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Respiratory response to low-intensity physical exercise in women with chronic fatigue syndrome

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KEYWORDS
Chronic fatigue syndrome;
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Abstract
Introduction: The aim of the study was to evaluate the cardiorespiratory parameters at rest and as the response to very low intensity physical exercise in women with chronic fatigue syndrome (CFS).
Material and methods: A group of 141 women suffering from CFS were compared with a control group (C) of 20 women while at rest and during 4 minutes of constant exercise on a cycloergometer with no work load (work load = 0 watts).
Results: Significant differences were found during the exercise: respiratory quotient (CFS = 0.9 ± 0.09; C = 0.8 ± 0.08; $p<0.05$); the respiratory equivalent for oxygen (CFS = 34.6 ± 10.1; C = 28.0 ± 3.4; $p<0.01$) and for carbon dioxide (CFS = 37.9 ± 7.7; C = 33.4 ± 3.8; $p = 0.01$). Differences were observed in the heart rate during the rest period (CFS = 86.8 ± 14,2 beats·min^{-1}; C = 79.8 ± 8.4 beats·min^{-1}; $p = 0.03$). There were no significant differences in the perception of effort made during rest (CFS = 10.3 ± 3.0; C = 6.2 ± 0.6; $p<0.001$) and just after exercise (CFS = 12.5 ± 2.8; C = 6.8 ± 1.4; $p<0.01$).
Conclusions: It was concluded that women with chronic fatigue syndrome had less ventilatory efficiency than the controls during low intensity physical exercise. This condition could be improved through specific rehabilitation programs.

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PALABRAS CLAVE
Síndrome de fatiga crónica;
Ejercicio;
Respuesta fisiológica

Respuesta respiratoria al ejercicio físico de baja intensidad en mujeres con síndrome de fatiga crónica

Resumen

Introducción: El objetivo del estudio fue evaluar los parámetros cardiorrespiratorios en condiciones de reposo y la respuesta durante el ejercicio físico a muy baja intensidad en mujeres con síndrome de fatiga crónica (SFC).

Material y métodos: Un grupo de 141 mujeres afectadas por el SFC se compararon con un grupo control (C) de 20 mujeres en condiciones de reposo y durante 4 min de ejercicio constante en un cicloergómetro sin carga de trabajo (carga de trabajo = 0 vatios).

Resultados: Se encontraron diferencias significativas durante el ejercicio: el cociente respiratorio (SFC = 0,9 ± 0,09; C = 0,8 ± 0,08; $p<0,05$); equivalente respiratorio para el oxígeno (SFC = 34,6 ± 10,1; C = 28,0 ± 3,4; $p<0,01$) y para el dióxido de carbono (SFC = 37,9 ± 7,7; C = 33,4 ± 3,8; p = 0,01). Se observaron diferencias en la frecuencia cardíaca durante el período de descanso (SFC = 86,8 ± 14,2 latidos·min^{-1}; C = 79,8 ± 8,4 latidos·min^{-1}; p = 0,03). No hubo diferencias significativas en la percepción del esfuerzo realizado durante el descanso (SFC = 10,3 ± 3,0; C = 6,2 ± 0,6; $p<0,001$) y justo después del ejercicio (SFC = 12,5 ± 2,8; C = 6,8 ± 1,4; $p<0,01$).

Conclusiones: Se concluye que las mujeres con síndrome de fatiga crónica tenían menos eficiencia ventilatoria que los controles durante el esfuerzo físico a baja intensidad. Este aspecto podría ser mejorado mediante programas específicos de rehabilitación.

Introduction

One of the main characteristics of patients affected by chronic fatigue syndrome (CFS) is their reduced exercise capacity and increased fatigue symptoms. CFS patients have a marked ratio of perceived exertion (RPE) hours and even days after physical effort[1]. Several studies have reported a reduction in aerobic power in CSF patients, with low values of maximal oxygen uptake (VO_{2peak}), heart rate, and workload[2-4]. Patients with CFS had a higher RPE at the beginning of physical exercise, during submaximal and peak workloads, and during recovery time[5]. Most of the research has assessed the functional capacity of these patients using incremental protocol test methods. The aim of these tests is to obtain the maximum cardiorespiratory values. However, there are no studies of the cardiorespiratory response in CFS during light exercise, which could represent CSF patients' daily activities.

Therefore, we assessed some physiological parameters in CSF patients during rest and during very low intensity, steady state physical exercise.

Methods

A group of 141 women affected by CFS (age: 46.7 ± 8.7 years; height: 160.4 ± 0.6 cm; weight: 67.1 ± 13.2 kg) were compared with a control group (C) of 20 women (age: 42.9 ± 11 years; height: 158.9 ± 6.4 cm; weight: 66.7 ± 10.9 kg) with similar social and activity levels. The study was approved by the Ethical Committee (IDIBELL. Campus od Bellvitge). All subjects signed the corresponding consent form. Patients were carefully assessed to check that they met CDC (Centre for Disease Control) criteria for CFS. Previous diagnoses were confirmed by the consensus of two specialists.

