

Dyspnea on exertion provokes unpleasantness and negative emotions in women with obesity



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ABSTRACT

Purpose: While dyspnea on exertion (DOE) is a common complaint in otherwise healthy obese women, less is known about feelings of unpleasantness and/or negative emotions provoked by DOE. We examined whether ratings of perceived breathlessness (RPB) during exercise were associated with ratings of unpleasantness and negative emotions (depression, anxiety, frustration, anger, and fear) in obese women.

Methods: Seventy-four women (34 ± 7 yrs, 36 ± 4 kg/m², $46 \pm 5\%$ body fat) performed 6 min of constant-load cycling (60 W); RPB (0–10 scale), and unpleasantness and negative emotions (visual analog scales, 10 cm) were assessed at the end.

Results: RPB were significantly correlated with unpleasantness and negative emotions ($p < 0.05$). The strongest correlations were between RPB and unpleasantness ($r = 0.61$, $p < 0.001$), and RPB and anxiety ($r = 0.50$, $p < 0.001$).

Conclusions: DOE can significantly provoke unpleasantness and negative emotions during exercise in obese women. This may affect their willingness to engage in regular physical activity.

1. Introduction

Dyspnea is described as “a subjective experience of breathing discomfort that consists of qualitatively distinct sensations that vary in intensity” (Parshall et al., 2012, p. 436). The symptom of dyspnea results from interactions between numerous physiological, psychological, social, and environmental factors (Parshall et al., 2012). Furthermore, dyspnea is a multidimensional symptom (Lansing et al., 2009; Laviolette et al., 2014; Parshall et al., 2012; von Leupoldt et al., 2006). It has been proposed that the symptom of dyspnea has at least two dimensions: a sensory dimension, which is the perceived intensity of the stimulus, and an affective dimension, which is composed of the unpleasantness, associated negative emotions, and the degree of distress due to the stimulus (Banzett et al., 2000, 2008; Lansing et al., 2009; von Leupoldt et al., 2006).

Dyspnea during exercise is especially common in individuals with obesity, even in the absence of signs and symptoms of disease (Gibson, 2000). Approximately 36% of obese adults in a large sample ($n = 16,692$) reported dyspnea when walking up a hill (Sin et al., 2002) and 80% of obese adults experienced dyspnea after climbing two flights

of stairs compared to 16% of non-obese subjects (Sjostrom et al., 1992). We have previously reported that 37–44% of healthy obese men and women experience dyspnea on exertion (DOE) during constant-load cycle exercise (Babb et al., 2008a; Bernhardt and Babb, 2014a; Bernhardt et al., 2014, 2013). The underlying mechanisms of the increased perception of DOE remain unclear since physiological variables such as body fat percentage, fat distribution, lung function, and gas exchange parameters were not significantly different between obese adults with and without DOE (Babb et al., 2008a; Bernhardt and Babb, 2014b; Bernhardt et al., 2016, 2013).

Previous studies by us and others have focused on the sensory dimension of DOE in obese individuals (Babb et al., 2008a; Bernhardt and Babb, 2014a; Bernhardt et al., 2014, 2013; Sin et al., 2002; Sjostrom et al., 1992). It is unknown how the affective dimension of DOE is perceived in healthy young obese women. This is important to study because unpleasantness and negative emotions experienced with DOE could influence decisions to engage in regular exercise, which could be counterproductive for weight management (Ekkekakis et al., 2016).

The purpose of this study was to investigate the relationship(s) between DOE (ratings of perceived breathlessness, RPB) and

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unpleasantness and negative emotions (i.e., depression, anxiety, frustration, anger, and fear) during submaximal constant load exercise. Additionally, we also investigated potential relationship(s) between relative exercise intensity (i.e., %VO_{2peak}, % of peak HR, and lactate concentration), and unpleasantness and negative emotions. Lastly we compared unpleasantness and negative emotions between obese women with DOE and obese women without DOE.

2. Methods

2.1. Study design

Volunteers participated in a larger interventional study that investigated the effects of 12 weeks of aerobic exercise training on respiratory function, exertional dyspnea, and exercise tolerance in obese women 20–45 years old (Bernhardt and Babb, 2014a, b). The data presented in this paper are the result of a secondary analysis of pre-intervention data. The analysis of these data was done in two parts.

