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Weight loss reduces dyspnea on exertion in obese women☆

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ABSTRACT

During submaximal exercise, some otherwise healthy obese women experience breathlessness, or dyspnea on exertion (+DOE), while others have mild or no DOE (−DOE). We investigated whether weight loss could reduce DOE. Twenty nine obese women were grouped based on their Ratings of Perceived Breathlessness (RPB) during constant load 60 W cycling: +DOE ($n = 14$, RPB ≥ 4, 34 ± 8 years, and 36 ± 3 kg/m^2) and −DOE ($n = 15$, RPB ≤ 2, 32 ± 8 years, and 36 ± 4 kg/m^2) and then completed a 12-week weight loss program. Both groups lost a moderate amount of weight (+DOE: 6.6 ± 2.4 kg, −DOE: 8.4 ± 3.5 kg, and $p < 0.001$). RPB decreased significantly in the +DOE group (from 4.7 ± 1.1 to 3.1 ± 1.6) and remained low in the −DOE (from 1.5 ± 0.7 to 1.6 ± 1.1) (interaction $p < 0.002$). Most physiological variables measured (i.e. body composition, fat distribution, pulmonary function, oxygen cost of breathing, and cardiorespiratory measures) improved with weight loss; however, the decrease in RPB was not correlated with any of these variables ($p > 0.05$). In conclusion, moderate weight loss was effective in reducing breathlessness on exertion in obese women who experienced DOE at baseline.

1. Introduction

The prevalence of obesity has increased dramatically over the past several decades. Currently, 33% of adults are classified as overweight and another 35% as obese in the United States (Ogden et al., 2014). Obesity is a complex multifactorial condition and is associated with a myriad of medical problems, such as type 2 diabetes, hypertension, stroke and heart attacks, sleep disordered breathing, and respiratory disorders (Azagury and Lautz, 2011; Kenchaiah et al., 2002; Van Gaal et al., 2006).

Dyspnea on exertion (DOE) is also a very common symptom in obesity (Gibson, 2000; O'Donnell et al., 2010; Sin et al., 2002) and a major barrier in the management of obesity. We have repeatedly found approximately one-third of otherwise healthy obese women and men to experience an elevated intensity of dyspnea during submaximal constant load cycling exercise at 60 W or 105 W, respectively (or <4 METs) (Babb et al., 2008a; Bernhardt and Babb, 2014; Bernhardt et al., 2013b). DOE and breathing discomfort may discourage obese individuals from being physically active.

It is unknown if weight loss alone (i.e. without aerobic exercise training) could decrease DOE in otherwise healthy obese women. This is a clinically important question as the American College of Sports Medicine, the National Institutes of Health, and other agencies recommend a combination of diet and aerobic exercise training for weight loss (Clinical guidelines, 1998; Donnelly et al., 2009). Additionally, the mechanism by which weight loss may improve DOE is also unclear; several factors could be involved, such as a decreased oxygen cost of breathing (Babb et al., 2008a), more efficient breathing mechanics and/or breathing pattern (Babb et al., 2002, 2008b), changes in body composition and fat distribution (Babb et al., 2008b), and changes is cardiorespiratory measures and/or exercise capacity (Babb et al., 2008a; Bernhardt and Babb, 2014).

The objectives of this study were to investigate (1) whether weight loss via a 12-week diet and resistance exercise program could reduce DOE in obese women who experienced DOE at baseline and (2) whether changes in body composition, fat distribution, pulmonary function, oxygen cost of breathing, and/or cardiorespiratory measures were associated with the potential reduction in DOE. We hypothesized that weight loss would decrease RPB, i.e. improve exertional dyspnea, during submaximal exercise in those obese women who experienced DOE before entering the weight loss program compared with those obese women who had no or only mild DOE at baseline. Furthermore, we hypothesized that changes in body composition, fat distribution, pulmonary function, oxygen cost of breathing, and/or cardiorespiratory measures

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during exercise, which could improve with weight loss, would be significantly associated with the decrease in RPB following weight loss.

2. Methods

2.1. Subjects

Twenty-nine obese women were initially identified based on BMI ($\geq$30 $\leq$ 50 kg/m^2), which was confirmed by underwater weighing (body fat $\geq$30 $\leq$55%). Exclusion criteria included history of smoking, asthma, cardiovascular disease, sleep disorders, or musculoskeletal abnormalities that would preclude maximal exercise. Subjects participating in regular vigorous exercise (exercise more than 2×/wk) during the last 6 months were also excluded. Written informed consent was obtained before participation in accordance with the University of Texas Southwestern IRB (STU122010-108).

The present study was designed as a pre–post intervention experiment. Some pre-intervention data have been previously published in manuscript (Bernhardt and Babb, 2014) and abstract form (Bassett et al., 2013; Bernhardt et al., 2013a, 2014; Moran et al., 2013; Pineda et al., 2013).

Participants underwent the same testing procedures before and after a 12-week weight loss program. Testing was performed on four separate visits each before and after the intervention.

