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European Journal of Physical and Rehabilitation Medicine 2017 October;53(5):751-8
DOI: 10.23736/S1973-9087.17.04543-9

ORIGINAL ARTICLE

Oxygen uptake and body composition after aquatic physical training in women with fibromyalgia: a randomized controlled trial

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ABSTRACT

BACKGROUND: Aquatic physical training (APT) has been strongly recommended to improve symptoms in fibromyalgia syndrome (FMS). However, its effects on body composition and whether lean body mass (LBM) directly influences the aerobic functional capacity of this population are still not clear.

AIM: To investigate whether APT can help improve body composition and increase the aerobic functional capacity in women with FMS, and whether oxygen uptake (VO_2) related to LBM can better quantify the functional capacity of this population.

DESIGN: Randomized controlled trial.

SETTING: The Federal University of São Carlos, São Paulo, Brazil.

POPULATION: Fifty-four women with FMS were randomly assigned to trained group (TG, N.=27) or control group (CG, N.=27).

METHODS: All women underwent cardiopulmonary exercise test (CPET) to assess oxygen consumption at ventilatory anaerobic threshold (VAT) and at peak exercise, and also to assess body composition. The TG was submitted to APT program, held twice a week for 16 weeks. The exercise intensity was adapted throughout the sessions in order to keep heart rate and ratings of perceived exertion achieved at VAT.

RESULTS: After APT, body composition was not significantly different between groups (TG and CG). In VAT only TG showed increased VO_2 related to LBM, since in peak CPET, VO_2 in absolute units, VO_2 related to total body mass (TBM), VO_2 related to LBM and power showed significant differences. Significant difference between VO_2 related to TBM and VO_2 related to baseline LBM and after 16 weeks of follow-up, both in VAT as in peak CPET in both groups. Significant difference between VO_2 related to TBM and VO_2 related to LBM at VAT and at peak CPET in both groups at baseline and after 16 weeks of follow-up was observed.

CONCLUSIONS: APT with standardized intensities did not cause significant changes in body composition, but was effective in promoting increased VO_2 at peak CPET in women with FMS. However, VO_2 related to LBM more accurately reflected changes in aerobic functional capacity at VAT level after to APT.

CLINICAL REHABILITATION IMPACT: APT with standardized intensities at VAT level is of great interest, since VAT reflects better aerobic functional capacity of patients with FMS than maximum VO_2.

(*Cite this article as:* Andrade CP, Zamunér AR, Forti M, França TF, Tamburús NY, Silva E. Oxygen uptake and body composition after aquatic physical training in women with fibromyalgia: a randomized controlled trial. Eur J Phys Rehabil Med 2017;53:751-8. DOI: 10.23736/S1973-9087.17.04543-9)

Key words: Fibromyalgia - Cardiorespiratory fitness - Body composition - Exercise therapy.

Fibromyalgia syndrome (FMS) has multifactorial etiology characterized by various clinical manifestations such as chronic and diffuse musculoskeletal pain, fatigue and non-restorative sleep with physical and psychological damage to patients.[1, 2] In addition, epidemiological studies have shown higher overweight and obesity prevalence in this population, when compared to the general population, which contributes to worsening pain sensitivity, quality of life, aerobic functional capacity and ability to perform physical activities.[3-7]

Among treatments available to FMS, nonpharmacological options, with emphasis on aerobic exercises and hydrotherapy have been strongly recommended for promoting improvement of clinical symptoms, aerobic functional capacity,[4, 8-10] increasing lean body mass (LBM) [11] and reducing fat mass.[12, 13] FMS patients have good tolerance and adherence to training involving low-intensity physical exercises.[14, 15] However, studies involving aquatic aerobic physical training at moderate intensities controlled from the Borg effort perception scale or by the heart rate (HR) reserve method, have presented more satisfactory results.[8, 10, 12, 16] However, there are no reports in the present research literature on training involving aerobic physical exercises in the aquatic environment based on HR response achieved at the ventilatory anaerobic threshold (VAT) in the cardiopulmonary exercise test (CPET).

