Comparison on muscle strength, aerobic capacity and respiratory function in women with fibromyalgia

Comparaçãon na força muscular, capacidade aeróbica e função respiratória em mulheres com fibromialgia

Comparación en la fuerza muscular, capacidad aeróbica y función respiratoria en mujeres con fibromialgia

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Abstract

Objective: To compare two workout programs: the mode aerobic-breath to the mode combining aerobic-strength-breath, in order to know the effects in the strength, aerobic fitness and respiratory function of women with fibromyalgia (FM) after a period of 24 weeks.

Methods: A prospective longitudinal study using two groups of women with fibromyalgia has been conducted. Nine participants were monitored with regular exercise in the mode aerobic-breath group (AbG) and eight in the mode combining aerobic-strength-breath group (CG). Both groups were complemented with respiratory exercise through diaphragmatic breathing (DB). The measures used in the study were: measurements at rest, maximum and submaximal oxygen consumption (VO₂); maximum and submaximal aerobic power (W); concentric isokinetic strength at 60º/s of the extensor and flexor muscles of the leg (N.m); pulmonary function measurements by spirometry (ventilatory test) and maximum respiratory pressures (MRP).

Results: Significant improvements in aerobic condition, strength and respiratory function were obtained by both groups. Initially the participants AbG vs. CG presented decreased aerobic condition (20-24 ml/kg/min). The range of functional normality of the strength for the classification of the Freedson percentile was reduced (≤ 10). Even discarding respiratory diseases, the respiratory muscle strength was lower than the values predicted for healthy people. Over the 24 weeks, there were no differences between AbG vs. CG in aerobic and respiratory exercises. The differences were mostly observed in the results of strength.
Conclusion: Our results suggest that intervention programs may be supplemented with respiratory exercises. However, new studies with longer-term programs are required to compare the absolute impact of different workouts. It is also mandatory to know if the isolated practice of respiratory exercises has any applicability for patients with FM.

Key words: aerobic training, combined training, breathing exercise, fibromyalgia.

Resumo
Comparar dois treinos, um no modo aeróbio-respiratório e outro no modo combinado: aeróbio-força-respiratório, para conhecer os efeitos na força muscular, capacidade aeróbia e função respiratória de mulheres com fibromialgia depois de um período de 24 semanas.

Métodos: Se realizou um estudo longitudinal prospectivo utilizando dois grupos de mulheres com fibromialgia. Nove participantes foram monitoradas com o exercício regular aeróbio-respiratório (AbG) e oito no modo combinado: aeróbio-força-respiratório (CG). Ambos foram complementados com exercício respiratório a través de respiração diafragmática (RD). As medidas utilizadas foram: medidas em repouso; consumo máximo e submáximo de oxigénio (VO₂); potência aeróbia (W) máxima y submáxima; força isocinética concéntrica a 60º/s dos músculos extensores y flexores da perna (N.m); medidas de função pulmonar por espirometria (prova ventilatória) e pressões máximas respiratórias (PMR).

Resultados: Melhoras significativas na condição aeróbia, na força e na função respiratória foram obtidas por ambos os grupos. Inicialmente os participantes AbG e CG apresentaram diminuída condição aeróbia (20-24 ml/kg/min). A escala de normalidade funcional da força para a classificação do percentil de Freedson foi diminuído (≤ 10). Mesmo descartando patologias respiratórias, a força muscular respiratória foi inferior a aos valores previstos para as pessoas saudáveis. Ao longo de 24 semanas não se observou diferenças entre os tipos de treino AbG vs CG no exercício aeróbio e respiratório. As diferenças foram mostradas em grande parte dos resultados da força.

Conclusão: Nossos resultados sugerem que os programas de intervenção sejam complementados com exercícios respiratórios. No entanto, novos estudos com programas a mais longo prazo são necessários para comparar o impacto absoluto dos diferentes treinos. Igualmente, é necessário saber se a prática isolada de exercícios respiratórios tem alguma relevância em pacientes com FM.

Palavras chaves: Treino aeróbico, treino combinado, exercício respiratório, fibromialgia.

1. Introduction
Fibromyalgia (FM) is a rheumatologic disorder characterized by widespread muscle pain and tenderness of at least 11 of 18 specific tender points (Wolfe et al., 1990) usually accompanied by a wide spectrum of symptoms such as: morning stiffness, fatigue, non-restorative sleep, mood alterations and poor health-related quality of life (HRQoL) (Silverman, Harnett, Zlateva & Mardekian, 2010; Segura-Jiménez, 2015). In addition, the population with this disorder presents deterioration of articular amplitude, muscular resistance and strength likewise below average cardiovascular fitness levels (Busch, Schachter, Overend, Peloso &
Barber, 2008). The deterioration of respiratory function is also described as a common feature in these patients (Forti, Zamuñér, Andrade & Silva, 2016).