2.2. Body composition and pulmonary function (Visit 1)

Standard measures of height and weight were taken. Circumference measurements were taken at the neck, chest, waist, and hips according to NHANES III guidelines (Plan and Operation of the Third National Health and Nutrition Examination Survey, 1994). Hydrostatic weighing was performed as previously described to determine percent body fat, lean body mass, and total body fat mass (Babb et al., 2008a, 2008b). Standard pulmonary function testing including spirometry, lung volume, and diffusing capacity was performed according to ATS/ERS guidelines (model V62W body plethysmograph, SensorMedics) (American Thoracic Society, 1995).

2.3. Cycling exercise testing (Visit 2)

2.3.1. Submaximal constant load exercise

Before the exercise test, participants were given the following written instructions for Rating of Perceived Breathlessness (RPB): "The number 0 represents no breathlessness. The number 10 represents the strongest or greatest breathlessness that you have ever experienced. Each minute during the exercise test you will be asked to point to a number, which represents your perceived level of breathlessness at the time." Exercise testing began with subjects seated on an electronically braked cycle ergometer (Lode Corival) with 3 min of resting baseline measurements after which a 6-min constant load exercise cycling test at 60 W was initiated. This exercise work rate was chosen based on prior studies on obese women who obtained ventilatory threshold at approximately 60 W (DeLorey et al., 2005) and has been used previously to establish obese women with strong (i.e. +DOE) or no to mild DOE (i.e. −DOE) (Babb et al., 2008a; Bernhardt et al., 2013b). RPB was collected using the modified Borg scale (Borg, 1982) every 2 min of the test and the last value recorded was used for analysis. Cardiorespiratory responses, including heart rate (HR), blood pressure (SunTech Tango), ventilation ($\dot{V}_E$), and gas exchange ($\dot{V}O_2$ and $\dot{V}CO_2$), were measured at rest and throughout exercise (custom software, DUFIS).

2.3.2. Peak cardiovascular exercise capacity

Peak exercise capacity was determined by graded cycle ergometry to volitional exhaustion or pedal rate $\leq$50 rpm. After resting baseline measurements, subjects started pedaling at 60–65 rpm with an initial work rate of 20 W. Work rate was increased by 20 W each minute until termination of the test; maximal effort was evidenced by achieving predicted peak heart rate >90%, [lactate] >7 mmol/L, and respiratory exchange rate >1.1.

2.4. Oxygen cost of breathing (Visit 3)

The oxygen cost of breathing was determined from 6-min measurements of $\dot{V}O_2$ and $\dot{V}_E$ at rest and 4-min measurements of $\dot{V}O_2$ and $\dot{V}_E$ during eucapnic voluntary hyperpnea at 40 L/min and 60 L/min as previously described (Babb et al., 2008a). The oxygen cost of breathing was assessed by calculating the slope of the $\dot{V}O_2$ (ml/min) vs $\dot{V}_E$ (L/min) relationship at rest and during the two levels of hyperpnea. Linearity of the slope was checked for each subject (r^2 range 0.91–1.00).

2.5. Body fat distribution (Visit 4)

Multiple T2-weighted, water-suppressed, Magnetic Resonance Images (MRI) were taken from the sternal notch to the pubic symphysis to estimate fat distribution in the chest, abdominal, subcutaneous, visceral, and peripheral regions as previously described (Babb et al., 2008a, 2011; Bernhardt et al., 2013b). Images were analyzed using custom interactive software (Wafter 1.3).

2.6. Weight loss program

Each participant completed a 12-week weight loss program. They received a customized meal plan, weekly shopping lists, and breakdown of individual meals and snacks. Additionally, they performed specific resistance exercises under supervision of a personal trainer three times per week. Subjects performed eight resistive exercises (i.e. lifting weights) with 10 slow (i.e. concentric phase of ~10 s) repetitions each targeting all major muscle groups (i.e. upper body, lower body, and core). The resistive exercises were utilized to increase – and/or minimize the loss of – lean body mass and thus increase basal metabolic rate. Aerobic exercise was not performed, so changes after the program could be attributed to weight loss only, not improvements in cardiorespiratory fitness. Participants were encouraged to lose 1–2 lb/week.

2.7. Data analysis

The 29 obese women were assigned to one of two groups according to their RPB (0–10 Borg scale) during minute 6 of the constant load 60 W exercise test. Those with an RPB $\leq$ 2 were designated as obese women with no or mild dyspnea on exertion (−DOE, n = 15) and those with an RPB $\geq$ 4 were designated as obese women with strong dyspnea on exertion (+DOE, n = 14). Those women with an RPB = 3 were excluded from the study in order to better delineate differences between the +DOE and −DOE groups. The grouping was based on our previous findings that obese women have an average RPB of 2 ± 1 at ventilatory threshold during incremental exercise (DeLorey et al., 2005) and has been used in previous studies (Babb et al., 2008a; Bernhardt et al., 2013b).

Differences between +DOE and −DOE groups before and after the weight loss program were analyzed using a two-way ANOVA (i.e. weight loss and group) with a repeated measure on one factor (i.e. weight loss). Relationships among variables were determined with Spearman rank correlation. Data was analyzed using SAS 9.2.