Seventy-four (n = 74) obese women were initially screened based on BMI of ≥ 30 but ≤ 50 kg/m² (Part I). Their obesity was confirmed by underwater weighing ($30 \leq$ body fat $\leq 55\%$). They were self-reported as healthy with no musculoskeletal abnormalities that would preclude cycling on a stationary cycle ergometer. They reported no participation in regular vigorous conditioning exercise in the last 6 months. They were not currently enrolled in any type of weight loss program. Prior to participation, informed consent was obtained in accordance with the University of Texas Southwestern Institutional Review Board (STU122010–108). The participants visited the laboratory on two separate days. During day 1, subject characteristics, body composition (i.e., hydrostatic weighing), and pulmonary function data were collected. During day 2, RPB (i.e., sensory dimension of DOE) was assessed during submaximal (60 W) constant-load cycling exercise and affective dimensions of breathlessness were measured immediately after the exercise.

The obese women were then assigned to groups according to their RPB (0–10 Borg scale) obtained during the submaximal constant-load cycle test. Those with an RPB ≤ 2 were assigned to the *none-to-mild* dyspnea on exertion group (-DOE) and those with an RPB ≥ 4 were assigned to the *strong* dyspnea on exertion group (+DOE). Those with an RPB = 3 (“moderate”) were excluded from additional testing in order to better delineate the + DOE and -DOE groups. The remaining subjects performed an incremental exercise test to exhaustion. Three subjects were excluded after the constant load exercise test, therefore, they did not complete the peak exercise test (n = 1 for exaggerated heart rate response and n = 2 for RPB ≥ 4 , because we had met our recruitment goals for the + DOE group). All subjects who had complete peak exercise data were included in the Part II analysis (n = 52; -DOE n = 24 and + DOE n = 28).

2.2. Subject characteristics, body composition, and pulmonary function

Measurements of height, weight, and circumference measurements (neck, chest, waist, hip) were performed according to the NHANES III guidelines (National Center for Health Statistics, 1994). Body composition (i.e., %body fat, lean body mass, and fat mass) was determined by hydrostatic (underwater) weighing as described previously (Babb et al., 2008a, b). Subjects completed standard spirometry, lung volume, and diffusion capacity tests (SensorMedics, Yorba Linda, CA; model 6200 body plethysmograph) according to American Thoracic Society guidelines (American Thoracic Society, 1995). The predicted values for spirometry, lung volume, and diffusion capacity were based on NHANES (Hankinson et al., 1999), Goldman and Becklake (Goldman and Becklake, 1959), and Burrows and colleagues (Burrows et al., 1961), respectively.

2.3. Measurement of DOE during submaximal cycling exercise at 60 W

During day 2, participants were given detailed written instructions for rating the intensity of perceived breathlessness (RPB) on the 0–10 Borg scale with verbal expressions of severity anchored (i.e., 0 is classified as “nothing at all” and 10 is classified as “very very strong (almost max)”) (Borg, 1982). Exercise testing began with subjects seated upright on an electronically braked cycle ergometer (Lode Corival, Lode B.V., The Netherlands) while resting measurements were obtained. This was followed by a 6-minute constant-load exercise cycling test at 60 W. RPB were collected every 2 min and the last value recorded was used for analysis. Blood lactate was collected during the last minute of cycling.

After the exercise, subjects were seated on a chair and were immediately asked to complete a questionnaire rating their unpleasantness of DOE and the negative emotions that accompanied their breathlessness. The questionnaire consisted of 6 visual analog scales (100 mm lines ranging from “none” to “maximal imaginable”). The subjects were asked to rate the level of unpleasantness, depression, anxiety, frustration, anger, and fear (adapted from Wade et al., 1996).

2.4. Incremental exercise test to exhaustion

Those subjects with an RPB ≤ 2 or ≥ 4 during the previous 60 W cycling test performed an incremental cycling test to voluntary exhaustion, starting at 20 W and increasing by 20 W each minute. Cardiorespiratory responses, including heart rate (HR), blood pressure (BP), minute ventilation (\dot{V}_E), and gas exchange (VO₂ and $\dot{V}CO_2$) were measured at rest and throughout exercise. Peak exercise was confirmed by heart rate of 90% of predicted, blood lactate concentration ≥ 7 mmol/L, and respiratory exchange ratio > 1.1 .