The necessity of the recovery of the physical components of strength, aerobic fitness and flexibility is supported by literature and associated to relieving symptoms like pain and fatigue (de Bruijn et al., 2011). The decrease in respiratory muscle function, as it has been described, is an important component which also needs to be explored in therapeutic physical recovery (Sahin, Ulubas, Calikoglu & Erdogan, 2004). The respiratory alterations may exacerbate the symptoms of fibromyalgia and chronic fatigue syndrome, including the aggravation of these diseases (Uveges et al., 1990).

Proliferating studies on FM have contributed to disclose different clinical trials through exercise and have showed interest in dose-response, impact on functionality, symptoms and adherence (García-Hermoso, Saavedra & Escalante, 2015). On the other hand, along the last years, the comparison between models of intervention exercise has been little approached.

One single review study with FM compared several clinical trials using different types of exercise, but the investigation did not describe the direct comparison of aerobic exercise (AE) vs. combined exercise (Aerobic and Strength); and did not include breathing exercises as a supplement or isolated intervention (Valim, 2006). The combination of a 20-week progressive program including strength and aerobic exercises was described as a secure application, well tolerated and effective manner to improve the functional status of women with FM (Rooks, Silverman & Kantrowitz, 2002). A more recent study, which adopted a program of 24-weeks, did a direct comparison between aerobic and combined exercises (aerobic, strength and flexibility) taking into account the time-program. The authors reported that women with FM gained additional health benefits when engaged in a combined exercise program (Sañudo et al., 2010). The breathing exercises were recommended as complements in multi-modal, mind-body yoga or water-based programs, all aiming at the improvement of symptoms such as pain, anxiety and relaxation (Ayan, 2009; Carson, 2010; Ide, Laurindo, Rodrigues-Júnior & Tanaka, 2008). The effectiveness of the response to respiratory muscle training was not directly assessed.

The latest reviews are interested in the most accurate exercise prescription and in its impact on functional status, symptom reduction and permanence in the workout programs (Busch, Schachter, Overend, Peloso & Barber, 2008; Bidonde, Jean Busch, Bath & Milosavljevic, 2014). The comparison between different types of programs that explore and add new interventions seems a gap yet to be explored in these patients. The objective of this study was to compare different types of exercise programs used in FM and to know their effects phisiological on muscle recovery, aerobic fitness and respiratory function over a 24-week period.
Material and method

Participants

All members of a local FM association in Portugal were invited to participate in the study. Thirty-nine potentially eligible subjects searched for more information, twenty persons signed a written consent to participate in the study. Inclusion criteria were: i) women who were diagnosed with FM according to the American College of Rheumatology criteria (Wolfe et al., 1990; Wolfe et al., 2010), ii) sedentary for more than six months, and iii) aged between 35 and 55 years old. Exclusion criteria were: i) other diseases that could prevent physical loading, and ii) who has attended other physical therapy in the last 6 months. These 20 female were distributed either to an aerobic-breath group (AbG; n=10) or combined group – aerobic-strength-breath (CG; n=10). From the 20 participants, one of AbG and two of CG were excluded leaving voluntarily or failure to attend 80% of the exercise sessions. Finally, 9 participants from the AbG and 8 participants from the CG fully completed the study protocol and their results were included in the analysis. The study was approved by the Committee on Biomedical Ethics of the University of Córdoba and followed the updates of the Declaration of Helsinki.

Procedure

Each participant performed the physical tests in two sessions. The order of application was the same from the beginning to the end of the 24-week intervention. The first session was divided in: lung function test (1) and cardiorespiratory exercise test (2) (CPET). After an interval of 48 hours for recovery, the second session was performed by using a strength test (3).

