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Original Research Article

Effect of changes in mood on exertional dyspnea in healthy subjects

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Abstract

Background: This study examines the impact of different mood states on exertional dyspnea during standard exercise stress test in healthy subjects.

Methodology: 25 healthy subjects went through standard cycle ergometer exercise test on three separate days. On each day, subjects viewed randomly assigned images designed to induce positive, negative, or neutral mood states. For each condition, at minute intervals, subjects rated dyspnea (sensory and affective domains) in the first test and mood (valence and arousal domains) in the second test. Respiratory rate and heart rate were measured throughout the exercise.

Results: In comparison to negative mood state, there was significant decrease in dyspnea [3.2(2.0-3.9) vs. 4.6(4.2-5.4)], botherness to dyspnea [3.2(2.2-3.8) vs. 4.6(4.0-5.8)], respiratory rate [29.0(26.3-31.6) vs. 32.2(29.7-35.3) cycles/min] and heart rate [114(102.7-138.7) vs. 123(109.9-144.3) beats/min] in positive mood state. Likewise, in comparison to neutral mood state, there was significant increase in dyspnea [4.6(4.2-5.4) vs. 3.4(3.0-3.8)], botherness to dyspnea [4.6(4.0-5.8) vs. 3.6(2.8-4.2)], respiratory rate [32.2(29.7-35.3) vs. 28.4(26.6-31.2) cycles/min] and heart rate [116.4 (105.4-128.4) vs. 123(109.9-144.3) beats/min] in negative mood state.

Conclusion: The result suggests that negative mood state increase and positive mood state decrease perceived dyspnea. These findings can have profound impact via psychotherapeutic interventions on patients of cardiorespiratory diseases to reduce dyspnea.

Keywords: Dyspnea, Mood states, cycle ergometer exercise, cardiorespiratory diseases, psychotherapeutic interventions

1.Introduction

The American Thoracic Society defines dyspnea as ‘‘a subjective experience of breathing discomfort that consists of qualitatively distinct sensations that vary in intensity’ [1]. Dyspnea on exertion is considered normal in healthy subjects during high to severe exercise intensity, but it is indicative of a clinical problem when it occurs at a level of activity that would not cause any difficulty for a healthy individual. Clinically, dyspnea is commonly reported and is considered to be the cardinal symptom of a range of cardiorespiratory diseases, principally Chronic Obstructive Pulmonary Disease (COPD) and Congestive Heart Failure (CHF) [2].

Despite decades of research into dyspnea, it has been difficult to elucidate the neurophysiological mechanisms that give rise to its sensory perception [3]. As a subjective experience, dyspnea can only be reported by an awake individual meaning that controlled and invasive studies in animal models are not feasible options for its study. Partly because of our limited understanding of how dyspnea arises, there has been little progress in developing pharmacological therapies to enable better symptom management in conditions where little can be done to treat the underlying cause. This contrasts with the situation for pain management where effective analgesics, with well-defined mechanistic targets, are widely available [4]. As a consequence, our understanding of the neural basis of this important symptom is limited. In recent years, neuroimaging studies during experimentally-induced dyspnea in conscious subjects have implicated the involvement of the limbic system in this perception [5, 6] but at this stage relatively poor discrimination of these techniques makes interpretation difficult.

Therefore, the present study examined the specific impact of positive, neutral, and negative mood states on the distinct dimensions of exertional dyspnea to improve our understanding of dyspnea and emotion relation that determine perception of dyspnea in conscious human subjects.

2. Materials and Methods

2.1 Subjects

25healthy male volunteers of age ranging from 18-30 years with informed consents were studied in the exercise physiology lab, department of basic and clinical physiology, B.P. Koirala Institute of Health Sciences, Dharan, Nepal.

2.2 Study protocol:

2.2.1 Experimentally induced changes in mood

The study involved cycle ergometer for standard exercise stress test. The standard exercise stress test was performed with parallel viewing of International Affective Picture System (IAPS) [7] pictures displayed on a monitor in front of the cycle ergometer to induce change in mood of the subject. IAPS comprises about 1200 pictures each with a quantitative rating of its effect on the mood and categorized into positive, negative or neutral pictures. We selected 31 pictures each for positive, neutral and negative mood condition. Each picture in a set was displayed for 6 seconds followed by 3 second interval before the next picture. Thus, 31 pictures showing took 5 min which included assessment of dyspnea and mood state.

