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Affective responses to exercise in overweight women: Initial insight and possible influence on energy intake

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Abstract

It is unclear how exercise influences affect in overweight and obese individuals.

Objectives—To examine the effect of a single exercise session on positive and negative affect and examine whether pre- to post-exercise changes in affect influence subsequent energy intake (EI).

Methods—Nineteen sedentary, overweight/obese women walked for ~40 minutes at a moderate-intensity on one day and rested for a similar duration on a separate day. Positive (PA) and negative affect (NA) were assessed pre-testing, post-testing, 60, and 120 minutes post-testing using the Positive and Negative Affect Schedule. Energy intake was determined by measuring food intake before and after a buffet meal 1–2 hours post-exercise/rest.

Results—For PA, the time x condition interaction was significant ($p<0.05$). There was a trend for those subjects with improved PA from pre to post-exercise (58%) to consume fewer calories post-exercise (524 ± 260.9 kcal) compared to post-rest (566.1 ± 303.0 kcal), while those who had a worsening or no change in PA (42%) had a higher EI following exercise (588.0 ± 233.7 kcal) compared to rest (524.6 ± 281.7 kcal; $p=0.08$). NA was not significantly altered by exercise.

Conclusions—Some overweight/obese individuals appear to experience an increase in positive affect with exercise; however, there is a high degree of individual variability in responses that warrants further examination. This study also provides initial evidence that a worsening in affect following exercise may unfavorably impact eating behaviors. These preliminary findings have the potential to enhance our understanding of factors mediating the relationship between exercise and EI.

Keywords

Affect; Mood; eating behaviors; physical activity; food intake; positive affect; negative affect; obesity

INTRODUCTION

Engagement in sufficient doses of physical activity can reduce the risk of numerous chronic diseases including cardiovascular disease (Oguma & Shinoda-Tagawa, 2004), diabetes (Bassuk & Manson, 2005), and many forms of cancer (Friedenreich & Orenstein, 2002), and has been shown to elicit psychological benefits and improvements in quality of life (Martinsen, 2008; Netz, Wu, Becker, & Tenenbaum, 2005; Rejeski & Mihalko, 2001). Physical activity is also an important behavior for body weight regulation, particularly the

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maintenance of weight loss and prevention of weight regain (Jakicic, Marcus, Lang, & Janney, 2008; Unick, Jakicic, & Marcus, 2009; Wing & Phelan, 2005). Despite the numerous health benefits, only 4–10% of overweight and obese individuals meet the recommended physical activity guidelines (Tucker, Welk, & Beyler, 2011). Thus, it is important to understand factors that contribute to physical activity participation in this population.

Affect, or a person's expression of emotion, typically changes after an acute bout of exercise. In general, participation in a single exercise session increases state positive affect and decreases state negative affect post-exercise (Ekkekakis & Petruzzello, 1999). These findings are relevant in light of research that demonstrates that more favorable affective responses associated with an exercise session may increase exercise adherence in the short term (i.e., 7 days; M. Schneider, Dunn, & Cooper, 2009) and the long term (i.e., 6 and 12 months; Williams, et al., 2008).

Although research suggests that individuals generally experience pleasurable affective responses to exercise, there are also factors that may influence affective responses to an acute exercise bout. For example, more pleasurable responses to exercise have been shown for individuals without a history of depression (Wichers, et al., 2011), individuals who are more physically active (Welch, Hulley, Ferguson, & Beauchamp, 2007), and those who are more fit (Petruzzello, Hall & Ekkekakis, 2001); however, the relationship between fitness, affect, and exercise may be dose dependent (Ekkekakis & Petruzullo, 1999). In addition, individuals who exercise at a self-selected intensity (Ekkekakis, 2009) as well as those who have lower positive affect prior to exercise (Gauvin, Rejeski, & Norris, 1996) may experience greater improvements in affect post-exercise as compared to those who exercise at an imposed intensity level or those with with higher baseline positive affect, respectively.