Materials and measures

Lung function test was assessed by global body plethysmography Masterlab (Medizintechnik mit System Erich Jaeger GmbH®, Wuerzburg, Germany), with a specific software and complying with the standards of the ERS and ATS. Conventional pulmonary function test was used, based on the determination of the Spirometry (ventilatory proof) and Maximal Respiratory Pressure (PMR). The spirometry was used as a diagnostic evaluation with the aim to exclude additional diseases. The monitored parameters were: forced vital capacity (FVC), maximum expiratory volume in the first second (FEV1), Tiffeneau index = FEV1/FVC, ratio and maximal expiratory flow at 50% of FVC (MEF50). In the study of muscular efficiency, three parameters were monitored: the maximal inspiratory pressure (MIP), maximal occlusion pressure (P0.1 max) and maximal expiratory pressure (MEP). Basically, a high MIP (> 80 cmH2O = 7.85Kpa) or a MEP high (> 90 cmH2O = 8.80Kpa) excludes inspiratory or expiratory weakness as clinically important. The measurement of P0.1 max. is used because it is more
specific and is not affected by external interference. A minimum of 5 attempts was carried out to demonstrate a consistent effort, being two of these maximum reproducible manoeuvres (i.e. that were not different among themselves more than 5%) (ATS/ERS, 2002). The predicted values for healthy persons were calculated according to sex, age and height (Wilson, Cooke, Edwards & Spiro, 1984). This calculation was performed by global body plethysmography Masterlab software (Medizintechnik mit System Erich Jaeger GmbH®).

Cardiopulmonary test was evaluated by cardiopulmonary exercise test (CPET) in a cycle-ergometer (oxy-ergometry) with direct determination of VO₂ and blood gases. It was used an electromagnetic bicycle ergometerJAEGERT (0-600 Watt), an electrocardiograph 12-channel, a sphygmomanometer, a microanalyser equipment blood gases Radiometer ABL 5 and a set ergo-spirometric computerized Oxicon Pró - JAEGERT (RFA) for the registration of volumes and ventilatory debits by pneumotocagrofia open circuit (Medizintechnik mit System Erich Jaeger GmbH®, Wuerzburg, Germany). The parameters that were used for this study were: the measurements at rest, the submaximal and maximum oxygen consumption (VO₂) and the submaximal and maximal of aerobic power (W). The Wassermann incremental protocol was adopted in cycle ergometer (Wasserman, Van Kessel & Burton, 1967). The level of aerobic fitness for women according to age – VO₂ max (ml/kg/min) is based on the classification of the American Heart Association – AHA reference (American College of Cardiology & American Heart Association, 2000). The predicted values for healthy people were calculated by specific software.

Strength Test was evaluated by isokinetic dynamometer (Biodex, System 3, NY, U.S.A.) to measure isokinetic concentric strength of knee flexion/extension (N.m). The participant was positioned according to the instructions established for this equipment by Biodex Medical System. The test was preceded by 5 minutes of warming of the lower limbs on a bicycle (Monark) at 60 rpm and load regulation at 2% of total body weight. Moreover, before testing the participants, there was still a previous period of familiarization with the dynamometer. For the test interpretation, we evaluated the absolute values of the peak torque (N.m): three repetitions at 60/s. The Freedson classification to the degree of muscular strenght to 60/s (low) was applied (Zeevi, 2002).

Exercise intervention

Aerobic-breath group (AbG). The exercise program consisted of 3 weekly sessions of 60 minutes for 24-weeks. Each session included 30 minutes of aerobic exercise divided in static bicycle and treadmill. The intensity of aerobic exercise was individualized by power measurements (W) and heart rate of the anaerobic threshold (HR-AT) obtained through CPET with controlled speed between 50 and 60 RPM (revolutions per minute). After aerobic training,
joint mobilization exercises, stretches of major and the most contracted muscle groups were held. The workout ended with breathing exercises.

**Combined group (CG).** Combined exercise: aerobic-breath-strength training. The program consisted of 3 weekly sessions of 60 minutes. Each session included 30 minutes of aerobic exercise divided alike in static bicycle and treadmill. The intensity was also individualized through the measures of power (W) and anaerobic threshold (HR-AT) obtained CPET and the same 50 and 60 RPM. After and following aerobic exercises, it was combined strength exercises (muscular resistance) for 15 minutes in two of the three-day programs. This research complied with the recovery of 48 hours recommended. The strength exercises were carried out on bodybuilding machines for the large muscle groups of the trunk, with upper and lower limbs, based on guidelines suggested in the bibliography for fibromyalgia (Jones, Clark & Bennett, 2002). The measurements of the lower limbs were selected to analyse and interpret the results of this experiment. The CG patients also ended with breathing exercises.

**Breathing exercises** (carried out in both groups): At the end of each session, the exercise programs were completed with 15 minutes of breathing exercises (Goldstein, 1997). This consisted in five exercises (3 minutes for each) which were performed in the form of a circuit: an exercise on awareness of breathing, an exercise on costal expansion, and three diaphragmatic breathing exercise (Biehl-Printes & Costa, 2006).