Another important aspect that should be emphasized is that the aerobic functional capacity has been commonly evaluated based on ventilatory variables obtained both from VAT as from peak CPET. Oxygen uptake (VO_2) is measured by total body mass (TBM) and LBM.[17] However, during CPET, ventilatory responses related to VO_2 come almost exclusively from working muscles.[18, 19] Therefore, Cicoira *et al.*[18] suggest that VO_2 correction would be more suitable if carried out by LBM, that is, fat-free body mass in VO_2 quantification.

Despite the satisfactory clinical results, the effects of aquatic physical training (APT) are still controversial, if they are due to muscular adaptations that contribute to reduce muscle weakness or to the greater supply of oxygen to working muscles.

Therefore, it is essential that VO_2 is quantified by both TBM and LBM.

Thus, given that women with FMS may have a predominance of fat body mass and low aerobic functional capacity, the aim of this study was to test the hypothesis that APT can help improve body composition and increase VO_2 related to LBM in women with FMS.

Materials and methods

This study was a randomized controlled clinical trial conducted at the Federal University of São Carlos, São Paulo, Brazil. Participants were recruited through posters and leaflets distributed at strategic points of the city (rheumatology, orthopedics and physiotherapy clinics) from December 2013 to December 2014. One-hundred and twenty women with clinical diagnosis of FMS were interviewed, and 54 were eligible and agreed to participate. All participants should present clinical diagnosis of FMS conducted by a rheumatologist physician, according to criteria established by the American College of Rheumatology.[1, 20] Participants' age was 30-60 years and had low levels of physical activity according to the International Physical Activity Questionnaire.[21] Volunteers who had systemic uncontrolled diseases (*e.g.*, diabetes mellitus, hypertension), musculoskeletal changes that could directly interfere in assessments (*e.g.*, joint diseases at advanced levels), cardiovascular system abnormalities, presence of infections and any other rheumatic diseases (*e.g.* osteoarthritis, connective tissue disease, rheumatoid arthritis) were excluded.

Randomization was performed *via* numerical sequence with 1:1 ratio randomly generated from the following website: http://www.randomization.com. Thus, participants included in the study were randomly distributed into trained group (TG, N.=27) who received APT or control group (CG, N.=27) who received guidelines for the maintenance of daily activities.

All participants read and signed the free and informed consent form prior to participation in the study, which was approved by the Ethics Research Committee of the institution (protocol no. 112508) and registered in ClinicalTrials.gov under no. NTC01839305.

Outcome measures

The primary outcome was to assess the effects of APT on oxygen consumption and body composition in women with FMS. The secondary outcome was to determine whether VO_2 related to LBM could be better predicted in relation to VO_2 related to TBM in this population.

Measures

Experiments were performed in 4 steps. In the first step, clinical and physiotherapeutic assessment was carried out in which the number of active tender points and anamnesis was found. In the second step, familiarization with equipment and experimental protocol was performed to reduce anxiety and a cardiovascular assessment maximum effort test was performed. In the third step (baseline), body composition and aerobic functional capacity were assessed from the submaximal CPET. In the fourth step, after 16 weeks of follow-up (post), the experimental protocols in the third step were repeated.

All volunteers were evaluated in the morning (between 7:30 a.m. and 12:00 p.m.). Temperature was maintained between 22 °C and 24 °C and relative humidity between 40% and 60%. After baseline evaluations, a person not involved in the study and blind to patients' data performed the randomization and provided researchers with the allocation of groups.

Body composition evaluation

Quadrupole bioimpedance of Biodynamics® model 310 analyzer (Biodynamics Corporation, Seattle, WA, USA) was used for body composition assessment according to the full-body technique (hand-foot) using single frequency (50 kHz, 800 µA). Volunteers were instructed to remove all metal accessories, empty bladder before the test and not to eat or drink anything 4 hours before evaluation. Volunteers were also instructed not to perform any exercise and not to consume alcohol 48 hours before evaluation.[22, 23] Four electrodes were placed on the dorsal surface of hand, wrist, foot and ankle of the right body hemisphere.[22, 24] During measurement, volunteers remained in supine position on a nonconductive surface. The measurement results were presented as: TBM (kg), fat mass percentage (%), fat mass (kg), LBM (kg), total body water (L) and basal metabolic rate (Kcal). Height (cm) was measured using stadiometer.

