the control group (FM: 23.5±5.2 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$; control: 28.3±6.9 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$; adjusted for age, p=0.07). However, they mention that more participants with FM than participants from the control group were excluded from the test because of comorbidities. It is not clear how many participants from each group completed the maximal exercise test. Finally, the average revised FIQ total score was 43, which is considered a moderate level of FM severity.

One of the purposes of the study by Sener *et al*. [24] was to investigate the maximal aerobic capacity of women with FM (n=39). The results were compared with a control group of 40 BMI-matched healthy women. There was no significant difference in age between the groups. Participants' V'_{O_2max} was estimated using a submaximal exercise protocol (Astrand) on a computerised cycle ergometer (Monark; Sverige, Sweden). The results did not show a significant difference in V'_{O_2max} between the FM group (40.2±10.3 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$) and the control group (37.3±8.4 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$), with a p-value above 0.05 (p=0.627).

The study by Nielens *et al*. [25] also used a submaximal cycle ergometer test. This study compared the CRF of 30 women with FM to a control group of 67 age-matched healthy women. They used a graded multistage test, starting at 25 Watts (W) with increments of 25 W every three or four 2-min stage. The test was stopped when the participant's heart rate reached 65% of the heart rate reserve using the Karvonen formula. Based on the calculation, their results showed no significant difference (p=0.08) between the FM group (1.52±0.42 physical working capacity index of 65% ($PWC_{65\%}$) per kg) and the control group (1.67±0.39 $PWC_{65\%}$ per kg).

The third study to use a submaximal testing protocol on a cycle ergometer employed Astrand's method of indirect measurement to estimate the maximum oxygen uptake [26]. The FM group included 37 women (median (range) age: 34 (21–42) years) and the control group included 20 heathy sedentary women (age: 31 (22–44) years). The results showed no significant difference in estimated V'_{O_2max} between the FM group (28 (25–33) mL $O_2 \cdot min^{-1} \cdot kg^{-1}$) and the control group (31 (24–33) mL $O_2 \cdot min^{-1} \cdot kg^{-1}$) (p=0.8).

The remaining two studies, one by Nørregaard *et al*. [27] and the other by Simms *et al*. [28], used a maximal exercise test on a cycle ergometer. Nørregaard *et al*. [27] included a control group as part of the overall study, but the control group was not part of the CRF evaluation. 126 women with FM participated in this CRF testing. The median age of the FM group was slightly lower than 47 years, ranging from 39 to 54 years. The testing protocol did not include gas exchange. The results were estimated using a formula. Therefore, the corresponding maximal performance was 21 (16–25) mL $O_2 \cdot kg^{-1} \cdot min^{-1}$. However, the median maximal heart rate was only 63% (44–90%) of the predicted maximal heart rate (220 − age). Considering the expected maximal heart rate, the estimated aerobic capacity (V'_{O_2max}) would have been 30 (24–39) mL $O_2 \cdot kg^{-1} \cdot min^{-1}$. This estimated V'_{O_2max} corresponds to the normative values for "normal" physically inactive individuals of the same age [27]. The other study by SIMMS *et al*. [28] included 13 women with FM and 13 "normal" physically inactive women. There was no significant difference in terms of age, height and weight between the groups. Continuous monitoring of gas analysis was included as part of the measurements. The V'_{O_2peak} between the FM group (29.7±8.1 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$) and the control group (32.1±7.2 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$) did not show a significant difference (p=0.43).

Figure 3 shows the percentage difference in V'_{O_2peak} between the FM and the control groups in studies not showing a significant difference between the two groups. However, out of the six studies, two studies were not included in figure 3: NIELENS *et al*. [25] used a different unit of measurement ($PWC_{65\%}$ per kg) and the study carried out by NØRREGAARD *et al*. [27] did not evaluate the V'_{O_2peak} of the control group. Of the remaining four studies, one showed V'_{O_2peak} results from the FM group were nonsignificantly superior to the V'_{O_2peak} results of the control group. The other three studies demonstrated a nonsignificant reduction in V'_{O_2peak} in participants from the FM group. The percentage difference between the FM and the control group ranged from 7.8% to –17.0% with a mean difference of –6.6%. The study by NIELENS *et al*. [25] (not included in figure 3) showed a percentage difference of –9% with lower V'_{O_2peak} results from the FM group.