2.2.2 Assessment of Dyspnea

At regular intervals of 1 minute during the cycle ergometer exercise test, the participants were asked to rate the prevailing level of exertional dyspnea in both sensory (intensity of dyspnea) and affective domains (botherness / unpleasantness of dyspnea). For this, a numeric scale was displayed on a monitor in front of the cycle ergometer and subjects used a mouse to select a number between 0 and 10 which represented the intensity of their perceived dyspnea. If subject felt no shortness of breath, he/she would rate 0 and if the shortness of breath was so intense that the subject had to stop exercising, he/she would rate 10. The numbers in between was used to indicate how strong shortness of breath was relative to those extremes. Immediately after numeric scale for measuring intensity of dyspnea, a second 0 to 10 scale was replaced for rating unpleasantness of dyspnea where 0 meant shortness of breath was not bothering subject at all while 10 meant that shortness of breath was extremely troubling subject. Again the numbers in between was used to indicate how strong shortness of breath was bothering subject relative to those extremes.

2.2.3 Assessment of Mood

Likewise, at regular intervals of 1 minute during the cycle ergometer exercise test, the participants were asked to rate the existing mood using a nine point pictorial rating scale called Self-Assessment Mankin (SAM) [7]. Similar to dyspnea scale, two subsets of SAM were displayed for rating their existing mood states in both the domains i.e. valence (extremely happy to extremely unhappy) and arousal (extremely calm to extremely excited). The SAM scale for valence and arousal domain ranged from 1 to 9. If viewing the pictures made subject feel completely unhappy for valence and completely calm for arousal, subject was asked to indicate this by selecting the figure on the left i.e. 1. On the other hand, if viewing the picture made subject feel completely happy for valence and completely excited for arousal, subject was asked to indicate this by selecting the figure on the right i.e. 9. The other figures in between allowed the subject to indicate intermediate feelings of pleasure and arousal. If subject felt completely neutral i.e. neither happy nor unhappy for valence or neither calm nor excited for arousal, subject was asked to select the figure in the middle i.e. 5.

2.3 Experimental protocol

2.3.1 Visit 1 (Familiarization visit)

The first visit involved familiarizing the participant with the laboratory environment. Informed consent was sought and *American Heart Association*/American College of Sports Medicine (ACSM) [8] risk screening was performed. The subjects were familiarized with the methodology of viewing and attending to images while performing standard exercise stress test on cycle ergometer. They were also trained to rate their exertional dyspnea. In addition, they were familiarized with the rating of mood in the dimensions of valence and arousal as established by the IAPS protocol. Cycle ergometer was standardized at work load of 200 watt with speed of 35-40 revolutions per minute

2.3.2 Visits 2-4(Experimental visit)

During the second to fourth visits, the subjects performed two cycle ergometer exercise tests at the speed and work load as mentioned. The two tests were separated by an interval of 30 min and both tests were performed while viewing the IAPS images according to the standard protocol. Prior to undertaking exercise on each of these visits, subjects completed a 24-point Brunel Mood Scale questionnaire (BRUMS) [9, 10] to enable the assessment of any significant differences in baseline mood between the three visits. The showing of positive, negative or neutral pictures to the subjects while doing exercise was done randomly i.e. if one subject was tested with positive picture first followed by negative and neutral, the next subject could have different sequence of picture showing. Only one set of test was done in a day.

Set 1:

- Standard exercise stress test while viewing the 'positive picture' series with ratings of dyspnea and measurement of respiration rate simultaneously.
- Standard exercise stress test while viewing the 'positive picture' series with rating of mood using a standardized Self-Assessment Manikin (SAM) rating scale.

Set 2:

- Standard exercise stress test while viewing the 'neutral picture' series with ratings of dyspnea and measurement of respiration rate simultaneously.
- Standard exercise stress test while viewing the 'neutral picture' series with rating of mood using a standardized Self-Assessment Manikin (SAM) rating scale.

Set 3:

- Standard exercise stress test while viewing the 'negative picture' series with ratings of dyspnea and measurement of respiration rate simultaneously.
- Standard exercise stress test while viewing the 'negative picture' series with rating of mood using a standardized Self-Assessment Manikin (SAM) rating scale.

2.4 Physiological variables measurement

Different anthropometric and cardiorespiratory parameters like age, height, BMI, systolic and diastolic blood pressure, resting heart rate, respiratory rate and lung function were recorded.