Cardiopulmonary exercise test (CPET)

Volunteers were instructed to perform light meal 2 hours before CPET. The CPET protocol was continuous ramp type performed in cycle ergometer with electromagnetic braking (Quinton Corival 400, Seattle, WA, USA) with seat adjusted to allow about 5 to 10 degrees of knee flexion. Volunteers were instructed to keep pedaling cadence at 60 revolutions per minute (rpm) and not to perform isometric contraction of upper limbs during the test.

CPET consisted of 1 min at rest in the sitting position on the cycle ergometer followed by 4 minutes of warm-up exercises at power intensity of 4 W. Then, power was increased until physical exhaustion (peak exercise), defined as the time when subjects were unable to maintain pedaling at 60 rpm or until the manifestation of a limiting symptom (*e.g.* pain, dizziness, nausea) or respiratory fatigue.[25]

Power increments were determined for each volunteer according to formula proposed by Wasserman *et al.*:[17]

$$\text{Power} = \{[(\text{height} - \text{age})\ 0.14] - [150 + (6 \times \text{body mass})]\} / 100$$

During CPET, electrocardiogram and HR were recorded beat to beat in real time through CardioPerfect® electrocardiograph (Welch Allyn CardioPerfect Workstation, Skaneateles Falls, NY, USA).

At the end of CPET, three trained observers identified VAT through visual graphic method to estimate the disproportionate increase of ventilatory and metabolic variables during dynamic incremental exercise.[26] The criterion adopted was the loss of parallelism between VO_2 and carbon dioxide production (VCO_2).[26]

Ventilatory and metabolic variables

VO_2 variables (mL/min^{-1}) and VO_2 related to TBM were obtained breath to breath throughout CPET through a system that measures expired gases (Ultima PFX system, Medical Graphics, St. Paul, MN, USA) calibrated before each test. Correction of VO_2 related to LBM was obtained from the ratio between VO_2 in absolute units and LBM.

APT program

The APT program was conducted in heated pool (30±2 °C). The protocol consisted of 32 sessions of 45 minutes, twice per week (alternate days) for 16 weeks. Sessions were held in groups of 5 women supervised by three physiotherapists. The protocol included the following phases: 1) warm-up (10 min): stretching the muscles of lower and upper limbs and neck; walking exercises and lateral displacement (5 min); 2) exercise protocol (30 min): aerobic exercises at three HR percentages reached at VAT. Level 1: lower limb exercises sitting on floats (5 min) at 80%

VAT HR; level 2: jumping on a trampoline (Polimet®, Brazil) (10 min) at 110% VAT HR; level 3: exercises in aquatic cycle with resistance adjustment (Hidrocycle®, Brazil) at 100% VAT HR (10 min). At the end of the protocol, resistance exercises of upper limbs using floats (5 min). Relaxation (5 min): Volunteers used floating devices in order to help them stay in the most comfortable position possible. The aerobic exercise progression was adjusted throughout the sessions in order to maintain HR and ratings of perceived exertion (RPE) achieved at VAT level.

In all sessions, BP (auscultation), HR (Polar® model FT1, Electro Oy, Finland) and RPE (Borg CR-10) were evaluated during each session.

Statistical analysis

Sample size was calculated using the GPower software v. 3.1 based on a pilot study (N.=20). For the analysis, effect size 0.70 was obtained for VO_2 related to TBM. The sample size suggested was 20 participants in each group. The significance level was set at 5% with power of 80%.

The intention-to-treat analysis was performed using the multiple imputation method to impute values for all missing data.[27] Analysis using only patients with complete data was also performed (protocol analysis).