Affective responses to exercise may also be influenced by body weight. While the majority of studies in this area have investigated normal weight individuals, the influence of exercise on affect in an overweight or obese population is not well understood. There is initial suggestive evidence that overweight and obese individuals may have different affective responses to an exercise bout as compared to individuals in other weight categories. For example, Ekkakakis, Lind, & Vazou (2010) showed that both normal weight and overweight women had similar responses to exercise, and obese women experienced a negative affective response to exercise sooner into an exercise session as compared to their non-obese counterparts. Although it has not been tested, one possibility is that poorer physical functioning and increased bodily pain associated with increasing body weight (Fontaine & Barofsky, 2001) may make exercise more difficult and less affectively pleasurable for those who are overweight or obese. Another study showed that there is individual variability in affective responses to exercise for people who are overweight and obese with approximately 37% of participants increasing negative affect and 63% experiencing no change or a decrease in negative affect after a three-minute moderate-intensity exercise session (K. L. Schneider, Spring, & Pagoto, 2009). Further research is needed to understand how overweight and obese individuals respond to exercise using bouts consistent with those recommended within national guidelines (Haskell, et al., 2007). Thus, the primary aim of the present paper is to examine positive and negative affective responses to a moderate-intensity bout of exercise as compared to a resting session in overweight/obese women. In addition, the individual variability in affective response to an exercise bout will be explored.

Changes in affect in response to exercise may also influence other weight control behaviors. For example, there is a well-established relationship between affect and eating behavior, such that increased negative emotions may lead to overeating (Greeno & Wing, 1994; Hepworth, Mogg, Brignell, & Bradley, 2010). Although the exact mechanism is not clear, results from two studies provide possible links between emotion and overeating. In a study of undergraduates, Evers, Stok, & de Ridder (2010) found that irrespective of the experience of negative emotion, individuals who utilized maladaptive emotion regulation strategies (i.e., suppression) to regulate negative emotions had an increased likelihood of eating higher-fat “comfort” foods. Another possibility specific to exercise-induced emotion is related to hedonic wanting for food, or the pleasure derived from anticipation of food. Finlayson, Bryant, Blundell, & King (2009) found that a tendency to increase energy intake after an acute exercise bout was related to exercise-induced increased hedonic responses for food in a sample of healthy females.

In the present study, it is hypothesized that a worsening in affect, either by negative affect increasing or positive affect decreasing, following an acute exercise bout will lead to an increase in energy intake, yet very little research has been conducted to examine this pathway. Results from a related study showed that following a 3-minute moderate-intensity stair stepping exercise, overweight participants whose negative affect increased consumed more calories post-exercise compared to a resting condition (K. L. Schneider, et al., 2009). However, no prior research has examined this finding in a bout of exercise consistent with nationally recommended levels.

We previously examined whether a bout of exercise that was approximately 40 minutes in duration influenced hunger, appetite regulating hormones, and energy intake in overweight and obese women (Unick, et al., 2010). The primary findings from this study were that exercise did not significantly affect physiological parameters or energy intake at the group level. However, a great degree of individual variability was observed in energy intake following exercise, with some individuals eating more post-exercise while others eating less post-exercise compared to a resting, control condition. Observation of this variability, coupled with the fact that differences in hunger scores were not associated with the difference in EI between exercise and resting conditions, led to the analysis of secondary outcome measures from this study and the development of this manuscript. Thus, a secondary aim of this paper is to examine whether affective responses to exercise influence energy intake in overweight and obese women.

METHODS

Subjects

Nineteen healthy, pre-menopausal, women with a BMI between 25 and 39.9 kg/m^2 participated in this study. Women were between the ages of 18 and 45 and sedentary defined as exercising at a moderate-intensity for < 30 minutes/week over the past 6 months. Exclusion criteria have been reported previously (Unick, et al., 2010). Briefly, subjects were overweight/obese but otherwise healthy and did not have any health problems that would limit their ability to exercise. This study was approved by the Institutional Review Board at the University of Pittsburgh and all subjects provided written informed consent.