Maximal *versus* submaximal testing protocol

15 studies [10–21, 23, 27, 28] used a maximal exercise test protocol and only three [24–26] used a submaximal testing protocol. None of the studies showing a lower CRF among women with FM used a submaximal exercise test protocol. Therefore, three of the six studies showing no difference in CRF among women with FM when compared to a control group used a submaximal exercise test protocol.

Cycle ergometer *versus* treadmill testing protocol

13 out of the 18 studies [10–16, 23–28] used a cycle ergometer to evaluate CRF. All the studies showing no difference in CRF among women with FM used a cycle ergometer, and seven out of the 12 studies showing a lower CRF among women with FM used a cycle ergometer [10–16].

FM severity level

SAÑUDO and GALIANO [19] compared the participants' V'_{O_2max} to the ACSM (1998) normative values and reported that participants in the moderately affected group scored in the 35th percentile compared with the severely affected participants who were under the 10th percentile. Therefore, these authors concluded that the CRF of FM participants is different based on FM severity. Furthermore, the study by VALIM *et al*. [21] reported that participants with a CRF level below average (weak and very weak) presented the worst results with the FIQ.

Deconditioning: physiological aspects and its impact on functional capacities

Of the 18 articles identified, 12 studies showed a reduction in V'_{O_2VAT} and/or V'_{O_2peak} in women with FM compared with a control group or normative values [10–21]. The physiological explanation for lower CRF might be due to deconditioning. Individuals with FM often adopt a more sedentary lifestyle, which might include bed rest, in response to their symptoms. This sedentary lifestyle might lead to a reduction of their CRF level and impact their functional capacities. Therefore, individuals with FM might experience more difficulties in completing certain physical activities. Furthermore, it has been suggested that FM patients have lower respiratory muscle endurance, inspiratory muscle strength and thoracic mobility [3], which could also contribute to a lower CRF. Consequently, individuals with FM who have a secondary condition affecting

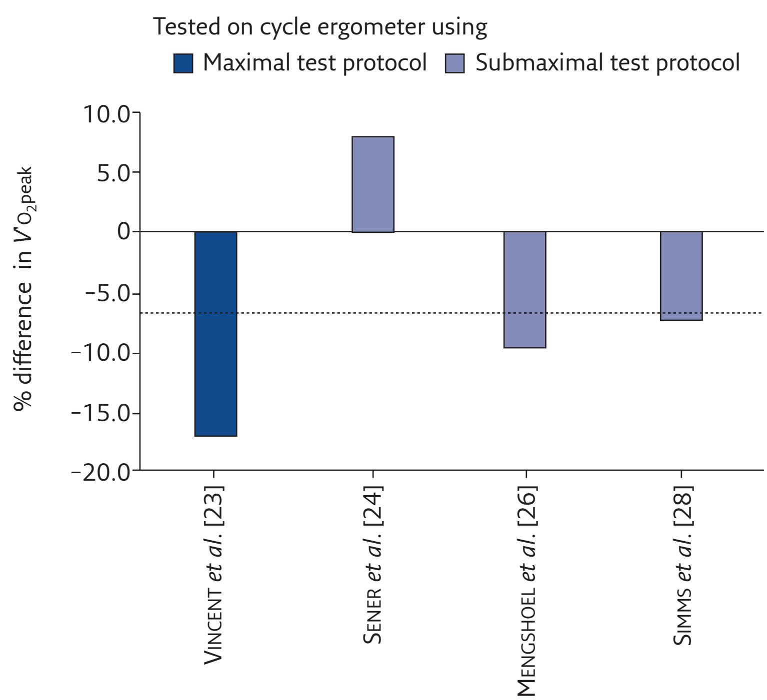

Figure 3 *Percentage difference in V'_{O_2peak} between the FM and control groups in studies not showing a significant difference between the two groups. The dotted line represents the mean percentage difference.*

their V'_{O_2}VAT and/or V'_{O_2}peak, for example asthma or chronic obstructive pulmonary disease, might present with a greater reduction in their CRF that may not be entirely related to their lung disease. This can cause more dyspnoea on exertion and have a greater impact on their ability to perform certain physical activities. These observations are relevant for healthcare providers because FM could influence the prognostic outcome of patients living with other comorbidities such as asthma, chronic obstructive pulmonary disease or cardiovascular disease.