**Statistical analysis**

Normality and homogeneity of variance of data were initially tested using the Shapiro-Wilke and Levene tests, respectively. The statistical significance between groups was evaluated using non-parametric Mann-Whitney test to compare independent samples, in baseline (M0), in 24-week (M1). Wilcoxon test was implicated to compare paired data before and after intervention (M0-M1) and also to compare the values of ventilatory parameters, maximum respiratory pressures and VO$_2$ max with predicted values calculated for healthy persons. The relationships between the selected variables were assessed by the Spearman test. The effect size (ES) analysis for all outcomes that did not achieve statistical significance was conducted using Cohen interpretation (< 0.5 small, 0.5 - 0.8 average, and > 0.8 large) (Sullivan & Feinn, 2012). For all tests it was considered a significance level < 0.05. The analyses were performed using SPSS v.22.0 (IBM, New York, USA).

**Results**

Baseline data did not show any significant differences in characteristics

**Table 1.** Characteristics of females with fibromyalgia at baseline.
Table 1. Values expressed as mean ± standard deviation. P-values of Mann-Whitney test to compare differences between groups in baseline. AbG: aerobic-breath group (n=9); CG: combined group (n=8). Considered a significance level < 0.05 between groups (table 1), nor in ventilatory parameters compared to predicted values calculated for healthy people used to exclude respiratory diseases (figure 1).

<table>
<thead>
<tr>
<th></th>
<th>AbG</th>
<th>CG</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>49.0 ± 6.3</td>
<td>46.1 ± 5.8</td>
<td>0.435</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64.2 ± 7.5</td>
<td>60.5 ± 7.7</td>
<td>0.520</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.57 ± 0.05</td>
<td>1.55 ± 0.03</td>
<td>0.260</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>26.1 ± 3.5</td>
<td>25.2 ± 3.3</td>
<td>0.873</td>
</tr>
<tr>
<td>Number of tender points</td>
<td>16.3 ± 2.1</td>
<td>17.0 ± 1.8</td>
<td>0.181</td>
</tr>
<tr>
<td>Duration of condition</td>
<td>12.1 ± 10.6</td>
<td>10.8 ± 7.3</td>
<td>0.747</td>
</tr>
<tr>
<td>Diagnostic (years)</td>
<td>4.0 ± 1.1</td>
<td>5.1 ± 1.9</td>
<td>0.204</td>
</tr>
<tr>
<td>Number of specific drugs</td>
<td>2.2 ± 1.8</td>
<td>2.8 ± 2.1</td>
<td>0.870</td>
</tr>
</tbody>
</table>

Figure 1: Ventilatory parameters used as a diagnostic to exclude respiratory diseases in baseline. Values of forced vital capacity (FVC), maximum expiratory volume in the first second (FEV1), FEV1/FVC ratio, and maximal expiratory flow at 50% of FVC (MEF50) in women with fibromyalgia syndrome and predicted values for healthy persons calculated according to sex, age and height in software (Medizintechnik mit System Erich Jaeger GmbH®, Wuerzburg, Germany). Values expressed as mean. AbG: aerobic-breath group (n=9); CG: combined group.
In (table 2) significant differences were detected in MIP and P0.1 max in favour of predicted values calculated for healthy persons. Additionally, no significant differences in baseline data for muscular efficiency of the MRP between AbG and CG. After 24-weeks MIP and P01 max were significant in both groups. There were not observed any significant differences between groups for these variables. The effect size was small in most of the variables (ES <0.5). For MEP no significant difference was observed. Moreover, the significant correlations were shown between P0.1 max and MIP in baseline (r = 0.61; p = 0.030) and week 24 (r = 0.60; p = 0.030).

**Table 2. Maximal respiratory pressures in women with fibromyalgia syndrome at baseline and after 24 weeks of intervention.**

<table>
<thead>
<tr>
<th></th>
<th>Baseline (M0)</th>
<th>Week 24 (M1)</th>
<th>Effect Size Cohen’s d</th>
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<tbody>
<tr>
<td></td>
<td>AbG</td>
<td>CG</td>
<td>AbG</td>
</tr>
<tr>
<td></td>
<td>M0</td>
<td>M1</td>
<td>M0</td>
</tr>
<tr>
<td>MIP (kPa)</td>
<td>5.2 ±1.7</td>
<td>4.3 ±0.9</td>
<td>6.3 ±1.2</td>
</tr>
<tr>
<td>MIP (kPa)</td>
<td>11.0 ±0.0</td>
<td>11.0 ±0.0</td>
<td>11.0 ±0.0</td>
</tr>
<tr>
<td>MEP (kPa)</td>
<td>5.8 ±1.4</td>
<td>6.6 ±2.5</td>
<td>5.9 ±1.8</td>
</tr>
<tr>
<td>MEP (kPa)</td>
<td>7.2 ±0.6</td>
<td>7.7 ±0.3</td>
<td>7.2 ±0.6</td>
</tr>
<tr>
<td>P0.1 max (kPa)</td>
<td>1.1 ±0.4</td>
<td>1.4 ±0.72</td>
<td>1.6 ±0.7</td>
</tr>
<tr>
<td>P0.1 max (kPa)</td>
<td>7.6 ±0.0</td>
<td>7.7 ±0.0</td>
<td>7.6 ±0.0</td>
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</tbody>
</table>

