

Original Article

Cardiorespiratory response to exercise in men and women with obstructive sleep apnea

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Abstract

Background: OSA severity has been associated with self-reported lack of exercise. Most of the research has been done with men recruited from sleep clinics. There is limited data on the exercise performance of women with OSA. Therefore, the aim of this study was to assess exercise performance in a prospective, consecutive sample of men and women with OSA to compare their cardio respiratory parameters, arterial blood pressure and heart rate responses during and after exercise.

Methods: Sixty-two subjects (32 men) completed the protocol. Men had a higher peak VO_2 , percent predicted peak VO_2 , VCO_2 , heart rate, systolic BP, and oxygen pulse than women.

Results: There were no differences between men and women for peak oxygen saturation, peak Borg scales for dyspnea and leg fatigue and diastolic BP. A significant negative correlation was found between severity of OSA as measured by AHI, and peak VO_2 ($r = -0.4$) in women, but not in men.

Conclusion: Men with OSA have higher peak VO_2 and higher peak exercise heart rate than women with OSA; they also have higher end-exercise systolic BP than women and higher SBP during recovery from exercise; although this difference is not significant when adjusted for peak systolic BP. In men with OSA, there is no correlation between peak VO_2 and AHI, but there is a significant correlation between these variables in women. Heart rate and blood pressure behaved similarly during exercise in both groups.

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Keywords: Blood pressure; Heart rate; Oxygen consumption; Obstructive sleep apnea; Exercise performance; Cardiovascular response

1. Introduction

Obstructive sleep apnea (OSA) is a common condition caused by an intermittent collapse of the upper airway during sleep that results in repetitive hypoxemia and nighttime arousals, poor sleep quality, and excessive daytime somnolence. OSA has been named a risk factor for a number of cardiovascular conditions, such as arterial hypertension [1,2], congestive heart failure [3], and stroke [4], and has been associated with increased cardiovascular mortality [5]. Physical exercise poses signif-

icant stress for the cardiovascular and pulmonary system and often leads to early diagnosis of cardiovascular (CV) abnormalities, such as coronary artery disease or cardiac arrhythmias [6–8].

OSA severity has been associated with self-reported lack of exercise, independent of body habitus, after adjusting for body mass index (BMI) [9]. OSA subjects are frequently overweight and often complain of fatigue and exercise intolerance, yet it is not clear whether OSA impairs exercise performance. A significant decrease in peak oxygen consumption was noted in patients with moderate to severe OSA in some studies [10–12], while, in others, the exercise performance of OSA subjects was normal [13,14]. Most of the research has been done with

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men recruited from sleep clinics. There are limited data on the exercise performance of women with OSA or on cardiovascular response to exercise for men and women with OSA.

The aim of this study was to assess exercise performance in a prospective, consecutive sample of men and women with OSA to compare cardiorespiratory parameters, blood pressure, and heart rate responses during and after exercise.

2. Methods

2.1. Subjects

Patients eligible were those subjected to polysomnography at the Sleep Institute Universidade Federal de São Paulo (UNIFESP) due to clinical suspicion of OSA with an apnea hypopnea index (AHI) > 5 . A total of 108 patients with AHI > 5 were consecutively selected in March and April 2006, and 68 of them agreed to participate. Subjects were included if they were over 18 years old, sedentary, capable of performing a treadmill test, and reported no recent hospitalization or change in medication. Exclusion criteria included BMI > 40 , chronic pulmonary disease based on the spirometric classification defined as FEV₁/FVC under 0.7, history of bronchial asthma, smoking, New York Heart Association class III or IV heart failure, unstable angina, valvular heart disease, life-threatening arrhythmia, atrial fibrillation, left bundle branch block, uncontrolled hypertension, renal disease, and neuromuscular conditions.

All subjects were asked to abstain from caffeinated beverages and to come to the Sleep Clinic at 8:00 AM for a physical examination by a staff cardiologist prior to assessment from the following: the Epworth sleepiness scale (ESS), a 12-lead ECG, spirometry, a symptom-limited maximum cardiorespiratory exercise study (CPET) on a treadmill, and an echocardiogram. The study was approved by UNIFESP's Ethics Committee, and all subjects signed an informed consent form.

2.2. Polysomnography

Overnight polysomnography was performed using an EMBLA digital system[®] (17 channels, Medicare Medical Devices). The following variables were monitored: electroencephalogram (EEG) (four channels: C3-A2, C4-A1, O1-A2, and O2-A1), electrooculogram (two channels: LOC-A2 and ROC-A1), electromyogram (two channels: submental and anterior tibialis muscles), electrocardiogram (one channel), snoring, and body position. Airflow was monitored using a thermocouple and pressure transducer. Chest and abdominal piezosensors monitored respiratory effort. Arterial oxygen saturation (SaO₂) and pulse were recorded with a pulse

oximeter (Nonin[®], model 9500, Plymouth, USA). All polysomnograms were performed and scored by an experienced sleep technician following guidelines for sleep studies [15] and reviewed by a sleep medicine physician. Arousals were defined using criteria from the Sleep Disorders Atlas Task Force of the American Sleep Disorders Association [16], and respiratory events were rated using the American Academy of Sleep Medicine Task Force criteria [17]. An apnea was defined as a decrease in airflow of at least 80% for 10 s or more, and hypopnea was defined as a decrease in airflow of at least 50% for 10 s or more. An apnea–hypopnea index (AHI) > 5 was considered diagnostic for OSA.

2.3. Spirometry

Lung function testing was performed with a computerized spirometer, i.e., a KoKo spirometer[®] (Pulmonary Data Service Instrumentation, Inc., Louisville, KY, USA), following the procedures recommended by the American Thoracic Society [18] to exclude pulmonary disease. The lung function system was calibrated with a 3 L syringe at different flow rates at least once daily. All spirometric measurements were performed in a sitting position. Forced expiratory volume in 1 s (FEV₁), forced vital capacity (FVC), and FEV₁/FVC ratio were measured in each subject, recorded in absolute values and percent predicted. All measurements were performed by technicians experienced in lung function testing. Bronchodilators were not administered during the spirometry.

2.4. Cardiopulmonary exercise test

All patients fasted for two hours before the cardiopulmonary exercise test (CPET). Subjects underwent a maximum, symptom-limited CPET on a treadmill (ErgoPC13, Micromed[®], Brasilia, Brazil) in a quiet air-conditioned room with an average temperature of 21 °C and full resuscitation facilities. During the tests, subjects were monitored with a 12-lead ECG by pulse oximetry (Nonin[®], model 9500, Plymouth, USA), a non-invasive brachial artery blood pressure sphygmomanometer and breath-by-breath measurement of respiratory parameters: oxygen consumption (VO₂), carbon dioxide production (VCO₂), minute ventilation (VE), respiratory rate (RR), and tidal volume (V_T) through a mask (Vista CPX[®], Vacumed, Ventura, CA, USA). After calibration, CPET was performed on a treadmill with a ramp protocol taking into account age and sex of the subject [19]. Each test was supervised by an experienced cardiologist, nurse, and physiotherapist.

Arterial blood pressure was measured at baseline, every 3 min during exercise and at 1, 2, 4, and 6 min during recovery. Modified Borg scales were obtained at rest and at peak exercise for dyspnea and leg fatigue [20].

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