2.5 Statistical Methods

Measurements of many variables were non-normal in distribution and thus, nonparametric tests were used for statistical analysis. Variables were compared between the different emotional picture groups and statistical significance was tested with Friedman test followed by Wilcoxon Signed Ranks test. All analysis were calculated with SPSS 16 software with value <0.05 considered significant.

3. Results

3.1 Subjects

All subjects studied had normal blood pressure and lung function. (Table 1)

Table 1: Anthropometric and cardio-respiratory variables of subjects

Variables	Mean ± SD
Age, yrs.	22.8 ± 2.7
Height, cm.	169.4 ± 3.3
Weight, kg	62.8 ± 7.2
Body mass index, kg/m^2	21.8 ± 2.0
Resting respiratory rate, cycles/min	16.9 ± 0.9
Resting heart rate, beats/min	71.6 ± 7.2
Systolic blood pressure, mmHg	113.6 ± 3.9
Diastolic blood pressure, mmHg	76.3 ± 3.3

3.2 Baseline Mood state

Prior to viewing of neutral, positive, or negative images, statistical analysis showed no significant difference in the mean group values for any of the six category domains of baseline mood state (BRUMS).

3.2.1 Emotional Ratings

As shown in the fig 1, in comparison to neutral picture series, ratings of valence in Self-Assessment Manikin (SAM) for Happy vs. Unhappy mood show significant increase in Positive Picture series [7.2(6.3-7.4) vs 5.0(5.0-5.0), p<0.01] and significant decrease in Negative picture series[3.2(2.9-3.4) vs 5.0(5.0-5.0), p<0.01]. Likewise, in comparison to neutral picture series, ratings of arousal in Self-Assessment Manikin (SAM) for feeling Calm vs. Excited show significant increase in Positive Picture series [6.4(5.9-6.8) vs 5.0(5.0-5.1), p<0.01] and significant decrease in Negative picture series[3.2(3.0-3.7) vs 5.0(5.0-5.1), p<0.01]. This conforms that the subject was in happy mood and feeling excited while viewing positive picture series, unhappy mood and feeling calm neither while viewing negative picture series and neutral mood and feeling neither calm nor excited while viewing neutral picture series.

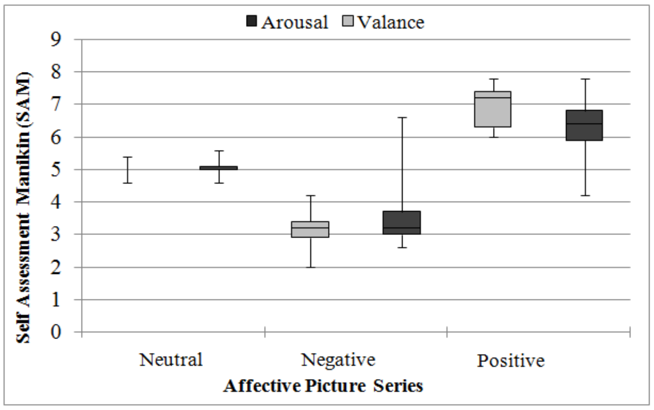

Figure 1: Median (Q1-Q3) level of comparison of ratings of mood states [Valence (Happy vs. Unhappy) and Arousal (Calm vs. Excited)] with neutral, negative and positive mood states performing cycle ergometer exercise test.

International Affective Picture System images and rated two domains of mood (valence: 1-very unpleasant, 9- very pleasant; arousal: 1 -very calm, 9-very excited).

3.2.2 Perceived Dyspnea

As shown in the figure 2, in comparison to neutral mood state, there was significant increase in shortness of breathing [4.6(4.2-5.4) vs. 3.4(3.0-3.8), p<0.05] and botherness to shortness of breathing [4.6(4.0-5.8) vs. 3.6(2.8-4.2), p<0.05] in negative mood state whereas there was no significant difference in those variables in positive mood state. Likewise, in comparison to negative mood state, there was significant decrease in shortness of breathing [3.2(2.0-3.9) vs. 4.6(4.2-5.4), p<0.05] and botherness to shortness of breathing [3.2(2.2-3.8) vs. 4.6(4.0-5.8), p<0.05] in positive mood state.

