EFFECT OF BODY MASS INDEX ON AFFECT AT INTENSITIES SPANNING THE VENTILATORY THRESHOLD [1,2]

SERGIO G. DASILVA, HASSAN M. ELSANGEDY, KLEVERTON KRINSKI, WAGNER DE CAMPOS

Department of Physical Education

Federal University of Parana, Curitiba, Brazil

COSME F. BUZZACHERA

Rome University Institute of Motor Sciences

Italian University Sport and Movement

MARESSA P. KRAUSE, FREDRIC L. GOSS, ROBERT J. ROBERTSON

Department of Health and Physical Activity

University of Pittsburgh

[1] Address correspondence to Sergio Gregorio da Silva, Rua Coracao de Maria, 92 – Jd. Botanico, 80.215-370 – Curitiba, Parana, Brazil or e-mail (sergiogregorio@ufpr.br).

[2] This work was supported in part by grants from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (H. M. Elsangedy and K. Krinski) and Istituto per il Credito Sportivo (C. F. Buzzachera).

Summary.— The aim of this study was to compare acute affective responses at exercise intensities based on the ventilatory threshold between normal weight, overweight and obese women. Sixty-six sedentary women (22 in each body mass index group), performed a maximal graded treadmill test to determine their maximal oxygen uptake and the ventilatory threshold. The affective valence was compared at intensities corresponding to the ventilatory threshold, below, at and above. Affective valence below ventilatory threshold did not differ among the body mass index groups. The obese group had a lower affective response at ventilatory threshold and above ventilatory threshold than the normal weight and overweight groups. However, the normal weight and overweight group did not differ. The obese group had a lower affective response than the normal and overweight groups, which corresponds to a less pleasant experience. Our results highlight that exercise prescriptions for obese subjects targeting intensities below ventilatory threshold can provide a more pleasant experience, and may facilitate exercise adherence.

Affect is defined as “the most basic or elementary characteristic component of all valenced responses – positive or negative, pleasant or unpleasant – including, but not limited to, emotions and moods” (Ekkekakis & Petruzzello, 1999). Therefore, it has been argued that the quality of the subjective individual experiences should be one of the key outcomes of interest when trying to determine the association with continued exercise behavior (Rose & Parfitt, 2008). Indeed, it is crucial to identify those factors that help to determine whether an individual feels good or bad (i.e. a basic affect), while performing an exercise session (Ekkekakis, Hall, & Petruzzello, 2008).

Affective responses during exercise have been examined in an attempt to explain the relation between aerobic exercise intensity and individual subjective experiences, which in turn, influence adherence to regular physical activity (Ekkekakis & Petruzzello, 1999; Van Landuyt, Ekkekakis, Hall, & Petruzzello, 2000). Previous investigations observed an inverse relation between exercise intensity and exercise adherence in the general adult population (Sallis, Haskell, Fortmann, Vranizan, Taylor, & Solomon, 1986; Lee, Jensen, Oberman, Fletcher, Fletcher, & Raczynski, 1996). Additionally, exercise intensity indexed to the ventilatory threshold has been one of the primary factors that can influence the affective valence (Ekkekakis, Hall, & Petruzzello, 2005). The ventilatory threshold represents the transition from aerobic to anaerobic metabolism. Therefore, as exercise intensities increase, spanning the ventilatory threshold, physiological changes in the internal environment are exacerbate which difficult the maintenance of homeostasis, especially at intensities above the ventilatory threshold (Ekkekakis, Hall, & Petruzzello, 2004; DeMello, Cureton, Boineau, Singh, 1987).

According to Ekkekakis, Hall, and Petruzzello (2005), aerobic exercise intensities below the ventilatory threshold lead to homogenous and pleasant affective responses. However, as exercise intensity progressively increases, the affective valence becomes heterogeneous. Such heterogeneity persists until the highest exercise intensities are achieved. These high intensities are associated with homogenous and negative responses. These assumptions were tested by Ekkekakis, Hall, and Petruzzello (2004) examining affective responses during a maximal treadmill test in a mixed-gender sample of apparently healthy young adults. The finding supported an inverse relation between affective responses and exercise intensity, in which the affective responses were positive below the ventilatory threshold, decreasing progressively until attained the ventilatory threshold, and thereafter, became negative at intensities above the ventilatory threshold.

Ekkekakis and Lind (2006) examined the affective responses in normal weight and overweight apparently healthy adult women while performing treadmill exercise at a self-selected pace and an imposed intensity. The affective responses were similar between the normal weight and overweight groups for exercise intensities below the individually determined ventilatory threshold during the self-selected pace. However, during the imposed bout, performed at an exercise intensity between 88-115% of ventilatory threshold, the affective responses were heterogeneous between groups. In this case, the overweight group exhibited a less pleasant response than the normal weight women. Therefore, it seems that person with excess body weight tend to report a less pleasant affective responses during aerobic exercise depending on the exercise intensity performed. The higher body weight can lead to physiological and biomechanical dysfunction which makes use of a normal walking gait difficult as exercise intensity increases. This dysfunction can also negatively influence psychological and behavioral factors, leading to a less pleasant affective experience (Maw, Boutcher, & Taylor, 1997; Neugebauer, Katz, & Pasch, 2003; Hills, Byrne, Wearing, & Armstrong, 2006; Browning & Kram, 2007).