Table 2. Values expressed as mean ± standard deviation. P-values of Wilcoxon test to compare differences within group after 24 weeks of intervention and to compare the values maximum respiratory pressures with predicted values calculated for healthy persons. P-values of Mann-Whitney test to compare differences between groups in baseline (M0) and week 24 (M1). M0-M1: effect size within group; M0: effect size between groups in baseline; M1: effect size between groups in week 24; (ES>0.8): N.A: not applied. Parameters: MIP:
maximum inspiratory pressure; MEP: maximum expiratory pressure; P0.1max: maximum occlusion pressure and MIP; MEP; P01max predicted values to health persons calculated according with software (Medizintechnik mit System Erich Jaeger GmbH®, Wuerzburg, Germany). AbG: aerobic-breath group (n=9); CG: combined group (n=8). Considered a significance level < 0.05.

In (Table 3) at baseline, each group has physiological parameters within normal limits, as well the basal rate shows no significant differences. After 24-weeks, differences (p <0.05) were found in the oxygen consumption by both groups on the aerobic-anaerobic transition i.e. anaerobic threshold (VO₂AT) at maximum VO₂max (mL/min), VO₂max (mL/kg/min) and in the % VO₂max. The power (W) was significant in either group. There were no significant differences between groups for these variables. The effect size was small in most of the variables (ES <0.5).

Table 3. Oxygen consumption, and power in women with fibromyalgia syndrome at baseline and after 24 weeks of intervention.

<table>
<thead>
<tr>
<th></th>
<th>Baseline (M0)</th>
<th>Week 24 (M1)</th>
<th>AbG</th>
<th>CG</th>
<th>tP AbM0</th>
<th>tP AbM1</th>
<th>CG</th>
<th>tP CGM1</th>
<th>tP CGM0</th>
<th>M0-M1</th>
<th>M0 M1-</th>
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<tbody>
<tr>
<td>VO₂ basal (mL/min)</td>
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<td>Baseline</td>
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<tr>
<td></td>
<td>219.0±72.2</td>
<td>239.5±80.2</td>
<td>264.5±83.0</td>
<td>.08</td>
<td>.28</td>
<td>.5</td>
<td>.5</td>
<td>.31</td>
<td>.2</td>
<td></td>
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<tr>
<td>(mL/min)</td>
<td>198.5±50.</td>
<td>265.0±85.0</td>
<td>293.5±80.0</td>
<td>.28</td>
<td>.02</td>
<td>.5</td>
<td>.5</td>
<td>.31</td>
<td>.2</td>
<td></td>
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<tr>
<td>VO₂AT (mL/min)</td>
<td>1051.5±</td>
<td>1017.6±116.</td>
<td>1210.3±172</td>
<td>.01</td>
<td>.43</td>
<td>N.A</td>
<td>.18</td>
<td>.01</td>
<td>.2</td>
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<tr>
<td></td>
<td>204.5</td>
<td>6</td>
<td>1264.8±170.</td>
<td>.01</td>
<td>.13</td>
<td>.6</td>
<td>.4</td>
<td>.3</td>
<td>.2</td>
<td></td>
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<tr>
<td>VO₂Max (mL/min)</td>
<td>1330.8±</td>
<td>1428.1±</td>
<td>1497.0±141</td>
<td>.18</td>
<td>N.A</td>
<td>N.A</td>
<td>.5</td>
<td>N.A</td>
<td>N.A</td>
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<tr>
<td></td>
<td>225.6</td>
<td>9</td>
<td>1628.3±143.</td>
<td>.01</td>
<td>.03</td>
<td>6</td>
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<td>.3</td>
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<tr>
<td>VO₂Max health</td>
<td>1461.1±</td>
<td>1525.3±</td>
<td>1423.5±</td>
<td>.05</td>
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<td>N.A</td>
<td>N.A</td>
<td>N.A</td>
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<tr>
<td>persons predicted</td>
<td>186.4</td>
<td>6</td>
<td>1537.6±97.1</td>
<td>.10</td>
<td>N.A</td>
<td>N.A</td>
<td>N.A</td>
<td>N.A</td>
<td>N.A</td>
<td></td>
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<tr>
<td>(mL/kg/min)</td>
<td>20.6±3.3</td>
<td>24.4±5.0</td>
<td>24.3±3.4</td>
<td>.02</td>
<td>.20</td>
<td>N.A</td>
<td>N.A</td>
<td>.8</td>
<td>.64</td>
<td></td>
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<tr>
<td></td>
<td>7</td>
<td>13</td>
<td>27.1±4.4</td>
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<td>.29</td>
<td>7</td>
<td>.0</td>
<td>.0</td>
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<tr>
<td>%VO₂ Max</td>
<td>91.1%±</td>
<td>94.1±11.3</td>
<td>106.6±12.1</td>
<td>.01</td>
<td>.34</td>
<td>N.A</td>
<td>N.A</td>
<td>.23</td>
<td>N.A</td>
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<tr>
<td></td>
<td>12.3</td>
<td>3</td>
<td>106.5±13.7</td>
<td>.01</td>
<td>.43</td>
<td>.4</td>
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</tr>
<tr>
<td>W-AT (W)</td>
<td>44.0±11.4</td>
<td>45.0±10.</td>
<td>60.0±4.5</td>
<td>.37</td>
<td>N.A</td>
<td>N.A</td>
<td>N.A</td>
<td>.08</td>
<td>.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5</td>
<td>63.0±5.5</td>
<td>.31</td>
<td>.31</td>
<td>3</td>
<td>.4</td>
<td>.5</td>
<td>.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>.35</td>
<td>.35</td>
<td>3</td>
<td>.4</td>
<td>.5</td>
<td>.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In (Table 4) it is seen that both groups show significant differences in the strength after 24-weeks. In the M1, in the majority of the results significant differences were found (p <0.05) between the groups. The effect size was medium on right extensors and flexor 60°/s. The level of classification of the normative values (N.m) of Freedson was initially low with evolution no more than an percentile of 50 after 24 weeks.