Laboratory Tests

All tests were performed in the endurance laboratory of the Department of Physiological Sciences II (IDIBELL-University of Barcelona. Campus of Bellvitge). Environmental parameters were stable and optimum throughout the tests (temperature: 22-24 °C; relative humidity: 55-66%). Participants did not perform any kind of high-intensity physical activities in the 72 hours previous to the test and all stated that they had slept normally the night before. The tests were conducted in the morning after a light breakfast with no stimulant or depressant beverages. Subjects were evaluated while resting for 2 minutes on the cycloergometer (Excalibur, Lode, Groningen, Netherlands). Then, they cycled with no workload (0 watts) at 50 rpm for 4 minutes. This exercise time is sufficient to achieve a steady state in heart rate, ventilation, oxygen and carbon dioxide kinetics, particularly during a test with no workload. A breath-by-breath automatic system (Metasys TR-plus, Brainware

S.A., La Valette, France) measured airflow and volume continuously and simultaneously determined expired carbon dioxide (VCO_2) and oxygen uptake (VO_2) using a two-way mask (Hans Rudolph, Kansas, USA). Heart rate (HR) was monitored continuously by means of a pulsometer (Polar Acurex Plus, Polar Electro OY, Finland) and blood pressure was recorded at the end of both the rest and exercise phases. Age-based, predicted values of VO_{2max} were calculated from regression equations derived from maximal testing in a cohort of healthy sedentary women (VO_{2max} in $ml \cdot kg^{-1} \cdot min^{-1} = 42.3 - [0.356 \cdot \text{age in years}]$)[6].

The RPE was determined using the Borg Scale[7] during resting and just after the exercise period. Ventilation (VE), VO_2, VCO_2 and HR data were averaged for the whole rest period and for the last 2 minutes of the exercise period.

Table 1 The characteristics of both groups

	CFS group	Control group
Age (years)	46.7 ± 8.7	42.9 ± 11.0
Weight (kg)	67.1 ± 13.2	66.7 ± 10.9
Height (cm)	160.4 ± 0.6	158.9 ± 6.4
VO_2 theoretical max ($ml \cdot kg^{-1} \cdot min^{-1}$)	25.7 ± 3.3	27.0 ± 3.9
HR theoretical max ($beats \cdot min^{-1}$)	173.8 ± 8.8	177.7 ± 10.9
Work Powe rtheoretical max (w)	131.5 ± 21.8	136.6 ± 18.7

CFS: chronic fatigue syndrome, HR: Heart Rate, VO_2: Oxygen consumption.

Statistical Analysis

The Kolmogorov-Smirnov test was used to determine the normal distribution of the different variables. The differences between the values recorded in the C and CFS groups were analysed by Student's t test for unpaired samples. The significance level was $p < 0.05$ for all the statistical variables.

Results

There were no significant differences in the physical or functional characteristics of the subjects studied (Table 1).

There were no significant differences in the resting ventilatory values between both groups. However, the HR (mean ± SD) was significantly higher ($p = 0.03$) in CFS patients (CFS = 86.8 ± 14.2 $beat \cdot min^{-1}$; C = 79.8 ± 8.4 $beat \cdot min^{-1}$), as was the RPE scale (CFS: 10.3 ± 3; C: 6.2 ± 0.6; $p<0.001$).

During exercise, ventilatory differences were detected between both groups in the respiratory equivalents of VO_2 (CFS = 34.6 ± 10.1; C = 28±3.4; $p<0.01$) and VCO_2 (CFS = 37.9 ± 7.7; C = 33.4 ± 3.8; $p = 0.01$). We also found

Table 2 Physiological parameters during rest and cycling with no workload (0 watts) in the chronic fatigue syndrome (CFS) and control groups

	Rest		0 watts	
Parameters	**CFS group**	**Control group**	**CFS group**	**Control group**
V_E ($L \cdot min^{-1}$)	10.4 ± 2.9	9.57 ± 1.8	19.6 ± 7.3	16.0 ± 2.6
B_f ($breaths \cdot min^{-1}$)	17.8 ± 4.1	17.0 ± 4.0	23.3 ± 6.5	21.7 ± 4.2
V_T (L)	0.5 ± 0.1	0.5 ± 0.0	0.7 ± 0.2	0.6 ± 0.1
VO_2 ($L \cdot min^{-1}$)	0.3 ± 0.0	0.3 ± 0.0	0.5 ± 0.1	0.5 ± 0.1
VO_2($mL \cdot kg^{-1} \cdot min^{-1}$)	5.0 ± 1.4	4.7 ± 1.0	8.6 ± 2.4	8.7 ± 1.7
RER	0.8 ± 0.0	0.8 ± 0.0	0.9 ± 0.1	0.8 ± 0.0*
FEO_2 (%)	17.0 ± 0.6	16.9 ± 0.4	17.2 ± 0.7	16.6 ± 0.4*
$FECO_2$ (%)	3.2 ± 0.5	3.2 ± 0.3	3.3 ± 0.5	3.6 ± 0.3*
V_E/VO_2 (L)	32.2 ± 6.4	30.9 ± 4.7	34.6 ± 10.1	28.0 ± 3.4*
V_E/VCO_2 (L)	39.0 ± 7.5	38.1 ± 4.0	37.9 ± 7.7	33.4 ± 3.3*
PET O_2 (mmHg)	107.0 ± 5.7	105.4 ± 4.9	109.2 ± 7.5	103.2 ± 3.8*
PET CO_2 (mmHg)	34.6 ± 4.6	35.0 ± 3.2	34.4 ± 5.9	37.9 ± 3.2*
HR ($beats \cdot min^{-1}$)	86.8 ± 14.2	79.8 ± 8.4*	101.4 ± 7.9	96.3 ± 7.3
Systolic BP (mmHg)	124.01 ± 17.7	124.45 ± 19.4	132.3 ± 20.6	132.9 ± 16.1
Diastolic BP (mmHg)	79.09 ± 12.4	76.9 ± 8.8	85.0 ± 15.6	93.5 ± 13.0**
RPE	10.0 ± 3.0	6.2 ± 0.6**	12.5 ± 2.8	6.8 ± 1.4**