Despite the established relation between exercise intensities and affective valence, there is still a lack of research regarding the effect of excess of body weight on this relation, particularly for those individuals classified as obese, based upon body mass index. Therefore, the purpose of this investigation was to compare acute affective responses at exercise intensities indexed to the ventilatory threshold between normal weight, overweight and obese women based on body mass index classification.

The hypotheses underlying this investigation were based primarily on previous research by Ekkekakis, Hall, & Petruzzello (2004, 2005), who proposed a conceptual framework to categorize affective responses during exercise intensities spanning the ventilatory threshold. The maintenance of a physiological steady-state as exercise intensity increase can be a challenge for many of overweight individuals which would influence the affective responses (Ekkekakis, Hall, & Petruzzello, 2008). Based on these previous assumptions, it was hypothesized that 1) the affective valence corresponding to aerobic exercise intensities below the ventilatory threshold would not differ between body mass index groups; and 2) for exercise intensities at and above the ventilatory threshold would differ between body mass index groups, with the obese subjects reporting a less pleasant experience than the normal and overweight groups.

Methods

Participants

Sixty-six women between 20 and 45 years of age participated. Using the World Health Organization's body mass index classification[3], they were categorized as normal weight (18.5–24.9 kg·m^{-2}, n=22), overweight (25.0–29.9 kg·m^{-2}, n=22), and obese (>30 kg·m^{-2}, n=22). These groups are referred to as experimental groups. Participant' characteristics are presented in Table 1. During an initial screening session, procedures were explained, as need as the purpose of the study, potential benefits, and possible risks. The study protocol was approved by the Ethics Committee of the Universidade Federal do Paraná, according to the norms established in Resolution 196/96 of the National Health Council concerning research involving human participants. Each participant read and signed an informed consent form indicating their participation as voluntary.

The participants completed the Physical Activity Readiness Questionnaire. They were included if their responses to all questions were negative. Medical screening was then conducted to assess there was any contraindication to performing a maximal exercise test, and whether they were taking medications known to influence cardiovascular, metabolic, or cognitive function. All participants were classified as sedentary (<30 min. of moderate or 20 min. of vigorous physical activity per day on three or fewer days per week) and nonsmokers (for at least the past six months).

Measures

Height (cm; Sanny stadiometer™, São Paulo, Brazil) and body weight (kg; Toledo scale™, Sao Paulo, Brazil) were assessed using previously described techniques (Gordon,

[3] World Health Organization (2000) Obesity: preventing and managing the global epidemic. Report of a WHO consultation. Retrieved from http://www.ncbi.nlm.nih.gov/entrez/ query.fcgi?cmd =Retrieve&db= PubMed& dopt=Citation&list_uids=11234459.

Chumlea, & Roche, 1988). The body mass index (kg·m^{-2}) was calculated as body mass (kg) divided by height (m^2) for each participant. This value was the basis for assign means to a group – normal weight, overweight, or obese.

Oxygen uptake ($\dot{V}O_2$, mL·kg^{-1}·min^{-1}), carbon dioxide production ($\dot{V}CO_2$, mL·kg^{-1}·min^{-1}), and pulmonary ventilation ($\dot{V}E$, L·min^{-1}) were measured every 30 sec. using an open-circuit respiratory-metabolic system (STPD; True Max 2400, Parvo Medics ™, Salt Lake City, UT).

The Feeling Scale (Hardy & Regeski, 1989) was used to rate the affective response of pleasure or displeasure during exercise (Ekkekakis, Hall, & Petruzzello, 2005). An 11-point single-item bipolar measure, with anchors of -5: very bad, 0: neutral, and +5: very good. Affective responses were recorded during the last 15 sec. of each minute throughout the exercise test. At each measurement point, participants were asked to rate how they felt. In addition, before the exercise test began, each participant received the standard instructions for using the scale (Lind, Joens-Matre, & Ekkekakis, 2005).

Procedure

Before the maximal exercise test began, participants were familiarized with the open-circuit respiratory-metabolic system, treadmill, and the affective metric. During the treadmill familiarization, participants walked on a motor-driven treadmill (Model X Fit 7, Reebok Fitness™, London, UK) at 0% grade for 5 min. at a self-selected pace. Before each test, the respiratory-metabolic analyzers were calibrated with standard gases of known concentration (STPD).

A maximal graded treadmill test using a previously described protocol (Lind, Joens-Matre, & Ekkekakis, 2005) was administered in which $\dot{V}O_2$, $\dot{V}CO_2$ and $\dot{V}E$ were recorded every 30 sec. throughout the test. The treadmill test employed a standard warm-up, consisting of walking for 5 min. at a speed of 1.11 m·sec^{-1} followed by 1 min of seated rest.