2.5. Data analysis

Data were analyzed in two parts. In Part I, obese women who completed demographics, the 6 min constant load exercise test, and subsequent VAS measurements were studied to investigate the relationships between RPB, and unpleasantness and negative emotions. Differences between the -DOE, RPB = 3, and + DOE groups were tested using analysis of variance (ANOVA). Post hoc comparisons were made by Bonferroni (Dunn) test.

In Part II, obese women who completed the peak exercise test on Visit 2 comprised the sample for this analysis, which included investigation of potential relationship(s) between relative exercise intensity (i.e., %VO_{2peak}, % of peak HR, and lactate concentration), and unpleasantness and negative emotions.

Statistical Analysis System (SAS, version 9.3; 2011) was used for data analysis. All P values were calculated assuming two-sided alternate hypothesis; $p < 0.05$ was considered statistically significant. Q-Q plots as well as measures of skewness and kurtosis were used to test for normal distribution of the outcome variables. Main outcome variables were RPB, visual analog scales for unpleasantness, anxiety, depression, frustration, anger, and fear, and cardiorespiratory variables during exercise VO_{2peak}, %VO_{2peak}, VO_{2peak} as % predicted, %HRpeak, and lactate concentration. Pearson correlations were used to examine relationships between outcome variables (i.e. RPB, VAS measures, and cardiorespiratory measures).

3. Results

3.1. Subject characteristics, body composition, and pulmonary function

Subject characteristics, body fat measurements, and pulmonary function measurements are shown in Table 1. Of all the data for subject characteristics, body composition, and pulmonary function, only age was greater in + DOE women than in the RPB = 3 women ($p < 0.05$).

Table 1
Subject Characteristics, Body Composition, and Pulmonary Function.

Variable	All Subjects n = 74	-DOE n = 24	RPB = 3 n = 19	+DOE n = 31
Age, years	34 ± 7	32 ± 5	31 ± 8	36 ± 7 [*]
Height, cm	163.1 ± 6.8	164.4 ± 6.3	163.8 ± 7.0	161.6 ± 7.0
Weight, kg	95.0 ± 15	96.8 ± 15.3	97.0 ± 19.2	92.4 ± 12.3
Chest circumference, cm	104.0 ± 10.7	103.2 ± 10.1	104.4 ± 10.7	104.4 ± 11.6
Waist circumference, cm	105.3 ± 11.5	105.7 ± 13.1	106.7 ± 12.3	104.2 ± 9.7
Hip circumference, cm	118.7 ± 11.0	119.9 ± 10.8	118.4 ± 12.4	118.0 ± 10.5
Waist to hip ratio	0.89 ± 0.08	0.88 ± 0.09	0.90 ± 0.08	0.88 ± 0.06
BMI, kg/m ²	35.6 ± 4.4	35.7 ± 4.5	35.9 ± 4.9	35.4 ± 4.2
Body Fat, %	45.8 ± 4.8	46.6 ± 4.2	45.6 ± 4.5	45.3 ± 5.5
Fat weight, kg	43.7 ± 10.1	45.0 ± 9.7	44.9 ± 12.5	41.9 ± 8.8
Lean body mass, kg	51.0 ± 6.9	51.0 ± 6.9	52.2 ± 7.4	50.2 ± 6.6
FVC, % predicted	104.9 ± 12.6	106.0 ± 12.4	103.4 ± 13.0	105.0 ± 12.8
FEV ₁ , % predicted	101.4 ± 13.1	101.2 ± 11.6	98.2 ± 15.0	103.5 ± 13.0
FEV ₁ /FVC	82.4 ± 5.0	81.5 ± 5.0	80.9 ± 6.2	84.1 ± 3.8
PEF, % predicted	104.9 ± 14.1	102.5 ± 13.2	103.1 ± 14.7	107.8 ± 14.3
MVV, % predicted	104.7 ± 16.7	104.6 ± 15.3	101.8 ± 20.9	106.6 ± 14.8
TLC, % predicted	98.0 ± 9.4	99.1 ± 8.9	96.9 ± 10.2	97.9 ± 9.6
FRC, % predicted	87.7 ± 17.4	87.7 ± 18.0	91.2 ± 18.9	85.7 ± 16.3
RV, % predicted	68.4 ± 13.3	69.8 ± 15.7	66.6 ± 14.6	68.5 ± 10.5
DLCO, % predicted	80.2 ± 10.3	80.3 ± 11.3	80.8 ± 9.5	79.8 ± 10.4