V_E: minute ventilation; B_f: breathing frequency; V_T: tidal volume; VO_2: oxygen uptake; RER: respiratory exchange ratio; FEO_2: expiratory fraction of O_2; $FECO_2$: expiratory fraction of CO_2; V_E/VO_2: ventilatory equivalent for oxygen; V_E/VCO_2: ventilatory equivalent for CO_2; PET O_2: end-tidal PO_2; PET CO_2: end-tidal PCO_2; HR: heart rate; Diastolic BP: diastolic blood pressure; Systolic BP: systolic blood pressure; RPE: rating of perceived exertion.

*$p<0.05$; **$p<0.01$.

differences ($p<0.05$) in end-tidal pressures of oxygen (CFS = 109.2 ± 7.5 mmHg; C = 103.2 ± 3.8 mmHg) and carbon dioxide (CFS = 34.4 ± 5.9 mmHg; C = 37.9 ± 3.2 mmHg). Likewise, differences ($p<0.05$) were detected in the respiratory quotient during exercise (CFS = 0.9 ± 0.09; C = 0.8 ± 0.08) (Table 2).

Discussion

This study found substantial differences between women with CFS and a healthy sedentary control group after physical exercise, even at very low workloads. To avoid age, weight and activity level related influences, the selected patients had the same characteristics as the control group. There were no differences between the groups in the estimated VO_2, HR and work power peaks. This study had a larger sample than other studies that have evaluated cardiorespiratory function during submaximal exercise[5].

When resting, HR was 9% higher in CFS patients. This could be explained by the following: *a)* a higher level of anxiety; *b)* autonomic system dysfunction with a sympathetic overactivity[8] or decreased vagal tone[9], and *c)* smaller left systolic and diastolic ventricular dimensions and mass[10], which would produce an increased HR to maintain cardiac output. Although we did not detect significant differences in resting blood pressure between both groups, the diastolic values in CFS patients were slightly higher. This suggests that CSF patients may have decreased vagal tone.

CFS patients showed a markedly worse response than controls during exercise with no added workload. In particular, CSF patients had higher respiratory equivalents for oxygen and carbon dioxide, leading to lower ventilatory efficiency than control subjects, who had 24% higher ventilation for the same VO_2 uptake. In addition, we observed a higher percentage of oxygen; a higher end-tidal pressure of oxygen; a lower percentage of carbon dioxide; and lower carbon dioxide end-tidal pressures. This suggests that the alveolar pressure of both gases was probably secondary to a certain hyperventilation state. The differences in ventilation efficiency, evaluated by the respiratory equivalents for oxygen and carbon dioxide, could be explained by weaker thoracic muscles producing shallow breathing in CSF patients. It could also be linked to hyperventilation from anxiety caused by protocol procedures used in the laboratory. We evaluated ventilation during the final exercise phase and during the previous period to assess whether exercise decreased anxiety. The kinetics of these parameters could also be related to the patients' symptoms. CSF patients stated that they had a sensation of dyspnoea during the very light physical effort. The sensation of dyspnoea could increase anxiety and affect the respiratory response during exercise.

Finally, these findings could be due to reduced oxidative metabolism by muscle cells[11] or an altered ability to get oxygen into small muscle vessels, related to abnormal control of peripheral circulation[12]. Physical inactivity causes a decrease in oxygen delivery and in the oxidative capacity of tissues. The CFS group had a significantly higher respiratory quotient. This indicates that they used a higher percentage of glucose fuels to perform the same work by mainly aerobic metabolism, as the value was less than the unit.

Conclusion

According to our results, women with CFS had markedly less ventilatory efficiency than controls during periods of very low physical effort. Efficiency could be improved by means of rehabilitation programs, which would have great psychophysical benefits on CSF patients' daily activities.

Conflict of interest

The authors declare they have no conflicts of interest.

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