Data distribution was evaluated using the Shapiro-Wilk normality test. For comparisons between groups (CG×TG) related to hemodynamic and age variables, the Student *t*-test for independent samples was used. Two-way analysis of variance (ANOVA) with repeated measures was used to evaluate the difference between TG and CG during the 16 weeks of follow-up for body composition and CPET variables. When there was significant interaction, analysis of the main effects was disregarded and the test for multiple comparisons with Bonferroni adjustment was performed.

To control a possible effect of confounding variables, analysis of covariance (ANCOVA) was performed considering VO_2 related to TBM and VO_2 related to LBM as covariates, since they showed significant difference between groups at baseline.

Analyses were performed using SPSS software v. 20.0. The significance level was set at 5%.

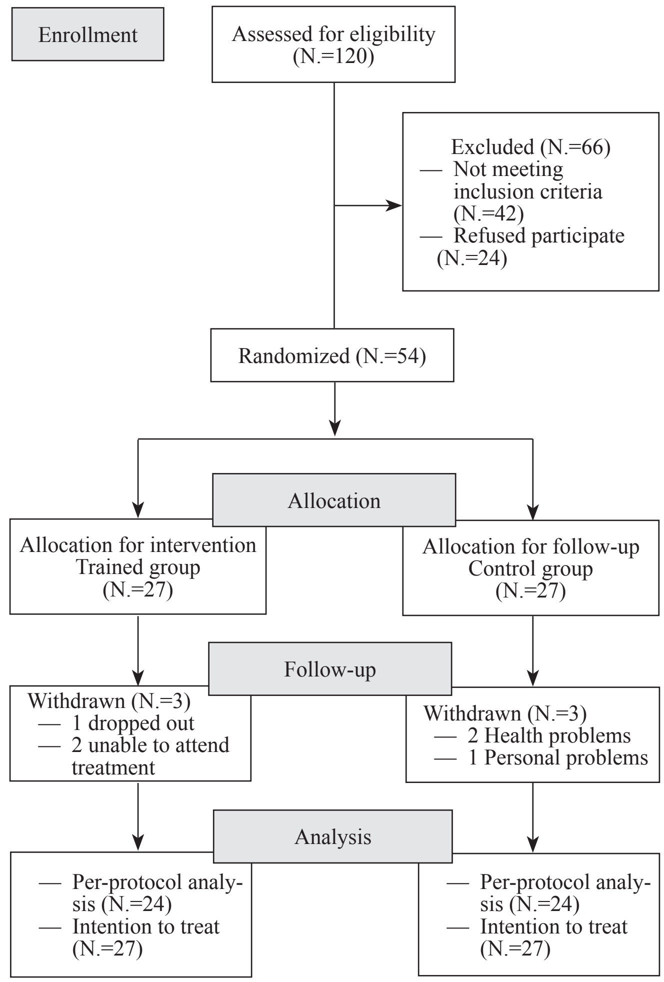

Figure 1.—Flow chart of the study.

Results

Participants and baseline characteristics

Figure 1 shows the flowchart of patients throughout the study. Fifty-four women were eligible and agreed to participate. However, three volunteers from TG gave up participating of APT and 3 volunteers from CG refused to perform reassessments. Thus, 24 women from TG and 24 women from CG completed all stages and were considered for protocol analysis.

No significant differences were observed in either protocol analysis nor intention-to-treat analysis for variables related to body composition, cardiorespiratory and metabolic variables obtained at VAT level and peak CPET between groups (P>0.05). Thus, the

TABLE I.—*Clinical characteristics of the study population.*

Patient characteristics	Treatment group (N.=27)	Control group (N.=27)
Age, years	48±8	47±8
SAP, mmHg	121±12	121±11
DAP, mmHg	78±6	75±2
HR, bpm	77±9	73±10
Duration of diagnosis, years	9±5	10±5
Medications, N. (%)		
Anxiolytics	3 (14%)	2 (7%)
Antidepressants	8 (29%)	12 (44%)
AF	2 (7%)	0 (0%)
AN	17 (62%)	17 (62%)
MR	15 (55%)	16 (59%)

Data are presented as mean±SD or count (percentage).
SAP: systolic arterial pressure; DAP: diastolic arterial pressure; HR: heart rate; AF: anti-inflammatory drugs; AN: analgesic drugs; MR: muscle relaxant drugs.

results were presented only based on the intention-to-treat analysis.