Procedures

Study procedures have been previously described in greater detail (Unick, et al., 2010). In short, subjects completed two experimental testing conditions (exercise and resting) in a randomized order. Testing sessions were separated by at least 2 days and were approximately 4 hours in length. Subjects reported to the lab between 07:00 and 09:00 and were instructed to consume a liquid meal replacement equivalent to 15% of their measured resting metabolic rate 2 hours prior to the start of their visit. To demonstrate compliance to this requirement, subjects brought their empty beverage container to the lab, and when queried, all subjects confirmed that they met this requirement. Immediately prior to the start of the exercise or resting sessions and immediately following, subjects were asked to complete the Positive and Negative Affect Schedule (PANAS; see below). Subjects rested for two hours post-exercise/rest. During the first hour, they were asked to remain sedentary and were permitted to watch videos that were provided by the investigator. During the second hour, subjects were provided ad-libitum access to a buffet style meal that included bagels, cream cheese, butter, peanut butter, granola, a variety of cereals, milk, yogurt, mini-donuts, a variety of nutrition or snack bars, mixed berries, tea, and coffee. Subjects were blinded to the monitoring of energy intake; they were told that additional study measures were going to be collected 2-hours post-exercise/rest and they would be provided with food as a courtesy for participating in the study. Energy intake (EI) was calculated by weighing the food before and after the 1-hour feeding period. The affect questionnaires were re-administered at 60 and 120-minutes post-exercise/rest (just prior to and following feeding).

Exercise Testing Protocol—Subjects walked at a speed of 3.0 mph and a grade that elicited a heart rate (HR) between 70 and 75% of their age-predicted maximal HR. Oxygen consumption was measured continuously via a metabolic cart (Vmax Spectra; SensorMedics, Yorba Linda, CA), and HR was monitored each minute. If at any point the subject's HR fell outside the predetermined HR range for two consecutive minutes, the workload was adjusted appropriately. The exercise testing session was terminated once an energy expenditure of 3.0 kcal/kg/body weight was achieved based upon the American College of Sports Medicine's prediction equation for the energy expenditure of walking (American College of Sports Medicine, 2010)

Resting Condition Protocol—Oxygen consumption and HR were monitored each minute while the subject rested in a seated position for a predetermined length of time. During this time, subjects were asked to remain sedentary and were permitted to watch a video of their choice from the selection provided. Because the order of the testing sessions was randomized, the length of the resting session was estimated such that it would coincide with the predicted duration of the exercise session based upon the subject's HR response from an initial exercise test that was conducted at the beginning of the study to ensure subject safety. This test has been described elsewhere (Unick, et. al., 2010).

Measurement of Affect—Positive and negative affect were measured using the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). The PANAS is a 20-item measure that lists affect-related adjectives and asks participants to indicate the extent to which they have felt a particular way. The responses cluster into 10-item subscales for positive affect (PA) and negative affect (NA), respectively. The directions instructed participants to rate how they were feeling "right now."

Statistical analyses

Statistical analyses were performed using SPSS for Windows (SPSS Inc., Chicago IL, version 14.0). This was a sub study of the parent study, which was powered to detect differences in energy intake following exercise and rest. Therefore, a priori power calculations are not included. Descriptive statistics were computed for all variables and if data was not normally distributed, a nonparametric test was performed. Repeated measures ANOVAs were used to examine reported PA and NA over time and whether PA and NA differed between experimental conditions. The difference in EI between conditions ($EI_{diff} = EI_{rest} – EI_{ex}$) was calculated and the difference between conditions for the change in affect from pre- to post-testing, pre- to 60-minutes post-testing, and post- to 60-min post-testing was computed for both NA and PA [e.g., $(Pre_{ex} – Post_{ex}) – (Pre_{rest} – Post_{rest})$]. Spearman correlational analyses were then performed to examine the relationship between the EI_{diff}

and changes in PA or NA. If any of these associations were significant, 2 x 2 ANOVAs were performed using a dichotomous approach, previously used by K. L. Schneider et al. (2009).