<table>
<thead>
<tr>
<th>Right leg strength</th>
<th>Baseline (M0)</th>
<th>Week 24 (M1)</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AbG</td>
<td>CG</td>
<td>(M)</td>
</tr>
<tr>
<td>Extensors 60°/s</td>
<td>102.23±1</td>
<td>102.71±25</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>90.3</td>
<td>7.23</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>.09</td>
<td>.01</td>
<td>.16</td>
</tr>
<tr>
<td>Percentile Freedson</td>
<td>118.7±18.</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>(10-30-50-70-90)</td>
<td>5±2</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>8</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>&lt;10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Discussion

In the last 25 years aerobic exercise and strength training has been strongly recommended for the management of FM (Busch et al., 2011). The respiratory disorders, identified as a common factor for these individuals, is attributed to a dysfunction of the respiratory muscles much associated with the diaphragm (Lurie, Caidahl, Johansson & Bake, 1990; Sahin, Ulubas, Calikoglu & Erdogan, 2004). Despite this, the literature is still scarce about the effects of respiratory intervention on these patients. In this sense, the present study showed that patients with FM recover in 24 weeks the functional performance in traditional physical components, aerobic fitness, strength and respiratory function, without differences between the programs.

Symptoms such as tiredness, fatigue and non-restorative sleep directly influence the functional response of people with FM, impairing the carrying out the activities of daily living (ADLs) (Huijnen, Verbunt, Meeus & Smeets, 2015). Still associated with this low capacity of strength and resistance aerobic, the limitations in respiratory muscle function interfere in the best performance of cardiorespiratory function (Pamplona & Morais, 2007). Therefore, seems more prudent a guideline of exercise focused on the simultaneous recovery of diminished parameters through a combination of these elements than interventions in isolation.