Data are presented as mean ± SD. BMI = Body mass index; FVC = forced vital capacity; FEV₁ = forced expiratory volume in the first second; PEF = peak expiratory flow; MVV = maximal voluntary ventilation; TLC = total lung capacity; FRC = functional residual capacity; RV = residual volume; DLCO = diffusion capacity of the lung for carbon monoxide; *P < 0.05.

All pulmonary function measurements were within normal limits.

3.2. Part I - relationships between RPB, and unpleasantness and negative emotions

During minute 6 of constant load cycling, 31 women (42%) rated RPB ≥ 4 compared with 24 women (32%) who rated RPB ≤ 2, and 19 women (26%) who rated RPB = 3 (see characteristics of participants by group in Table 1). Fifty-four women (74%) rated 0 for depression (0.30 ± 0.85; mean ± SD for women who did not rate zero), 26 (35%) rated 0 for anxiety (1.61 ± 2.35), 42 (56%) rated 0 for frustration (0.96 ± 2.10), 56 (75%) rated 0 for anger (0.47 ± 1.73), and 50 (67%) rated 0 for fear (0.69 ± 1.78). Only 7 (9%) rated unpleasantness as a 0 (2.50 ± 2.30).

Unpleasantness was significantly greater in the +DOE women (3.9 ± 2.3) than in the RPB = 3 (1.6 ± 1.3) and -DOE (1.4 ± 2.0) women (p < 0.001) (Fig. 1). Ratings of depression, frustration, and anger were not significantly different among the groups. But ratings of anxiety (2.8 ± 3 vs 0.72 ± 1.2 and 0.86 ± 1.3, respectively) and fear (1.3 ± 2.5 vs 0.04 ± 0.2 and 0.4 ± 1.0, respectively) were significantly higher (p < 0.05) in the +DOE group compared with RPB = 3 and -DOE.

Fig. 2 shows the correlations between RPB and the affective

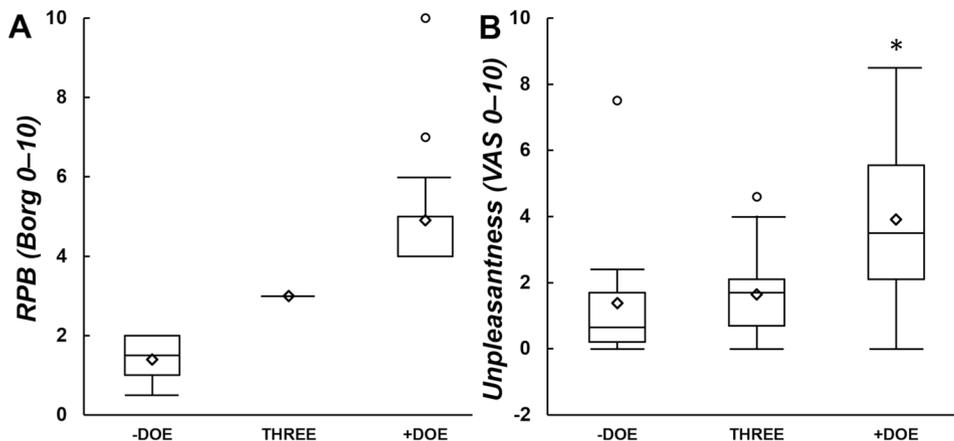


Fig. 1. Box plots showing ratings of perceived breathlessness (Panel A) and unpleasantness from a visual analog scale (VAS- Panel B) in +DOE, -DOE, and RPB = 3 groups from the 6 min constant load cycling test at 60 W. ○ Indicates outlier data points. ◇ Indicates mean. * Unpleasantness was significantly higher in +DOE. n = 74.

dimension of breathlessness. There was a moderate positive significant correlation between RPB and unpleasantness (r = 0.61; p < 0.0001) and RPB and anxiety (r = 0.50; p < 0.0001). There were also weak positive significant correlations between RPB and depression (r = 0.23; p = 0.0453), frustration (r = 0.30; p = 0.0082), as well as fear (r = 0.29; p = 0.0097). However, there was no association between RPB and anger (r = 0.01; p = 0.91).