RESULTS

Subject characteristics (n=19) and descriptive statistics from the exercise and resting conditions are presented in Table 1. An extreme outlier (greater than two standard deviations from the mean) was seen only at the 60-min post-exercise time point and this subject was excluded from the ANOVA analyses.

Affective responses to exercise

Figure 1 displays the change in PA over time for the exercise and resting conditions. The main effects of condition and time were not significant for PA, but there was a significant condition x time interaction effect (p<0.05). Simple effects for the interaction showed a non-significant effect of exercise on PA (p=0.74) and a trend towards a decrease (p=0.06) in PA immediately following the resting session. However, by 60-minutes post-testing, there was no significant difference between conditions. Of note, baseline ratings of positive affect were not a significant moderator of the interaction effect.

Analyses of the individual data indicated that 58% of subjects reported an increase in PA post-exercise (mean change = 5.7 ± 4.7) while 42% reported a decrease or no change (mean change = −4.9 ± 3.9). The magnitude of increase in PA ranged from 2–15 points (5% to 38% above pre-testing scores) and the range for decrease or no change in PA was 0–11 points (0–61% below pre-testing scores). Only one subject reported no change in PA from pre to post-exercise. Negative affect scores were similar between resting (10.6 ± 0.5) and exercise (10.7 ± 1.1) conditions at baseline (p=0.71) and did not significantly change over time (p=0.17). In fact, from pre- to post-exercise, 79% of subjects reported a negative affect change of zero.

The influence of changes in affect on energy intake post-exercise

To examine the association between changes in PA and EI, EI_{diff} was correlated with each time period throughout the experimental session: pre-test to post-test changes in PA (r=0.–0.47; p=0.04), pre-test to 60-minutes post-test (r=−0.16, p=0.95), and post-test to 60-minutes post-test (r=0.15, p=0.55) were calculated. Given that pre-test to post-test changes in PA were most highly correlated with the EI_{diff}, we further explored this relationship by grouping subjects into 2 categories: 1) increase in PA from pre- to immediately post-exercise (n = 11), and 2) decrease or no change in PA (n = 8). A 2 x 2 ANOVA revealed a trend (p=0.08) and large effect size (Cohen's d=0.84) for those who had an increase in PA from pre- to immediately post-exercise to consume fewer calories post-exercise compared to post-rest (−41 kcal; Figure 2). Those who had no change or a decrease in PA had a higher EI immediately post-exercise compared to post-rest (+63 kcal). Eight of the 11 subjects who had improved PA post-exercise had a lower EI following exercise compared to rest. Similar analyses were performed for NA. The EI_{diff} was not significantly correlated with pre- to post-test (r=0.04; p=0.88), pre- to 60-minutes post-test (r=−0.44, p=0.07), and post-test to 60-minutes post-test changes in NA(r=−0.36, p=0.14). Given these non-significant findings, no further analyses were performed for NA.

DISCUSSION

This study provides initial insight into how a dose of moderate intensity exercise acutely influences affect in sedentary, overweight/obese women. The pattern of change in PA from pre-testing to 60-minutes post-testing was significantly different between the exercise and resting conditions, yet NA was unaltered by the exercise bout. Despite a large degree of variability in the change in PA from pre- to post-exercise, more than half of the overweight women reported an increase in PA following exercise. These findings are consistent with those of Carels, Coit, Young, & Berger (2007), which suggest that some overweight and obese individuals experience the mood enhancing benefits of exercise, similar to those previously seen in active, lean populations (Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991; Yeung, 1996). However, the fact that 42% of the subjects in the current study reported a worsening or no change in PA deserves further attention. Specifically, this finding presents the possibility that a 40-minute bout of exercise may not be affectively rewarding for some sedentary overweight and obese individuals and some individuals may actually feel worse after exercise as compared to before. This may have implications for the dose of exercise that initially should be prescribed for this population. Future studies should examine whether shorter bouts of exercise similarly influence affect.