The baseline characteristics of the study volunteers are shown in Table I.

Body composition and variables obtained in CPET

Table II presents the results related to body composition, cardiorespiratory and metabolic variables obtained at VAT level and peak CPET. VO_2 was presented in absolute units (L/min) units related to TBM (mL/kg^{-1}/min^{-1}) and units related to LBM (mL/kgLBM^{-1}/min^{-1}).

There was no significant interaction for variables related to body composition. Significant interaction between group and treatment for VO_2 related to LBM ($F_{(1,27)}$=2.84, P=0.04) in VAT was observed. The intra-

TABLE II.—*Body composition, cardiorespiratory and metabolic variables obtained at ventilatory anaerobic threshold and peak cardiopulmonary exercise test in the two study groups.*

	TG		CG		P value		
	Pre	Post	Pre	Post	G	T	I
Body composition							
TBM, kg	71.0±10.3	71.2±9.2	75.7±15.4	75.8±6.9	NS	NS	NS
BMI, kg/m^2	28.4±4.1	28.5±4	30.0±5.3	30.0±5.4	NS	NS	NS
Fat mass percentage, %	35.8±4.9	35.7±4.6	35.8±4.8	36.6±4.8	NS	NS	NS
Fat mass, kg	25.8±6.3	25.8±6.3	27.5±8.6	28.2±9.1	NS	NS	NS
LBM, kg	44.9±5.3	45.3±4.8	48.1±7.9	47.6±7.2	NS	NS	NS
Total body water, L	32.5±3.3	32.5±3.0	34.6±5.7	34.2±5.3	NS	NS	NS
Basal metabolic rate, kcal	1369±57	1374±147	1428±180	1446±11	NS	NS	NS
VAT							
HR, bpm	105±12	99±8	103±17	105±11	NS	NS	NS
SAP	147±21	145±19	146±27	148±22	NS	NS	NS
DAP	84±11	84±9	84±10	84±11	NS	NS	NS
RPE-L	3.4±2.4	4.1±3.1	3.3±2.6	4.2±2.5	NS	NS	NS
RPE-D	3.8±3.0	3.6±2.8	3.3±2.3	3.4±2.8	NS	NS	NS
VO_2, mL/kg^{-1}/min^{-1}	9.9±2.9	10.8±3.1	9.2±1.9	9.2±2.1	NS	NS	NS
VO_2, L/min	0.68±0.22	0.76±0.24	0.70±0.22	0.66±0.19	NS	NS	NS
VO_2, mL/kgLBM^{-1}/min^{-1}	15.4±5.1	16.7±4.8* †	14.4±3.5	14.6±4.7	NS	0.01	0.04
Workload, W	42±22	52±19	36±29	44±19	NS	NS	NS
PEAK							
HR, bpm	131±17	128±12	126±15	125±10	NS	NS	NS
SAP	165±22	163±22	166±24	165±19	NS	NS	NS
DAP	89±10	89±8	87±8	85±9	NS	NS	NS
RPE-L	6.4±2.9	6.9±2.5	6.4±2.3	6.6±2.1	NS	NS	NS
RPE-D	6.5±2.9	6.4±2.6	6.7±2.6	5.7±2.9	NS	NS	NS
VO_2, mL/kg^{-1}/min^{-1}	15.1±3.8	15.9±3.9* †	12.7±2.3	12.6±2.7	<0.01	NS	0.03
VO_2, L/min	1.02±0.24	1.10±0.25* †	0.95±0.19	0.93±0.22	0.01	NS	0.02
VO_2, mL/kgLBM^{-1}/min^{-1}	22.5±4.7	24.3±5.1* †	20.3±3.2	20.3±5.2	<0.01	NS	0.03
Workload, W	75±26	82±20* †	65±20	63±18	<0.01	NS	0.03

Data are expressed as mean±SD. TG: treatment group; CG: control group; TBM: total body mass; BMI: Body Mass Index; LBM: lean body mass; VAT: ventilatory anaerobic threshold; HR: heart rate; SAP: systolic arterial pressure; DAP: diastolic arterial pressure; RPE-L: ratings of perceived exertion for fatigue in the lower limbs; RPE-D: ratings of perceived exertion for dyspnea; VO_2: oxygen consumption; G: main group effect; T: main treatment effect: pre *vs.* post; I: interaction between group and treatment; NS: not significant. *P<0.05 *vs.* pre TG; † P<0.05 *vs.* post CG.