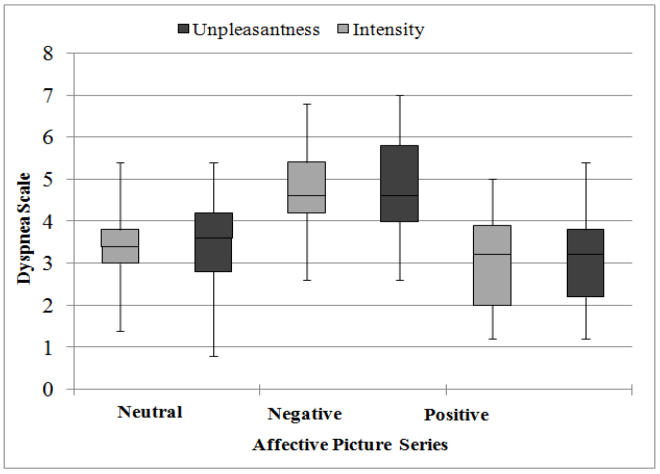

Figure 2: Median (Q1-Q3) level of comparison of shortness of breathing and its botherness with different mood states performing cycle ergometer exercise test.

International Affective Picture System images and rated two domains of dyspnea (intensity: 0-no dyspnea, 10-extreme dyspnea; unpleasantness: 0 -not at all unpleasant, 10 - extremely unpleasant)

3.3 Respiratory rate and Heart rate:

As shown in the figure 3 & 4, in comparison to neutral mood state, there was significant increase in respiratory rate [32.2(29.7-35.3) vs. 28.4(26.6-31.2) cycles/min, $p<0.05$] and heart rate [116.4 (105.4-128.4) vs. 123(109.9-144.3) beats/min, $p<0.05$] in negative mood state whereas there was no significant difference in those variables in positive mood state. Likewise, in comparison to negative mood state, there was significant decrease in shortness of breathing [3.2(2.0-3.9) vs. 4.6(4.2-5.4), $p<0.05$], botherness to shortness of breathing [3.2(2.2-3.8) vs. 4.6(4.0-5.8), $p<0.05$], respiratory rate [29.0(26.3-31.6) vs. 32.2(29.7-35.3) cycles/min, $p<0.05$] and heart rate [114(102.7-138.7) vs. 123(109.9-144.3) beats/min, $p<0.05$] in positive mood state.

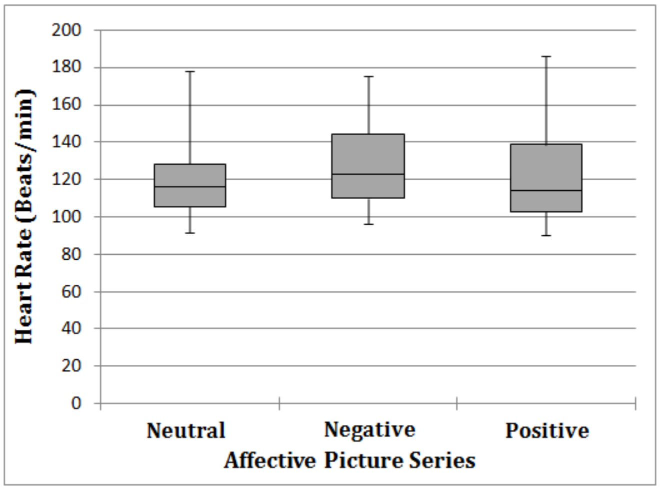

Figure 3: Median (Q1-Q3) level of comparison of heart rate with neutral, negative and positive mood states during cycle ergometer exercise test.

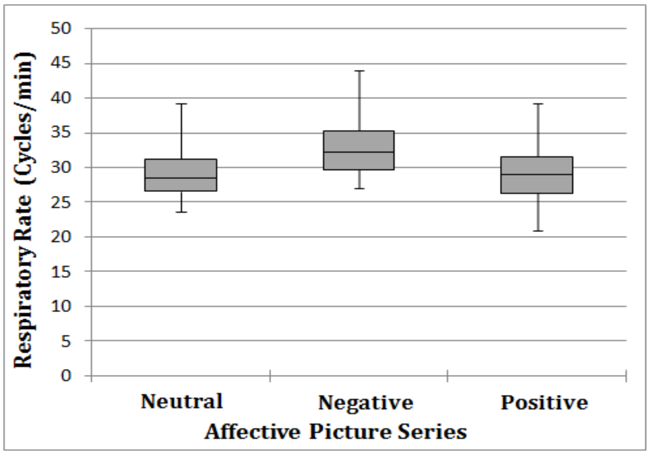

Figure 4: Median (Q1-Q3) level of comparison of respiratory rate with neutral, negative and positive mood states during cycle ergometer exercise test.