Understanding how affect changes in response to exercise may also have implications for future eating behavior. In the current study, there was a suggestive trend for individuals who reported improvements in PA immediately post-exercise to consume fewer calories 1–2 hours following exercise compared to a resting condition, and a reverse pattern was seen in those reporting a decrease or no change in PA immediately post-exercise. In light of previous research which demonstrates that emotions influence subjective appetite and eating behaviors (Greeno & Wing, 1994; Hepworth, et al., 2010), the current trend (p=0.08) and large effect size (d=0.84) is consistent with the idea that if exercise alters affect, energy intake will also be influenced when individuals are exposed to food within 2 hours post exercise. In addition, the magnitude of difference in EI between those who had an improvement in PA (−41 kcal) versus those who had a worsening in PA (+63 kcal) should not be overlooked. Research suggests that dietary changes of this approximate magnitude (i.e., 100 calories) can significantly impact weight long-term (Hill, 2009). However, an interesting finding was that affective measurements most proximal to the eating period (i.e., 60 minutes post-exercise) were not significantly correlated with EI. The fact that changes in affect from pre- to immediately post-exercise were most clearly associated with EI warrants further investigation.

Our findings are also partially supported by those of K.L. Schneider et al. (2009), who used a 3-minute, moderate-intensity, stair-stepping task and found that participants who experienced an increase in negative mood post-exercise consumed more calories compared to post-rest. Results from the current study suggest that a decrease in PA may lead to a similar EI response and that NA was not significantly changed by the exercise bout. Together, these findings support the possibility that increases in NA and decreases in PA may both lead to the same behavioral outcome of increased EI. However, our findings that PA and NA were not equally and oppositely affected by exercise are interesting in light of the possibility that PA and NA may be independent entities (Watson & Tellegen, 1985). Further research is needed in order to understand how PA and NA may have independent responses to exercise and uniquely influence eating behaviors.

The current findings are also important given that some people lose minimal, if any, weight when increasing levels of physical activity (Chaput, et al., 2011; Church, et al., 2009; Donnelly, et al., 2003). One possible explanation for these findings is that PA may decrease or remain unchanged post-exercise, and in turn, eating is sought out as a pleasurable reward to improve this worsened affective state. This mechanistic pathway linking both sides of the energy balance equation requires further investigation. Larger scale studies, should examine the effect of different exercise protocols (e.g., duration, intensity, self-paced vs. prescribed exercise) on affect and future eating behaviors. Post-hoc power analyses from the current study may provide informative data for future trials. For example, if a similar categorical approach were to be used, approximately 26 individuals would need to report an improvement in mood from pre- to post-exercise and another 26 would have to report no change or a worsening in mood in order to detect a similar effect size (0.80) with an alpha of 0.05 and 80% power. Future studies may also benefit by manipulating affect and determining how this influences EI.

Strengths of the current study include the counterbalanced design and the use of an exercise bout that is consistent with national recommendations. There are also several limitations. First, the larger project from which this study was designed was not intended to specifically examine this research question. The small sample size limits the power for the current research questions as well as generalizability of the findings beyond sedentary, overweight and obese women. However, these findings do open the door for future exploration in this area. An additional limitation of this study is that although measures were taken to blind subjects to the fact that EI was being measured, it is possible that some individuals altered their food intake after suspecting that EI was being monitored. Lastly, although participants were monitored for up to two hours post-exercise, it is unknown whether changes in affect or EI were altered later in the day, beyond the testing visit.