Different methods exist to measure the intensity of physical activities. These include oxygen uptake, heart rate and metabolic equivalent of tasks (METs) to name a few. METs is a measure used to describe the intensity and energy expenditure of physical activities. For example, the estimated standard METs to carry groceries up a flight of stairs is 7.5 METs [29], which represents 26.3 mL $O_2 \cdot kg^{-1} \cdot min^{-1}$. The energy expenditure required to complete this task might be above their V'_{O_2}VAT or even above their V'_{O_2}peak. This could result in greater difficulties completing certain daily activities or exercise, since fatigue increases significantly when working above the ventilatory anaerobic threshold and it might be impossible for some individuals with FM to complete activities above their V'_{O_2}peak.

Discussion

To our knowledge, this is the first review focusing on CRF in adults with FM and we found conflicting results in the current literature. Although most of the studies (12 out of 18) pointed towards a lower CRF among adults with FM, caution must be taken before drawing such a conclusion.

First, attention should be given to the heterogeneity of the methods used to evaluate CRF. The 12 studies [10–21] showing that women with FM have a lower CRF used a maximal exercise test protocol, whereas three [24–26] out of the six studies [23–28] that did not demonstrate a lower CRF in women with FM used a submaximal exercise test protocol. Using a maximal exercise test provides a better estimate of V'_{O_2max} [6]. This might partly explain these conflicting results.

Secondly, all six studies [23–28] that did not demonstrate a lower CRF among participants with FM used cycle ergometer protocols, whereas cycle ergometers (n=7) [10–16] and treadmills (n=5) [17–21] were used in the studies that identified a lower CRF. Using a treadmill in a FM population might represent a more natural type of movement, and one that is more representative of daily activities and requires less muscle strength in the lower extremities than using a cycle ergometer [30].

Moreover, certain issues regarding the clinical profile of the participants warrant consideration. The study by Sañudo and Galiano [19] concluded that the aerobic capacity of patients with FM differs depending on the severity of the disease assessed using the FIQ. Severely affected participants showed significant statistical differences in V'_{O_2}peak and V'_{O_2}VAT compared with moderately affected participants. Furthermore, the study by Valim *et al*. [21] reported that participants with a CRF level below average presented the worst results with the FIQ. This inverse correlation between FM severity level and aerobic capacity may help to establish CRF subgroups based on FM severity level to optimise activity and exercise prescription. Since an association between CRF and FM symptom severity was reported, the heterogeneity of the participants' clinical profile could be another explanatory factor for these conflicting results.

Looking at the results of the studies, the two lowest mean V'_{O_2}peak measurements, in mL $O_2 \cdot min^{-1} \cdot kg^{-1}$, from the FM groups were 16.9±1.32 and 18.6±3.7. These values represent 4.8 and 5.3 METs. It is also important to note that few studies provided data on V'_{O_2}VAT. However, the lowest mean V'_{O_2}VAT from the FM groups was 10.7±2.3 mL $O_2 \cdot min^{-1} \cdot kg^{-1}$ (age: 42.4±9.1 years), which is equivalent to 3.1 METs. It takes approximately 4.0 METs to push or pull a stroller with a child, to walk with a child at a speed of 2.5 to 3.1 miles per hour or to climb stairs at a slow pace; 5.0 METs to move or lift light loads; and 6.3 METs to climb a hill while walking [29]. On average, these activities are above the V'_{O_2}VAT of 3.1 METs, which might be difficult to maintain, since fatigue increases significantly when working above this threshold. Furthermore, it might be impossible for some of the participants to complete activities above their V'_{O_2}peak. Furthermore, the standard deviations imply that the V'_{O_2}peak and V'_{O_2}VAT measurements of some participants are even lower. Although pain is an important symptom to consider in the management of FM, CRF is as important since it could have an important impact on functional status.