Subsequently, the first test stage employed a speed of 1.11 m·sec^{-1} at 0% grade, for 2 min. Thereafter, the speed was increased by 0.18 m·sec^{-1} every two minute, while the treadmill grade remained constant until the participant volitionally terminated exercise owing exhaustion (Lind, Joens-Matre, & Ekkekakis, 2005). For an oxygen uptake value to be classified as maximal, at least two of the following criteria were required, (a) a plateau in $\dot{V}O_2$ (change of < 2.1 mL·kg^{-1}·min^{-1} over the last three consecutive 30 sec. values), (b) a respiratory exchange ratio (RER) of ≥1.10, and (c) heart rate within ±10 beats·min^{-1} of the age predicted maximal heart rate (Midgley, McNaughton, Polman, & Marchant, 2007).

The ventilatory threshold was assessed for each participant using the ventilatory equivalent method. The ventilatory threshold was identified as the time-point at which an exponential rise in $\dot{V}E/\dot{V}O_2$ occurred without a similar increase in $\dot{V}E/\dot{V}CO_2$ (Caiozzo, Davis, Ellis, Azus, Vandagriff, Pietto, McMaster, 1982). The visual identification of the ventilatory threshold was carried out independently by two experienced investigators. Next, three exercise intensities were calculated for each participant based on the individually determined ventilatory threshold: (1) 90% of the ventilatory threshold, (2) the ventilatory threshold, and (3) 110% of the ventilatory threshold. The exercise time-point at which each of these three intensities occurred (to the nearest minute) was used to obtain the $\dot{V}O_2$, heart rate, and the affective responses. The $\dot{V}O_2$, heart rate, and affective responses measure at the three target intensities were compared among the experimental groups.

Statistical analysis

Descriptive data are presented as means and standard deviations. A one-factor analysis of variance was used to compare participants' characteristics among body mass index groups: normal-weight, overweight, and obese. A two-factor (exercise intensity x group) analysis of variance, with repeated-measure on the within-subject factor of intensity was used to test differences among body mass index groups and intensities. These analyses were performed for the physiological and affective responses assessed during the graded treadmill exercise test at the three target intensities. Tukey's *post hoc* analyses were used to decompose significant main and interaction effects, with the statistical significance set a priori at $p<.05$. A sample size of 22 subjects for each of three cells was required based on an alpha level of .05, power of .70, and an effect size of .35 (*Cohen's d*). The statistical analyses were performed using SPSS, Version 16.0 for Windows (SPSS, Inc., Chicago, USA).

Results

Participants' characteristics are shown in Table 1. The mean age of participants was 33.0 (SD=8.8 yr). As expected, the mean body mass index was significantly different between groups. The obese group had the lowest mean $\dot{V}O_{2\ max}$ compared to the normal weight and overweight groups. However, the HR_{max} and VE_{max} did not differ among body mass index groups. The obese group also had the slowest maximal treadmill speed compared to the normal weight and overweight groups. Lastly, the normal weight group had the fastest speed at the ventilatory threshold compared to the overweight group and the obese group, who had the slowest speed at the ventilatory threshold.

Insert Table 1 here.

Physiological and affective responses are shown in Table 2. For the total sample, the lowest mean of percentages of maximal oxygen uptake was at the 90% of the ventilatory threshold compared to percentages of maximal oxygen uptake at the ventilatory threshold and 110% of the ventilatory threshold. The highest affective response mean was found at the 90%

of the ventilatory threshold, compared to affective response at the ventilatory threshold and 110% of the ventilatory threshold.

Insert Table 2 here.

Figure 1 compares the $\%\dot{V}O_{2\ max}$ among the three body mass index groups. The repeated-measure yielded no significant main effect for groups ($F_{2,63}$=.42, p=.66), or interaction for exercise intensity and group ($F_{4,12}$=.93, p=.45). The three body mass index groups had similar values of $\%\dot{V}O_{2\ max}$ at each of the target exercise intensities (90% of the ventilatory threshold, at ventilatory threshold, and 110% of the ventilatory threshold). However, the exercise intensity main effect was significant ($F_{2,12}$=270.06, p=.001; η^2=.811). The $\%\dot{V}O_2$ at 90% of the ventilatory threshold was significantly lower than at the ventilatory threshold and 110% of the ventilatory threshold (p<.05); and $\%\dot{V}O_2$ at the ventilatory threshold was lower than the 110% of the ventilatory threshold (p<.05).

Insert Figure 1 here.