In conclusion, findings from this study suggest that that overweight, sedentary woman have a large degree of individual variability in affective responses to exercise. Additionally, it is possible that affective responses to a bout of exercise may influence post-exercise energy intake. The reported trend suggests that increased PA following exercise may lead to a reduction in EI while decreased or no change in PA could increase subsequent EI. These findings have the potential to greatly enhance our understanding of factors that may mediate the relationship between exercise and EI. Future research is needed to confirm these findings using different doses of exercise, in different populations, and when extending the EI follow-up period. If these findings can be replicated, strategies to improve affect post-exercise (e.g. tailoring exercise prescriptions to be more enjoyable, use of non-food rewards post-exercise) could be incorporated into weight control interventions and serve as a practical method to assist individuals in controlling their body weight.

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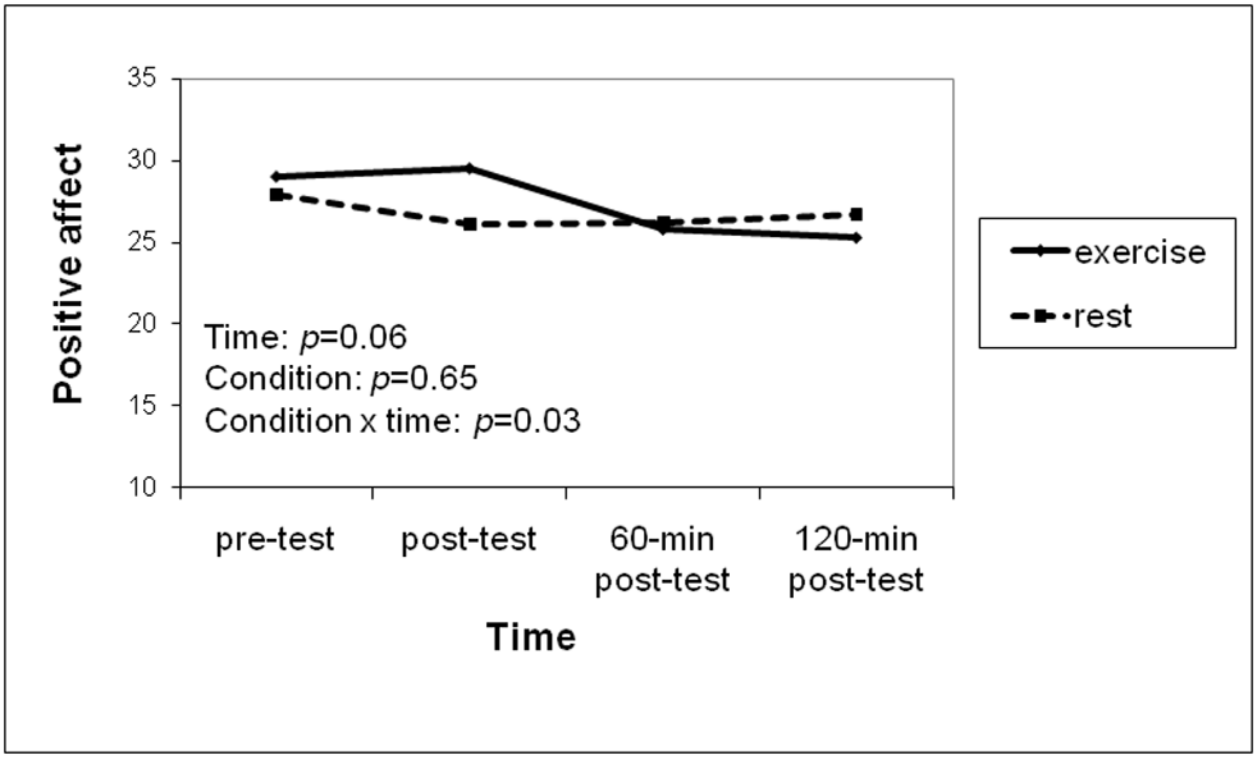

Figure 1.
Changes in positive affect over time for exercise and resting conditions