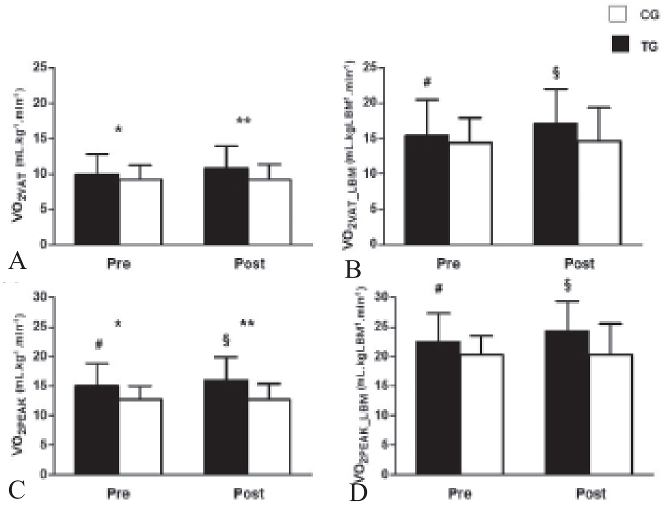

Figure 2.—Oxygen consumption (VO_2, mL/kg^{-1}/min^{-1}) related to total body mass (TBM) and to lean body mass (LBM), obtained at ventilatory anaerobic threshold (VAT) (A) and peak CPET (Peak) (B) of both groups (TG and CG) at baseline (Pre) and after 16 weeks (Post). *Statistically significant difference between VO_2 related to TBM *vs.* VO_2 related to LBM (Pre in both groups) (P<0.05); **statistically significant difference between VO_2 related to TBM *vs.* VO_2 related to LBM (Post in both groups) P<0.05; # statistically significant difference between Pre *vs.* Post (intragroup) (P<0.05); § statistically significant difference between TG *vs.* CG (intergroup) (P<0.05).

group analysis revealed that TG showed an increase in VO_2 related to LBM (P=0.04) at VAT after 16 weeks of APT. Higher VO_2 related to LBM (P=0.04) in the VAT of TG when compared to the control group after 16 weeks of follow-up was also evidenced. For cardiorespiratory variables obtained at peak CPET, significant interactions were observed between group and treatment for VO_2 in absolute units ($F_{(1,27)}$=5.05, P=0.02), VO_2 related to TBM ($F_{(1,27)}$=4.96; P=0.03), power ($F_{(1,27)}$=4.53; P=0.03) and VO_2 related to LBM ($F_{(1,27)}$=4.52; P=0.03). With respect to values obtained at peak CPET after 16 weeks of APT, TG showed increased VO_2 related to TBM (P=0.01), VO_2 in absolute units (P=0.02), power (P=0.01) and VO_2 related to LBM (P=0.01). Furthermore, the results demonstrate that TG showed higher VO_2 related to TBM (P<0.01), VO_2 in absolute units (P=0.02), power (P<0.01) and VO_2 related to LBM (P=0.03) compared to the control group after 16 weeks of follow-up. VO_2 related to TBM and VO_2 related to LBM at peak CPET after 16 weeks of follow-up showed significant differences between groups (P=0.05 and P=0.03, respectively) even after adjusting for covariance (Table II).

Significant difference between VO_2 related to TBM and VO_2 related to LBM at VAT and at peak CPET in both groups at baseline and after 16 weeks of follow-up was observed (Figure 2).