In light of this review, some recommendations are proposed for future studies or clinical practice to better evaluate and understand CRF among FM participants. To minimise the heterogeneity of the participants, FM severity should be taken into consideration and the use of the revised FIQ should be considered to evaluate the FM severity level. Also, when indicated, consideration should be given to using a maximal exercise test (V'_{O_2}peak) on a treadmill, which, in our opinion, better reflects functional activities than a cycle ergometer. Considering it was previously reported that FM patients have decreased thoracoabdominal mobility and impaired respiratory muscles mechanics, which could increase dyspnoea symptoms [3, 4], healthcare providers need to carefully assess FM patients to determine if dyspnoea symptoms are related to a lung disease or FM. Future studies should look at the impact of exercise training in FM patients on CRF and improvement in respiratory mechanics. Finally, none of the studies evaluated capacity to recover following a maximal exercise test. Re-evaluating participants with FM 24 h after an initial cardiorespiratory test could provide further information on their capacity to recover. This could help to optimise physical activity recommendations and minimise dropout rates from exercise and rehabilitation programmes, thus promoting independence with activities of daily living, leisure and work.

Conclusion

Studies on CRF among women with FM reveal conflicting results. The heterogeneity of the study design, participant symptom severity and the assessment protocol used might partly explain these conflicting results. However, most of the studies showed a decrease in CRF in participants with FM compared to a control group or normative values. This lower CRF might have an important impact on participants' capacity to complete certain activities. Therefore, it is an important aspect to consider in the management of this condition.

Self-evaluation questions

1 Studies on CRF among women with FM reveal:
   a) Significantly lower CRF in participants with FM compared with a control group or normative values
   b) No significant reduction in CRF in participants with FM when compared to a control group
   c) Conflicting results
   d) None of the above

2 The possible inverse association between FM severity level and CRF may help to establish CRF subgroups based on FM severity level to optimise activity and exercise prescription.
   a) True
   b) False

3 Low CRF might have an impact on participants' capacity to complete certain activities of daily living or work-related activities.
   a) True
   b) False

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Conflict of interest

None declared.

References

1. Lawrence RC, Felson DT, Helmick CG, *et al.* Estimates of the prevalence of arthritis and other rheumatic conditions in the United States. Part II. *Arthritis Rheum* 2008; 58: 26–35.
2. Walitt B, Nahin RL, Katz RS, *et al.* The prevalence and characteristics of fibromyalgia in the 2012 National Health Interview Survey. *PLoS One* 2015; 10: e0138024.
3. Forti M, Zamuner AR, Andrade CP, *et al.* Lung function, respiratory muscle strength, and thoracoabdominal mobility in women with fibromyalgia syndrome. *Respir Care* 2016; 61: 1384–1390.
4. Casas A, Pavia J, Maldonado D. Trastornos de los musculos respiratorios en las enfermedades de la pared del torax [Respiratory muscle disorders in chest wall diseases]. *Arch Bronconeumol* 2003; 39: 361–366.
5. Fitzcharles MA, Ste-Marie PA, Goldenberg DL, *et al.* 2012 Canadian guidelines for the diagnosis and management of fibromyalgia syndrome: Executive summary. *Pain Res Manage* 2013; 18: 119–126.
6. Pescatello LS. ACSM's guidelines for exercise testing and prescription, 9th Edn. Philadelphia, Wolters Kluwer Health/ Lippincott Williams & Wilkins, 2014.
7. Eich W, Hauser W, Arnold B, *et al.* Das Fibromyalgiesyndrom. Definition, Klassifikation, klinische Diagnose und Prognose [Fibromyalgia syndrome. Definition, classification, clinical diagnosis and prognosis]. *Schmerz* 2012; 26: 247–258.
8. Jones KD, Clark SR, Bennett RM. Prescribing exercise for people with fibromyalgia. *AACN Clin Issues* 2002; 13: 277–293.
9. Busch AJ, Schachter CL, Overend TJ, *et al.* Exercise for fibromyalgia: a systematic review. *J Rheumatol* 2008; 35: 1130–1144.
10. Bachasson D, Guinot M, Wuyam B, *et al.* Neuromuscular fatigue and exercise capacity in fibromyalgia syndrome. *Arthritis Care Res (Hoboken)* 2013; 65: 432–440.
11. Bardal EM, Olsen TV, Ettema G, *et al.* Metabolic rate, cardiac response, and aerobic capacity in fibromyalgia: a case-control study. *Scand J Rheumatol* 2013; 42: 417–420.
12. da Cunha Ribeiro R, Roschel H, Artioli G, *et al.* Cardiac autonomic impairment and chronotropic incompetence in fibromyalgia. *Arthritis Res Ther* 2011; 13: R190.
13. Hsieh LF, Chien HL, Chuang CC, *et al.* Aerobic capacity is reduced in Chinese women with primary fibromyalgia syndrome. *J Musculoskelet Pain* 2010; 18: 216–225.
14. McIver KL, Evans C, Kraus RM, *et al.* NO-mediated alterations in skeletal muscle nutritive blood flow and lactate metabolism in fibromyalgia. *Pain* 2006; 120: 161–169.
15. Lund E, Kendall SA, Janerot-Sjoberg B, *et al.* Muscle metabolism in fibromyalgia studied by P-31 magnetic resonance spectroscopy during aerobic and anaerobic exercise. *Scand J Rheumatol* 2003; 32: 138–145.
16. Nørregaard J, Buelow PM, Mehlsen J, *et al.* Biochemical changes in relation to a maximal exercise test in patients with fibromyalgia. *Clin Physiol* 1994; 14: 159–167.
17. Gomez-Cabello A, Vicente-Rodriguez G, Navarro-Vera I, *et al.* Influences of physical fitness on bone mass in women with fibromyalgia. *Adapt Phys Activ Q* 2015; 32: 125–136.
18. Soriano-Maldonado A, Ortega FB, Munguia-Izquierdo D. Association of cardiorespiratory fitness with pressure pain sensitivity and clinical pain in women with fibromyalgia. *Rheumatol Int* 2015; 35: 899–904.