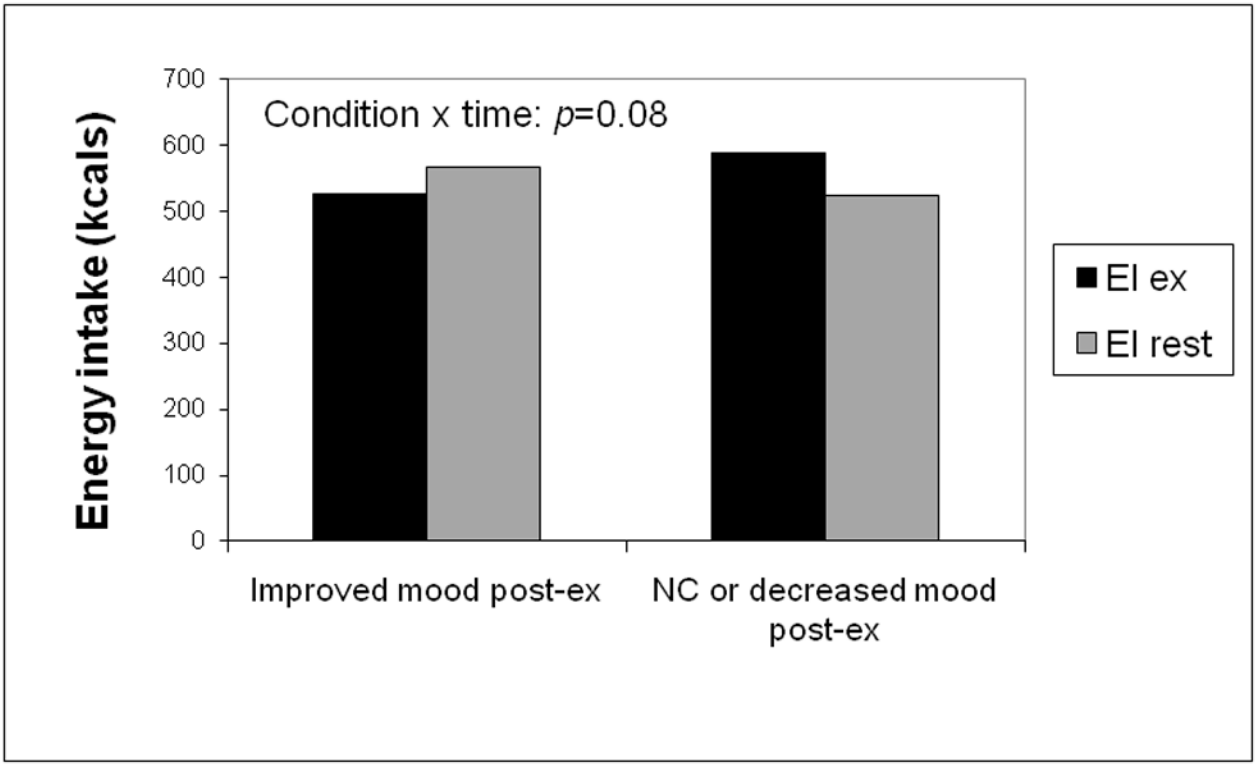

Figure 2.
Energy intake for testing conditions as a function of change in positive affect; PA = positive affect; NC = no change

Table 1

Subject characteristics and descriptive data from the testing sessions

	Mean ± SD
Subject characteristics	
Age (years)	28.5 ± 8.3
Height (cm)	163.0 ± 4.5
Weight (kg)	86.8 ± 13.5
BMI (kg/m^2)	32.5 ± 4.3
Fitness (submax METs)	6.5 ± 3.3
Body composition (% body fat)	41.7 ± 4.9
Testing Session	
Exercise duration (min)	42.3 ± 7.7
Resting duration (min)	35.3 ± 5.1
Energy expenditure of exercise (kcals)	353.6 ± 71.9
Energy expenditure of rest (kcals)	44.3 ± 8.9
EI following exercise (kcals)	551.5 ± 245.1
EI following rest (kcals)	548.6 ± 286.9

Mean ± standard deviation; EI = energy intake; Fitness is expressed as the metabolic equivalent (MET) at 85% of age-predicted maximal heart rate