Discussion

The main findings of this study revealed that women submitted to 16 weeks of APT showed no changes in body composition. However, they showed increased VO_2 related to LBM at VAT and at peak CPET and increased VO_2 related to TBM, absolute VO_2 and peak power of CPET.

Our findings corroborate the results of previous studies, which also found positive effects of APT on the aerobic functional capacity during peak CPET in women with FMS.[4, 10, 14, 15, 27] It has been reported that predominantly aerobic APT associated with the advantages brought about by the physical properties of water (*i.e.*, drag, thrust) and medium temperature effectively contribute to increase aerobic functional capacity.[4, 10, 28]

In addition to the above factors, it could be inferred that the standardization of the effort intensity using as main reference HR obtained at VAT was efficient to improve aerobic functional capacity of women with FMS. This aspect of the present study must be emphasized, since most studies that have proposed APT for patients with FMS did not standardize physical training nor controlled effort intensity.[29, 30]

Accordingly, standardizing the effort intensity is of great interest, since VAT reflects better the aerobic functional capacity of patients with FMS than maximum oxygen consumption, as these patients are often not able to perform maximal exercise during CPET.[3] Moreover, it is noteworthy that low to moderate intensity exercises should be prioritized at the expense of high-intensity exercises,[30] as low to moderate intensity exercise favors adherence to treatment protocol associated with the fact that the improvement of the aerobic functional capacity is not associated with clinical improvement.[3]

An interesting finding was the fact that only VO_2 related to LBM showed significant interaction in VAT. Thus, it could be inferred that it was more suitable to quantify adjustments promoted by APT compared to absolute VO_2 and VO_2 related to TBM at VAT.

Although no increase in LBM has been observed, this variable plays an important role in VO_2. Our results suggest that the increase of VO_2 related to LBM, both at VAT as at peak effort, can be attributed to peripheral adaptations, which may include increased amount of oxidative enzymes at muscle level, increased mitochondrial capacity and density, increased capillary density, increased gas exchange, substrate utilization in muscle tissue and muscle strength,[31, 32] since peripheral fatigue is the main limitation for maximal and submaximal exercise test in women with FMS.

Thus, the correction of VO_2 related to LBM allows obtaining more reliable values for the assessment of aerobic functional capacity than VO_2 values related to TBM, especially with regard to peripheral responses that lead to increased VO_2, which may be useful for evaluating the effectiveness of APT programs.

Regarding body composition, the results of this study corroborate the findings of other authors, who found no significant differences for TBM, Body Mass Index (BMI) and LBM variables in women with FMS after 12 and 24 weeks, respectively, of a combined training program that included aerobic exercises in heated pool, psychological therapy,[8] and ground exercises.[12]

On the other hand, Aparicio *et al.*[6] reported in a pilot study with women with FMS that nine weeks of physical training in heated pool including aerobic exercise of moderate intensity were enough to significantly reduce body fat percentage and BMI in this population.

The results of this study revealed that the average BMI values of women with FMS of both groups were above values recommended by the World Health Organization (WHO) both at baseline and after 16 weeks. However, it is well documented in literature that women with FMS have higher BMI and body fat percentage compared to values reported for healthy women.[13, 33]

Limitations of the study

Despite the interesting findings, more research is needed to determine whether longer (over 16 weeks) and more frequent programs (more than 2 sessions/week) and the control of eating habits, are effective to promote beneficial changes related to body composition in women with FMS.

Conclusions

It could be concluded that 16 weeks of APT with standardized intensities did not cause significant changes in body composition, but was effective in promoting increased VO_2 at peak CPET in women with FMS. However, VO_2 related to LBM more accurately reflected changes in aerobic functional capacity at VAT level in relation to APT.

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Funding.—This study received financial support from the São Paulo Research Foundation Support (FAPESP) (process #2011/22122-5 and #2013/17504-1) and from the National Council for Scientific and Technological Development (CNPq) (process #307187/2013-6).

Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Article first published online: April 4, 2017. - Manuscript accepted: March 22, 2017. - Manuscript revised: March 13, 2017. - Manuscript received: October 23, 2016.