3.3. Part II - relationships between unpleasantness and relative intensity of exercise, and negative emotions and relative intensity of exercise

There was a significant relationship between unpleasantness and %V̇O_{2peak}, r = 0.28 as well as %HR_{peak}, r = 0.39. Anxiety was also found to be correlated with %HR_{peak}, r = 0.28 (p < 0.05) (Table 2).

4. Discussion

The major finding of this study was that DOE can provoke significant levels of unpleasantness and negative emotions during constant load exercise in obese women. While these negative feelings are moderately related to RPB, they are only weakly related to relative exercise intensity. Thus, measurements of affective aspects of DOE are important

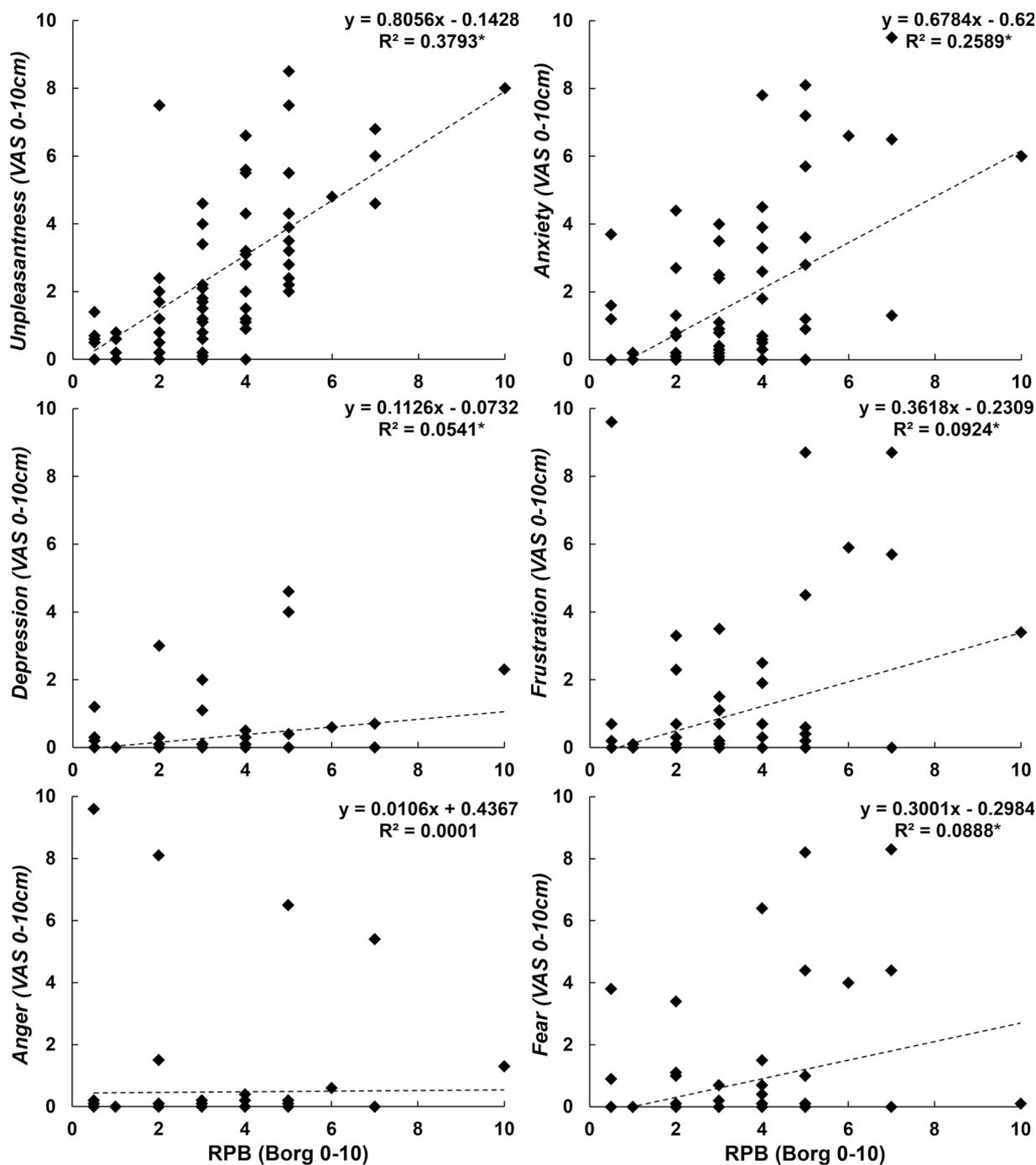


Fig. 2. Relationships between rating of perceived breathlessness (RPB) during exercise and affective dimensions of breathlessness including unpleasantness and negative emotions (n = 74). * $p < 0.05$.

to obtain in obese adults since the negative feelings provoked by DOE may not be reflected by RPB or exercise intensity. Also, the prevalence of DOE (RPB ≥ 4) during constant load cycling was 42%, which confirms that DOE is a common symptom experienced by healthy obese young women as found in previous studies (Babb et al., 2008a; Bernhardt and Babb, 2014a; Bernhardt et al., 2013; Sin et al., 2002).

The results of this study demonstrate that there is a moderate but significant relationship between RPB and unpleasantness, as well as RPB and negative emotions related to DOE (i.e., anxiety). RPB accounts for 37% and 25% of the variability in unpleasantness and negative emotions, respectively. There is also a significant relationship with the other negative emotions (i.e. frustration, fear, and depression) and their smaller correlation coefficients can be related to the limited variability