Figure 2 displays means for affective response among groups at the three target exercise intensities. The analysis of variance indicated a significant main effect for exercise intensity ($F_{2,13}$=100.01, p=.001; η^2=.614) and group ($F_{2,63}$=12.85, p=.001; η^2=.290). There was also a significant interaction between exercise intensity and group ($F_{4,13}$=10.07, p=.001; η^2=.242). The *post hoc* comparison for the main effect of exercise intensity, identify that the affective response for each group at ventilatory threshold and 110% of the ventilatory threshold were significantly lower than 90% of the ventilatory threshold (p<.05). In addition, the affective response at the ventilatory threshold was greater than 110% of the ventilatory threshold ($p<.05$). Consequently, these findings indicate a more pleasant response at 90% of the ventilatory threshold intensity, and a less pleasant one at 110% of the ventilatory threshold. The *post hoc* comparison for the group main effect, indicated that at the affective response at the ventilatory threshold, the obese subjects had a lower affective response (0.50, SEM=.29) ($F_{2,65}=12.15$, $p<.05$; $\eta^2=.865$) than the normal weight and overweight groups. Similarly, the obese group had a lower and negative affective response at the 110% of the ventilatory threshold that the normal weight and overweight groups ($F_{2,65}=18.03$, $p<.05$; $\eta^2=.642$).

Insert Figure 2 here.

Discussion

The hypotheses underlying this investigation were based primarily on previous research by Ekkekakis, Hall, & Petruzzello (2004, 2005), who proposed a conceptual framework to categorize affective responses during exercise intensities spanning the ventilatory threshold. In addition, the present study examined the affective responses in a range of ±10% of the ventilatory threshold. This design was chosen because the prior findings indicated that exercise intensity set at 10% above the ventilatory threshold can be considered a threshold supra intensity showing a distinct physiological “drift” over time. Therefore, the maintenance of a physiological steady-state during this comparatively high intensity can be a challenge for many of overweight individuals of low fitness and can elicit a stimulus that will influence the affective valence (Ekkekakis, Hall, & Petruzzello, 2008).

According to this framework, exercise intensities below the ventilatory threshold, referred to as the moderate domain, are linked to a homogeneous and positive affective response that is associated with a more pleasant experience. The explanation for affective response within the moderate domain is attributed partially to lower activation of physiological mediators. The comparatively lower physiological stress was not sufficient to elicit negative psychological stress. The affective response exercise intensities at and above the ventilatory threshold, referred to as the heavy domain, are linked to a heterogeneous and less positive affective response than those within the moderate domain. This domain can be considered the point at which either the psychological or physiological mediators is activated to influence the affective response.

Lastly, exercise intensities ranging from the maximal blood lactate steady-state to volitional termination owing to exhaustion are referred to as the severe domain. The affective response at these highest exercise intensities are linked to homogeneous and predominantly negative responses. Such responses are influenced mainly by physiological factors, such as the accumulation of lactate and depletion of muscle energy stores. These responses manifest as powerful mediators which generate the perceptions of fatigue and displeasure. Progressively increasing fatigue and displeasure may trigger a psychological protective mechanism relating to primary emotion. Consequently, the evaluative component of cognitive process, relate to secondary emotion (i.e., rudimentary evaluative component) may be not influenced these responses. Therefore, these complex mechanisms can justify, at least partially, the limited variability of affective response of most individuals who experience displeasure while exercising in this domain (Ekkekakis, Hall, & Petruzzello, 2005).

The present findings are consistent with the earlier hypotheses of Ekkekakis, Hall, & Petruzzello (2004, 2005). Affective responses recorded during a maximal incremental treadmill test were not different among the body mass index groups at exercise intensity corresponding to 90% of the ventilatory threshold. Although, during exercise intensities at and above the ventilatory threshold the normal weight group did not exhibit significant differences in affective response than for the overweight group, the obese group was significantly different from the other groups.

Recent investigations have reported similar results to those observed presently regarding the affective responses obtained at exercise intensity corresponding to 90% of the ventilatory threshold. Hall, Ekkekis, & Petruzzello (2002) investigated affective responses in a sample of 30 healthy university students performing an incremental maximal treadmill test. Their mean affective response showed little change at intensities below the ventilatory threshold. However, at intensities above the threshold the affective valence declined, becoming more negative. Moreover, Welch, Hulleyb, Fergusonb, & Beauchamp (2007), used a similar protocol to reproduce Hall, Ekkekakis, & Petruzzello findings (2002), testing inactive women. These inactive women also had showed positive affective responses during maximal treadmill exercise at intensities below the ventilatory threshold, but these declined over time, with the affective response becoming progressively more negative at intensities above the ventilatory threshold.