Table 4. Values expressed in N.m (mean ± standard deviation). †P-values of Wilcoxon test to compare differences within group after 24 weeks of intervention. ¶P-values of Mann-Whitney test to compare differences between groups in baseline (M0) and week 24 (M1). M0-M1: effect size within group; M0: effect size between groups in baseline; M1: effect size between groups in week 24; (ES>0.8); N.A.: not applied. Normative value Freedson. AbG: aerobic-breath group (n=9); CG: combined group (n=8). Considered a significance level < 0.05.
As reported in other studies with combined training (aerobic strength) in patients with FM, this study also shows significant evidence through the combined program in mode gradually and progressively (Rooks, Silverman & Kantrowitz, 2002). Studies on the strength production of the lower limbs with isokinetic assessment in patients with FM also reported a reduction of this capacity and indicated these patients have this function impaired (Tomas-Carus et al., 2009). According with these authors, the present study shows that participants with FM have the muscle strength in the lower limbs decreased relatively to baseline. This is confirmed according to Freedson's percentile as the FM participants have this decreased functional condition, in both extension and flexion of the knees. After the interventions, the improvements are remarkable, the normative level is increasing up to 50 of the percentiles as can be seen by the greater expressiveness of the results in CG. The muscle strengthening through the resistance muscle training appears as the most effective method for the recovery of muscle strength and has been described by many health organizations for the improvement of health and muscular condition (Pollock et al., 1998). The extensor and flexor muscles of the knees play a determining role in the stability of the body and locomotion. The use in the slow and fast walking, climbing stairs and raising from a chair has been well documented in studies kinematics, electromyography and kinetic analysis (Collado-Mateo et al., 2016). It also has been considered essential to enable the activities of daily living in patients with FM (Tomas-Carus et al., 2009). The effect of strength exercises applied to the lower limbs of CG caused an increase in muscle strength contributing to better performance on tasks such as locomotion, crouch down and up and down stairs.

On the other hand, another aspect that has been described in patients with FM and elderly is the consequence of the reduced muscle mass associated with the alterations in energy metabolism and aerobic capacity which predisposes the weakness and atrophy that leads the condition of increased risk of falls (Jones, Horak, Winters, Morea & Bennett, 2009; Lord, Ward, Williams & Strudwick, 1995). In this sense, un low aerobic capacity were assessed in the present study, which showed that both groups presented alterations, both at the submaximal level and at the maximum level of the evaluated parameters. In the basal rate there was an improvement in the availability of oxygen but expressionless in the statistical level. Therefore, the measurement of the maximum oxygen uptake (VO_{2max}), which corresponds to the maximum aerobic capacity of each individual, is the estimated parameter that best reflects the capacity of the cardiocirculatory and respiratory systems, and more specifically, the performance of the system for collecting, transport and peripheral utilization O_{2} (American College of Cardiology & American Heart Association, 2000). Indeed, these results corroborate with other studies based on the American Heart Association (AHA) classification, which described that most FM patients is below average levels of conditioning,
as well as the maximum oxygen consumption and the decreased anaerobic threshold are attributed to the consequences of physical inactivity, pain or fatigue (Pollock et al., 1998; Valim et al., 2002). Additionally, as also has been prized and recommended by the literature the use of submaximal parameters for the assessment and exercise prescription (Valim, 2006; Valim et al., 2002). As such, the criteria for classification of participants with FM in this study were initially low, classified as steady (24 ml/kg/min) to the CG and weak (20 ml/kg/min) to AbG. The CPET were suspended in all participants due to early muscle fatigue. The results obtained in the CPET show that in the baseline the physiological tolerance of the FM participants is normal to the effort. The average value of VO₂max is within the normal range for either group, i.e, above 84% of VO₂max (Saltin & Rowel, 1980). Concluding that, the functional capacity of the organism involved in O₂ transport system and the use of peripheral muscles is normal or that those small non-relevant changes that exist would be compensated by intervention. This includes the normality respiratory system (ventilation, diffusion capacity, exchanges of alveolar-capillary gases and pulmonary circulation) from the heart (HR and Systolic Volume) of the circulation (blood vessels and hemoglobin concentration) and the ability of the skeletal muscles to remove enough O₂ during exercise.

In sedentary individuals changes in aerobic condition are expected when they are subjected to an exercise program for a period of 6 months, 3 times / week, 30 min / day and the intensity of 75% VO₂max (Pollock, 1973). The established aerobic training for both groups showed significant evidence for obtaining VO₂max. This response was most evident in CG. In accordance with the proposed of training aerobic for patients with FM, based on submaximal measures, a greater effect of gains was obtained in the anaerobic threshold of VO₂ (VO₂AT) than in the maximum level (VO₂max) in both groups. Studies of sedentary individuals and patients with FM have demonstrated that lactic anaerobic threshold can increase with training, even without significant changes in VO₂max (Saltin & Rowel, 1980; Denis, Fouquet, Poty, Geyssant & Lacour, 1982). The significant increase in the VO₂AT obtained in both groups adds value to submaximal training and shows the positive effect of this. Once interested in the impact of submaximal training on fitness of the lower limbs, it is also important to highlight the changes in aerobic power (W) in both groups. Basically, in the analysis of oxygen consumption the CG shows a tendency to be more effective than AbG in 24 weeks. The results obtained in the study of aerobic condition were important because it enabled the accomplishment of most activities of daily living (ADLs) in aerobiosis. This way and through regular training the pain caused by physical effort may be excluded in moderate AVD.