that exists in the subjects' responses. The finding that there is a link between DOE and negative emotions during exercise is similar to previously reported findings in patients with COPD (von Leupoldt et al., 2010) and children with asthma (Rietveld and Prins, 1998). In healthy volunteers, similar findings have been established using inspiratory resistive loads, which can be used to induce dyspnea in the laboratory by increasing the work and effort of breathing (von Leupoldt et al., 2006).

As such, knowing the intensity of DOE cannot tell us how unpleasant the DOE is or if people have other negative feelings associated with it. Therefore, it is necessary to include in assessments of dyspnea, the perception of the unpleasantness, and negative emotions associated with the symptom of DOE. This is congruent with the proposition by

Table 2

Relationships between unpleasantness and negative emotions, and parameters for relative intensity of exercise and cardiorespiratory fitness (n = 52).

Unpleasantness and Negative Emotions	Mean ± SD	%VO ₂ peak	%HRpeak	6 min Lactate	VO ₂ peak % predicted
Unpleasantness	2.8 ± 2.5	<i>r</i> = 0.28 * <i>p</i> = 0.04	<i>r</i> = 0.39 * <i>p</i> = 0.004	<i>r</i> = 0.23 <i>p</i> = 0.10	<i>r</i> = - 0.21 <i>p</i> = 0.14
Depression	0.33 ± 0.94	<i>r</i> = 0.0003 <i>p</i> = 1.00	<i>r</i> = - 0.03 <i>p</i> = 0.85	<i>r</i> = - 0.12 <i>p</i> = 0.41	<i>r</i> = - 0.17 <i>p</i> = 0.22
Anxiety	1.87 ± 2.58	<i>r</i> = 0.12 <i>p</i> = 0.40	<i>r</i> = 0.28 * <i>p</i> = 0.04	<i>r</i> = 0.19 <i>p</i> = 0.16	<i>r</i> = 0.04 <i>p</i> = 0.77
Frustration	1.14 ± 2.35	<i>r</i> = 0.09 <i>p</i> = 0.53	<i>r</i> = 0.20 <i>p</i> = 0.17	<i>r</i> = 0.07 <i>p</i> = 0.60	<i>r</i> = 0.02 <i>p</i> = 0.86
Anger	0.62 ± 1.98	<i>r</i> = - 0.01 <i>p</i> = 0.94	<i>r</i> = - 0.02 <i>p</i> = 0.86	<i>r</i> = - 0.11 <i>p</i> = 0.43	<i>r</i> = 0.008 <i>p</i> = 0.95
Fear	0.91 ± 2.01	<i>r</i> = 0.07 <i>p</i> = 0.62	<i>r</i> = 0.24 <i>p</i> = 0.08	<i>r</i> = 0.05 <i>p</i> = 0.72	<i>r</i> = 0.03 <i>p</i> = 0.83