More previous studies support the assumptions of Ekkekakis, Hall, & Petruzzello (2004, 2005), however, none examined the effect of body mass index categories**,** specifically of obese subjects, on the affective response during a maximal graded treadmill test. Interestingly, the influence of body weight on affective response was the main finding of the present study. The obese group performed a slower treadmill speed at and above the ventilatory threshold than the normal and overweight group. Indeed, the obese group had a significantly lower affective response at the ventilatory threshold, as well as a negative response when the exercise intensity was above the ventilatory threshold (110% of the ventilatory threshold). Therefore, it seems that obesity led to exacerbation of an innate protective mechanism perceived and translated into a sensation of "*feeling bad*". This in turn, was associated with a less pleasant experience and a negative affective response (Ekkekakis, Hall, & Petruzzello, 2008). However, these findings need to be cautiously examined, because during an incremental test other factors also play an important role and can affect the affective response. Ekkekakis, Hall, & Petruzzello (2008) reported that the incremental maximal tests "cannot tease apart the influence of the ventilatory threshold intensity *per se* from that fatigue accumulated from earlier stages" (p. 146). Also, the graded exercise test does not represent the pattern of a typical exercise session. However, all participants in this study underwent the load incremental protocol. Therefore, the cumulative effect of previous stages was assumed to be similar among participants' allowing comparison among the three groups (Ekkekakis, Hall, & Petruzzello, 2008).

The mechanism underlying the different affective response between the obese and non-obese groups might be dependent on multiple factors (Backhouse, Ekkekakis, Bidle, Foskett, & Williams, 2007). Researchers have reported that a comparatively higher body mass index can lead to physiological and biomechanical dysfunction which makes use of a normal walking gait difficult as exercise intensity increases. This dysfunction can also negatively influence psychological and behavioral factors related to exercise adherence (Maw, Boutcher, & Taylor, 1997; Neugebauer, Katz, & Pasch, 2003; Hills, Byrne, Wearing, & Armstrong, 2006; Browning & Kram, 2007).

Physiologically, participants with a higher body mass index mean present a compromised thermoregulation during exercise stress. This could result in a comparatively higher brain temperature which would negatively influence affective responses during exercise (Maw, Boutcher, & Taylor, 1993). Furthermore, obese person usually experience more skeletal and muscular aches than normal weight participants during exercise owing to substantially increased force required for support and propulsion (Mattsson, Larsson, & Rossner, 1997).

Biomechanically, excess body weight, particularly for obesity, can alter such gait patterns, as stride rate and length, increasing mechanical stress and the metabolic cost of locomotion. The cumulative changes caused by the chronic unfavorable health condition of excessive body weight can interfere with daily functional activities leading to a negative affect during physical effort (Neugebauer, Katz, & Pasch, 2003).

Psychologically, the present findings may have relevance to adherence of obese participants to regular exercise training. Obese participants could perceive exercise as a comparatively less pleasant experience, given their unfavorable health condition. They may also perceive themselves as unable to engage in any physically challenging experience such as exercise, since it requires effort not usually encountered by those of excessive body weight (Mattsson, Larsson, & Rossner, 1997).

In summary, obese individuals generally have a higher physiological and psychological challenge to overcome during exercise. According to the Theory of Planned Behavior, perceived behavior control and self-efficacy influence individual intentions and attitudes, which in turn, may influence behavioral change. Therefore, such factors deserve consideration for persons who appear to lack perceived behavioral control and a lower self-efficacy. These in turn, could negatively influence a decision to engage in an exercise program. For this reason, it seems crucial that exercise programs for obese individuals lead to a more pleasant experience by prescribing a more acceptable exercise intensity. Indeed, a more pleasant exercise experience will positively influence self-efficacy considered a powerful method to enhance mastery experience (Buckworth & Dishman, 2002; Ekkekakis, 2003; Carr, Friedman, & Jaffe, 2007; Montaño & Kasprzyk, 2008). Finally, present findings indicate obese participants had a positive mean affective response at exercise intensity below the ventilatory threshold. Therefore, it seems reasonable to recommend that fitness instructors prescribe exercise intensities below the ventilatory threshold for individuals with excess of body weight, especially obese person, and for individual sedentary or who perceived a low self-efficacy related to exercise. This prescription can provide health benefits with a positive exercise experience ("feeling good") facilitating for these individuals support longer workouts, commit and adhere to exercise program.

The present results complement those previously reported. The affective response corresponding to intensities at and above the ventilatory threshold differed among body mass index groups. The obese group had a less pleasant response that was significantly different from the normal weight and overweight group at the ventilatory threshold. This response supported the second hypothesis of this study. Indeed, the obese group had a negative affective valence at intensities above the ventilatory threshold, whereas the normal weight and overweight groups had positive affect. These results suggest that the obese participants have been more responsive to physiological and biomechanical mediators. Also, these signals at higher intensities may have triggered a negative and aversive cognitive process for the obese groups, which could have led to an unpleasant experience and negative affective responses (Noble & Robertson, 1996; Ekkekakis, Hall, & Petruzzello, 2005).

In conclusion, present findings support the assumptions previously described regarding the association between affective valence and exercise intensity. As expected, affective response corresponding to intensities below the ventilatory threshold were positive and homogeneous, independent of body mass index group. Interestingly, the obese group had a less pleasant experience than normal and overweight groups for the exercise intensities at and above the ventilatory threshold, which suggests that excessive body weight can negatively influence the affective responses during weight-bearing aerobic exercise.