4. Discussion

In the present study, during the cycle ergometer exercise test, the mood state of the subject was successfully modulated by parallel viewing of emotional picture series, which led to significantly greater experience of pleasantness with parallel positive picture viewing compared to with parallel neutral and negative picture viewing; significantly least experience of pleasantness with parallel negative picture viewing compared to neutral and positive picture viewing and significantly neutral pleasantness with parallel neutral picture viewing compared to positive and negative picture viewing. Likewise, there was lower affective arousal during the negative picture series compared to the positive picture series. These findings resembles with results reported in many previous studies using affective International Affective Picture System (IAPS) picture series in various experimental contexts [11-15]. In our study, since the tests were performed in three different days, our concerned was day-to-day variations in general mood may have impact on the intensity and botherness of exertional dyspnea but the assessment of baseline mood state (BRUMS) before test showed no significant difference in mood before viewing mood modulating IAPS pictures.

Dyspnea was induced in healthy volunteers by constant cycle ergometer exercise test (CEET). During each CEET, the experienced degrees of intensity (=sensory dimension) and unpleasantness (=affective dimension) of dyspnea were also rated on numeric scale, ranging from 0(=not noticeable) to 10 (=maximally tolerable dyspnea). Results of our study shows that during cycle ergometer exercise test, a negative mood state when compared to positive and neutral mood state was associated with higher ratings of sensory intensity of dyspnea as well as affective unpleasantness or botherness due to dyspnea. These findings in healthy subjects are consistent with previous studies in healthy subjects or patients with asthma and COPD that showed increased reports of dyspnea in individuals with negative mood[16-22] or increased reports of dyspnea after laboratory induction of negative mood state[15,16,23,24]. A study by von Leupoldt [11] agrees with our study in terms of higher ratings of dyspnea in negative mood but contrary to our study and previous results affective unpleasantness of dyspnea was found to be increased in positive mood state without increase in sensory intensity of dyspnea. This discrepancy might be related to differences in experimental designs, considerably higher age group subjects and greater impairment in the patients with COPD and clearly deserves future studies. On the other hand, positive mood state when compared to neutral did not show statistical significance with sensory intensity of dyspnea and affective unpleasantness.

Likewise, other important finding of our study was increase in respiratory rate and heart rate in negative mood state as compared to neutral and positive mood state. These findings in healthy subjects are consistent with previous studies that showed increased reports of respiratory rate and heart rate in individuals with negative mood [25-29]. Some of the previous studies also revealed increased heart rate but decreased respiratory rate in negative mood state by showing disgust film clip [30]. In contrary to this, other study have shown decreased heart rate in negative mood state by showing disgust and sad film clip and standard pictures [31-

35]. These variations in heart rate and respiratory rate in different previous and present study might be due to different kinds of emotion induced for negative mood like sad, fear, disgust, anxiety, and anger while for positive mood like amusement, contentment, happiness, joy, anticipatory pleasure.

Also, the results of changing in intensity and botherness of dyspnea in response to modulation of mood states enable us to speculate the neurophysiological mechanism that give rise to sensory perception of dyspnea. Thus, we hypothesize that since emotions are regulated by limbic system of our brain, these areas of brain also are likely to be in involved in perception of dyspnea. This is supported by the study using fMRI by Aldhafeeri et.al [36] showing activation of right and left prefrontal cortex to include superior, medial, and middle frontal gyri, right anterior and posterior cingulate gyri and both temporal lobes with positive pictures of IAPS while activation of mainly amygdala with negative pictures of IAPS. Since, emotions are regulated by limbic system of our brain; these areas of brain also are likely to be in involved in perception of dyspnea. This view is supported by the increase or decrease in pain tolerance by viewing positive and negative IAPS pictures which also has limbic representation in brain as dyspnea. Thus, clear identification of the neurophysiological mechanism that gives rise to sensory perception of dyspnea will progress in developing pharmacological therapies to treat the underlying cause of dyspnea.

Hence, from the results of this study, it can be concluded that negative mood state increases exercise induced dyspnea but positive mood state reduces it, indicating its potential for therapeutic use. Thus, these findings can have profound impact on patients of cardiorespiratory diseases, principally chronic obstructive pulmonary disease (COPD) and congestive heart failure (CHF) for proper disease management, including psychotherapeutic interventions that can successfully reduce dyspnea in conditions where little has been done to treat the underlying cause of troublesome dyspnea.

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Conflict of Interest

Authors declare no conflict of interest.

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