Data are presented as mean ± SD. VO₂ = oxygen uptake; %VO₂peak = 6 min test VO₂ as a percentage of the peak VO₂; %HRpeak = 6 min test heart rate as a percentage of peak heart rate; 6 min lactate = lactate taken during the last minute of the constant load exercise test; VO₂peak % predicted = VO₂peak as a percentage of predicted (indicative of cardiorespiratory fitness); * *p* < 0.05.

several researchers that dyspnea is a multidimensional symptom that has at least two dimensions, the sensory and affective dimensions (Lansing et al., 2009; Laviolette et al., 2014; Parshall et al., 2012; von Leupoldt et al., 2006). Furthermore, it has been suggested that affective unpleasantness can motivate patients to seek appropriate medical attention or medication use or in some cases patients may decrease physical activity or delay treatment (Banzett et al., 2000; Lansing et al., 2009; von Leupoldt et al., 2006).

There was also a significant, but weak, relationship between the negative emotion of unpleasantness and %VO₂max and %HRmax and the negative emotion of anxiety with %HRmax. This agrees with our earlier findings where submaximal and maximal exercise variables were not strongly associated with DOE in healthy obese individuals (Babb et al., 2002, 2008a; Lorenzo and Babb, 2012). To our knowledge, no one has demonstrated an association between relative intensity of exercise and DOE; these findings could be interpreted to suggest that feelings of anxiety and unpleasantness act as mediators of the relationship between the intensity of exercise and DOE in certain individuals. Nevertheless, the relative intensity of exercise explained less than 16% of the variance in scores of unpleasantness and anxiety, suggesting that factors other than relative exercise intensity may play a role in provoking negative emotions during exercise. Physiologically, it has been proposed that respiratory sensations are regulated by neural gating systems that control information flow to the cerebral cortex (Banzett et al., 2000; Davenport and Vovk, 2009; Gerlach et al., 2013; Lansing et al., 2009). The first gating system is activated when the sensation of dyspnea is perceived and regulates afferent impulses coming to the brain from the periphery as well as efferent outputs via the phrenic and thoracic spinal nerves to the diaphragm and intercostal muscles. This gating process is referred to as “discriminative processing” and takes place in the brainstem where afferent input from the periphery first enters the central nervous system (Davenport and Vovk, 2009; Gerlach et al., 2013; Mahler and O’Donnell, 2014). A second gating system, known as “affective processing” (Davenport and Vovk, 2009; Mahler and O’Donnell, 2014), is found in the limbic system that regulates how this sensory information is associated with fear or alarm and is critical for the emotional response (i.e., pleasant/unpleasant) to dyspnea based on our previous experiences/expectations. Also, some people might have negative emotions (such as unpleasantness or anxiety) with exercise that are processed and/or encoded in the limbic system and in some cases these negative emotions can be overpowering enough to have a negative behavioral response such as to prevent/avoid engaging in an exercise routine (Gerlach et al., 2013). Therefore, we suggest that interventions to halt these feelings should concentrate in the affective dimension as well and not only in improving exercise fitness parameters.

4.1. Summary

In summary, DOE can provoke significant levels of unpleasantness

and negative emotions in obese women during submaximal exercise. Because negative feelings are only moderately related to RPB, and weakly related to relative exercise intensity, affective aspects of DOE are important to obtain in obese adults. As such, measurements of only the intensity of DOE could miss significant negative feelings associated with exertion. Therefore, assessment of the both sensory and affective dimensions of DOE is highly recommended in obese adults.

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