The respiratory function associated with physical intervention in patients with FM has been a shortcoming in physical activity programs of non-pharmacological treatment. Although there nearly three decades of conclusions on respiratory muscle weakness in these patients,
it was shown little besides characteristics of these parameters (Lurie, Caidahl, Johansson & Bake, 1990; Sahin, Ulubas, Calikoglu, & Erdogan, 2004).

Considering the set of physical disorders in FM, this study considered relevant integration of breathing exercises aiming to develop conditions to better explore the effect of aerobic training. The re-education of breath of a person interferes directly in the work and action of the respiratory muscle. The MRP have been used for assessing the respiratory muscle strength in patients with FM, showing that these patients have lower MIP and MEP values, which may indicate respiratory muscle dysfunction, including the diaphragm muscle (Forti, Zamunér, Andrade & Silva, 2016; Printes, 2012).

However, the influence of a possible mechanism related to the central brainstem should not be completely eliminated (Green, 2002). This study showed lower MIP and MEP values in these patients. In this sense, the test of spirometry was initially conducted to rule out any pathology superimposed. Thus, as shown in other studies, ours also showed that the parameters analysed for ventilator exclude the possibility of respiratory pathology (Forti, Zamunér, Andrade & Silva, 2016; Sahin, Ulubas, Calikoglu, & Erdogan, 2004).

The previous literature reported that factors such as motivation and cooperation of patients may affect maximal respiratory pressures measurements (ATS/ERS, 2002; Vincken, Ghezzo & Cosio, 1987). In this sense the use of plethysmography provides the measure of occlusion maximum pressure of air in the airways using 0.1 second (P0.1 max), measure that is not influenced by cooperation or motivation of the patient and has been explored in studies of respiratory function as a complement of MIP and MEP (Vincken, Ghezzo & Cosio, 1987; Burki, Mitchell, Chaudhary & Zechman, 1977). According to these bases, our study showed significant correlation between MIP and P0.1 max in baseline (r=0.61) and after 24 weeks of intervention (r=0.60), which could rule out any effect related to lack of motivation of patients in the measurements. Furthermore, the influence of the factor learning effect was excluded for having complied accurately with the conventional protocol of the European Respiratory Society (ERS) (ATS/ERS, 2002).

In the present study, differences for MIP were observed between participants with FM and predicted values calculated for healthy persons. The respiratory muscle training focused on the DB uses exclusively the muscle diaphragm (abdominal wall), reducing the movement of upper thoracic region, with a normal tidal volume and passive expiration (Goldstein, 1997; Biehl-Printes & Costa, 2006). Thus, our results indicate that the respiratory muscle training DB could also be useful for improving respiratory muscle strength and tolerance to exercise in patients with FM, as already proved for patients with asthma and subjects with subacute stroke (Burgess, Ekanayake, Lowe, Dunt, Thien & Dharmage, 2011; Sutbeyaz, Koseoglu, Inan & Coskun, 2010). As suggested in the few studies of respiratory function in FM patients, the
The present study corroborates and proposes that PMR values are attributed to probable muscle weakness of the respiratory muscles due to lack of use (Forti, Zamunér, Andrade & Silva, 2016; Sahin, Ulubas, Calikoglu, & Erdogan, 2004; Lurie, Caidahl, Johansson & Bake, 1990).

The present study also included limitations which require further discussion. The limited size of the sample may have contributed to lower statistical power to detect changes in some variables. Nevertheless, the most variables measured that did not show positive effects presented a small effect size (<0.5). The lack of difference after 24 weeks of different trial of exercise, AbG vs. CG, is attributed to the introduction of the training mode: “gradual and progressive”. We emphasize the importance of following the initial procedure indicated to preserve the security, adaptation, comfort and furthermore ensure adhesion and permanency of patients in programs (Rooks, D. S., Silverman, C. B., & Kantrowitz, F. G. (2002); Sañudo et al., 2010; Bidonde, Jean Busch, Bath & Milosavljevic, 2014; Jones, Clark & Bennett, 2002).

In conclusion, breathing exercises applied to both groups have an impact to be considered for rehabilitation due to the lack of studies applying the intervention of the DB as a co-adjuvant of physical exercise in the treatment of fibromyalgia. However, new studies with long-term programs are suggested to compare the absolute impact of different workouts, as well as the isolated practice of breathing exercises can be considered.

References