At this point, several investigations have confirmed the association between affective valence and aerobic exercise intensity based on the ventilatory threshold. However, the present results are important regarding exercise prescription for obese groups as obese person may be more susceptible to adverse physiological and biomechanical factors for intensities at and above the ventilatory threshold, leading to a negative experience during aerobic exercise. Therefore, it is reasonable to recommend that exercise prescription for obese person target intensities below the ventilatory threshold. These intensities can positively influence these mediators generating a more pleasant experience, and consequently, facilitating adherence to an exercise program.

To date, this is the first study to examine the relation between affective response and exercise intensity, specifically in obese participants. It is unknown how the protocol and the ergometer employed in this study could complicate the relations between respiratory/metabolic factors altering the affective and perceptual responses. Therefore, future studies should be conducted with the purpose to expand this knowledge base by using a similar protocol (i.e. graded exercise test), and it should consider a protocol which replicates the pattern of a typical exercise session.

Conflict

There is no conflict of interest among the authors.

References

Backhouse, S. H., Ekkekakis, P., Bidle, S. J., Foskett, A., & Williams, C. (2007) Exercise makes people feel better but people are inactive: paradox or artifact? *Journal of Sports and Exercise Psychology*, 29, 498-517.

Browning, R. C., & Kram, R. (2007) Effects of obesity on the biomechanics of walking at different speeds. *Medicine and Science in Sports and Exercice*, 39, 1632-1641.

Buckworth, J., & Dishman, R. K. (2002). *Exercise psychology*; Champaign, IL: Human Kinetics.

Caiozzo, V. J., Davis, J. A., Ellis, J. F., Azus, J. L., Vandagriff, R., Prietto, C. A., McMaster, W.C. (1982) A comparison of gas exchange indices used to detect the anaerobic threshold. *Journal Applied Physiology*, 53, 1184-1189.

Carr, D., Friedman, M. A., & Jaffe, K. (2007) Understanding the relationship between obesity and positive and negative affect: the role of psychosocial mechanisms. *Body Image*, 4, 165-177.

DeMello, J. J., Cureton, K. J., Boineau, R. E., Singh, M. M. Ratings of perceived exertion at the lactate threshold in trained and untrained men and women. Med Sci Sports Exerc 1987;19:354– 62.

Ekkekakis, P. (2003) Pleasure and displeasure from the body: perspectives from exercise. *Cognition Emotion*, 17, 213-239.

Ekkekakis, P., Hall, E. E., & Petruzzello, S. J. (2004) Practical markers of the transition from aerobic to anaerobic metabolism during exercise: rationale and a case for affect-based exercise prescription. *Preventive Medicine*, 38, 149-159.

Ekkekakis, P., Hall, E. E., & Petruzzello, S. J. (2005) Variation and homogeneity in affective responses to physical activity of varying intensities: an alternative perspective on dose-response based on evolutionary considerations. *Journal of Sports Science*, 23, 477-500.

Ekkekakis, P., Hall, E. E., & Petruzzello, S. J. (2008) The relationship between exercise intensity and affective responses demystified: to crack the 40-year-old nut, replace the 40-year-old nutcracker! *Annals of Behavioral Medicine*, 35, 136-149.

Ekkekakis, P., & Lind, E. (2006) Exercise does not feel the same when you are overweight: the impact of self-selected and imposed intensity on affect and exertion. *International Journal of Obesity (London)*, 30, 652-660.

Ekkekakis, P., & Petruzzello, S. J. (1999) Acute aerobic exercise and affect: current status, problems and prospects regarding dose-response. *Sports Medicine*, 28, 337-374.

Gordon, C. C., Chumlea, W. C., & Roche, A. F. (1988) Stature, recumbent length and weight. In T. G. Lohman, A. F. Roche & R. Martorell (Eds.), *Anthropometric standardization reference manual*, Champaign: IL: Human Kinetics, pp. 3-8.

Hall, E. E., Ekkekakis, P., & Petruzzello, S. J. (2002) The affective beneficence of vigorous exercise revisited. *British Journal of Health Psychology*, 7, 47-66.

Hardy, C. J., & Rejeski, W. J. (1989) Not what, but how one feels: the measurement of affect during exercise. *Journal of Sports Exercise Psychology*, 11, 204-317.

Hills, A. P., Byrne, N. M., Wearing, S., & Armstrong, T. (2006) Validation of the intensity of walking for pleasure in obese adults. *Preventive Medicine*, 42, 47-50.

Lee, J. Y., Jensen, B. E., Oberman, A., Fletcher, G. F., Fletcher, B. J., & Raczynski, J. M. (1996) Adherence in the training levels comparison trial. *Medicine and Science in Sports and Exercise*, 28, 47-52.

Lind, E., Joens-Matre, R. R., & Ekkekakis, P. (2005) What intensity of physical activity do previously sedentary middle-aged women select? Evidence of a coherent pattern from physiological, perceptual, and affective markers. *Preventive Medicine*, 40, 407-419.