Suggested answers

1. c.
2. a.
3. a.

19. Sañudo B, Galiano D. Using cardiovascular parameters and symptom severity to prescribe physical activity in women with fibromyalgia. *Clin Exp Rheumatol* 2009; 27: S62–S66.
20. Dinler M, Kasikcioglu E, Akin A, *et al.* Exercise capacity and oxygen recovery half times of skeletal muscle in patients with fibromyalgia. *Rheumatol Int* 2007; 27: 311–313.
21. Valim V, Oliveira LM, Suda AL, *et al.* Peak oxygen uptake and ventilatory anaerobic threshold in fibromyalgia. *J Rheumatol* 2002; 29: 353–357.
22. Wang CY, Haskell WL, Farrell SW, *et al.* Cardiorespiratory fitness levels among US adults 20-49 years of age: findings from the 1999-2004 National Health and Nutrition Examination Survey. *Am J Epidemiol* 2010; 171: 426–435.
23. Vincent A, Whipple MO, Low PA, *et al.* Patients with fibromyalgia have significant autonomic symptoms but modest autonomic dysfunction. *PM R* 2016; 8: 425–435.
24. Sener U, Ucok K, Ulasli AM, *et al.* Evaluation of health-related physical fitness parameters and association analysis with depression, anxiety, and quality of life in patients with fibromyalgia. *Int J Rheumat Dis* 2016; 19: 763–772.
25. Nielens HMD, Boisset VMD, Masquelier EMD. Fitness and perceived exertion in patients with fibromyalgia syndrome. *Clin J Pain* 2000; 16: 209–213.
26. Mengshoel AM, Vollestad NK, Forre O. Pain and fatigue induced by exercise in fibromyalgia patients and sedentary healthy subjects. *Clin Exp Rheumatol* 1995; 13: 477–482.
27. Nørregaard J, Bulow PM, Lykkegaard JJ, *et al.* Muscle strength, working capacity and effort in patients with fibromyalgia. *Scand J Rehabil Med* 1997; 29: 97–102.
28. Simms RW, Roy SH, Hrovat M, *et al.* Lack of association between fibromyalgia syndrome and abnormalities in muscle energy metabolism. *Arthritis Rheum* 1994; 37: 794–800.
29. Compendium of Physical Activities. https://sites.google.com/site/compendiumofphysicalactivities/Activity-Categories/home-activity Date last accessed: December 19, 2016. Date last updated: December 2016.
30. Balady GJ, Arena R, Sietsema K, *et al.* Clinician's guide to cardiopulmonary exercise testing in adults: a scientific statement from the American Heart Association. *Circulation* 2010; 122: 191–225.