Mattsson, E., Larsson, U. E., & Rossner, S. (1997) Is walking for exercise too exhausting for obese women? *International Journal of Obesity and Related Metabolism Disorders*, 21, 380-386.

Maw, G. J., Boutcher, S. H., & Taylor, N. A. (1993) Ratings of perceived exertion and affect in hot and cool environments. *European Journal of Applied and Physiology Occupation Physiology*, 67, 174-179.

Midgley, A. W., McNaughton, L. R., Polman, R., & Marchant, D. (2007) Criteria for determination of maximal oxygen uptake: a brief critique and recommendations for future research. *Sports Medicine*, 37, 1019-1028.

Montaño, D. E., & Kasprzyk, D. (2008). Health behavior and health education – theory, research, and practice. In K. Glanz, B. K. Rimer, & K. Viswanath (Eds.), *Theory of reasoned action, theory of planned behavior, and the integrated behavioral model,* 4th, San Francisco: Jossey-Bass, 67-92.

Neugebauer, A., Katz, P. P., & Pasch, L. A. (2003) Effect of valued activity disability, social comparisons, and satisfaction with ability on depressive symptoms in rheumatoid arthritis. *Health Psychology*, 22, 253-262.

Noble, B. J., & Robertson, R. J. (1996). *Perceived exertion*; Champaign, IL: Human Kinetics, 125-155.

Rose, E. A., & Parfitt, G. (2008) Can the feeling scale be used to regulate exercise intensity? *Medicine and Science in Sports and Exercise*, 40, 1852-1860.

Sallis, J. F., Haskell, W. L., Fortmann, S. P., Vranizan, K. M., Taylor, C. B., & Solomon, D. S. (1986) Predictors of adoption and maintenance of physical activity in a community sample. *Preventive Medicine*, 15, 331-341.

Van Landuyt, L. M., Ekkekakis, P., Hall, E. E., & Petruzzello, S. J. (2000) Throwing the mountains into the lakes: on the perils of nomothetic conceptions of the exercise: affect relationship. *Journal of Sports and Exercise Psychology*, 22, 208-234.

Welch, A. S., Hulleyb, A., Fergusonb, C., & Beauchamp, M. R. (2007) Affective responses of inactive women to a maximal incremental exercise test: a test of the dual-mode model. *Psychology of Sport and Exercise*, 8, 401-423.

Tables and Figures

1. Subject characteristics.

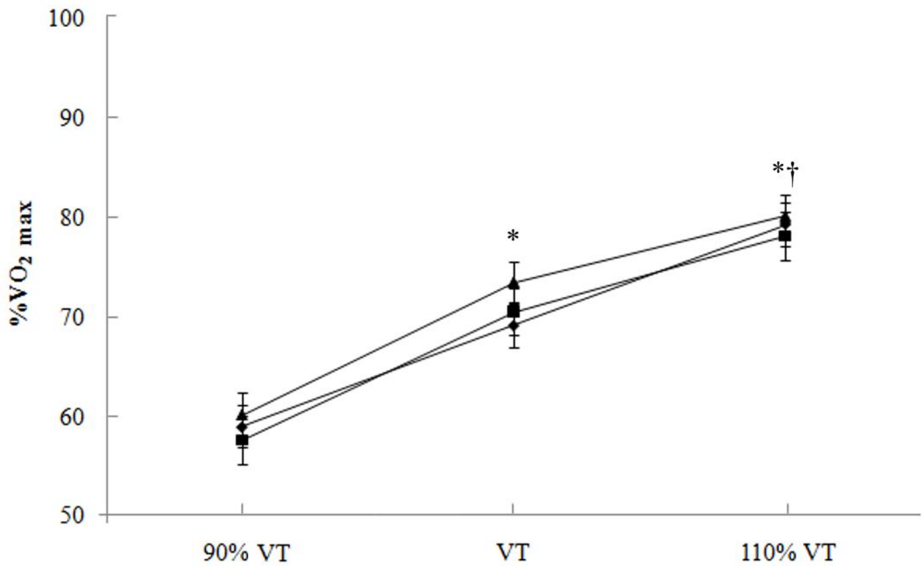
	Normal weight		Overweight		Obese		Total		F (2,65)
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	
Age (yr)	30.8	9.3	34.8	8.6	33.5	8.5	33.0	8.8	
Body mass (kg)	58.5	6.8	68.3	8.8*	89.3	8.9*#	72.0	15.2	
Height (cm)	162.6	7.0	160.2	7.4	160.1	5.6	161.0	0.1	
Body mass index ($kg \cdot m^{-2}$)	22.0	1.6	26.4	1.3*	34.9	4.1*#	27.8	5.9	129.15
$\dot{V}O_{2\,max}$ ($mL \cdot kg^{-1} \cdot min^{-1}$)	34.6	8.0	31.8	5.3	24.9	3.0*#	30.4	7.1	15.79
HR_{max} ($beats \cdot min^{-1}$)	184.6	12.0	179.7	14.4	180.1	9.3	181,4	11.9	
$\dot{V}E_{max}$ ($L \cdot min^{-1}$)	57.7	10.4	61.3	9.6	64.1	9.7	61.0	9.9	
Maximal Speed ($m \cdot sec^{-1}$)	2.94	0.27	2.50	0.27	1.94	0.02*#	2.58	0.51	
Speed at VT ($m \cdot sec^{-1}$)	2.06	0.37	1.82	0.87*	1.50	0.23*#	1.79	0.36	

Note - Mean ± Standard Deviation. $\dot{V}O_{2\,max}$: maximal oxygen uptake; HR_{max}: maximal heart rate; $\dot{V}E_{max}$: maximal pulmonary ventilation; and VT: ventilatory threshold. * $p < .05$ from normal weight group. # $p < .05$ from overweight group.

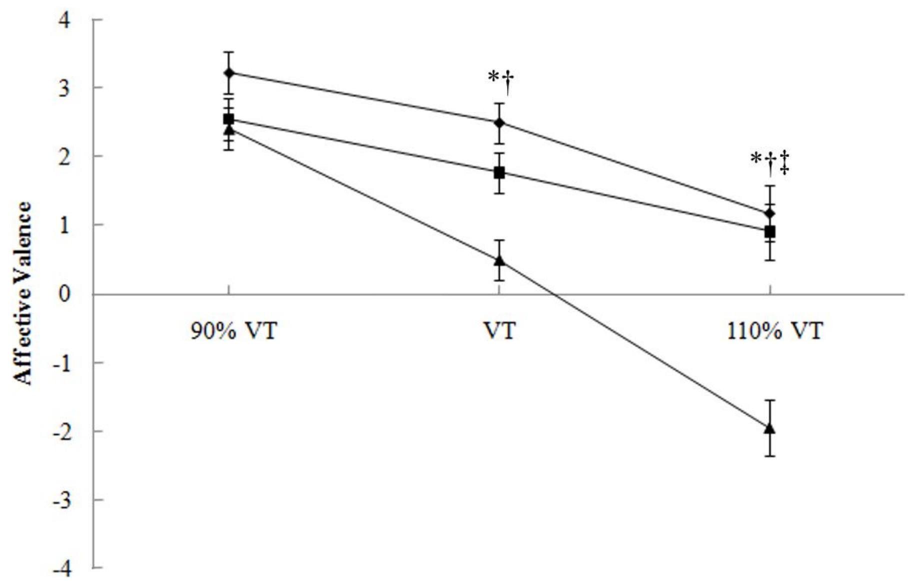
Table 2. Physiological and affective responses during graded treadmill exercise.

	Normal weight		Overweight		Obese		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
$\dot{V}O_{2\ 90\%VT}$ ($mL \cdot kg^{-1} \cdot min^{-1}$)	20.2	5.5	18.1	4.1	15.0	3.4	17.8	4.8
$\dot{V}O_{2\ VT}$ ($mL \cdot kg^{-1} \cdot min^{-1}$)	23.7	6.0	21.3	4.4	17.5	3.6	20.8	5.4
$\dot{V}O_{2\ 110\%VT}$ ($mL \cdot kg^{-1} \cdot min^{-1}$)	27.3	6.6	24.6	4.7	20.0	3.6	23.9	5.9
$AV_{90\%VT}$	3.23	1.34	2.55	.81	2.41	1.26	2.73	1.51
AV_{VT}	2.50	1.79	1.77	.27	0.50	0.85	1.59	1.57
$AV_{110\%VT}$	1.18	2.50	0.91	.13	-1.95	2.36	0.05	1.91

Note - Mean ± Standard Deviation. VT: ventilatory threshold; $\dot{V}O_{2\ 90\%VT}$: oxygen uptake at 90% of the ventilatory threshold; $\dot{V}O_{2\ VT}$: oxygen uptake at the ventilatory threshold; $\dot{V}O_{2\ 110\%VT}$: oxygen uptake at 110% of the ventilatory threshold; $AV_{90\%VT}$: affective valence at 90% of the ventilatory threshold; AV_{VT}: affective valence at the ventilatory threshold; $AV_{110\%VT}$: affective valence at 110% of the ventilatory threshold.



1. Comparison of percent of maximal oxygen uptake (%$\dot{V}O_{2\ max}$) for normal weight (▲), overweight (■), and obese (♦) groups at the three exercise intensities. Means ± Standard Error Mean. * $p < .05$ from 90% of the ventilatory threshold (VT). † $p < .05$ from ventilatory threshold.



2. Affective valence for normal weight (▲), overweight (■), and obese (♦) groups at three exercise intensities. Means ± Standard Error of Mean. * p <.05 for obese group. † p <.05 from 90% of the ventilatory threshold. ‡ p <.05 from ventilatory threshold.