ACUTE AFFECTIVE RESPONSES TO VARYING DURATIONS OF PHYSICAL ACTIVITY IN OVERWEIGHT AND OBESE ADULTS

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Although participation in physical activity has multiple physical and psychological health benefits, many people continue to be inactive (Tucker, Welk, & Beyler, 2011). Affect, or expressed emotion, throughout an exercise session has been shown to influence compliance to regular physical activity (Williams et al., 2008). National guidelines recommend 30 minutes or more of daily moderate-intensity physical activity, which may be performed in one session or in multiple bouts of at least 10 minutes in duration (U.S. Department of Health and Human Services, 2008). The current study investigated positive affect (PA) and negative affect (NA) in response to moderate-intensity exercise for 10 minutes (EX-10), 40 minutes (EX-40), and a 40-minute resting session (REST). Healthy, overweight and obese women (n = 28, BMI = 32.59±4.25 kg/m^2) participated in the exercise and resting sessions in a randomized, counterbalanced order. Findings showed that PA, but not NA, was significantly influenced by acute bouts of exercise across durations. Specifically, PA over time differed for EX-10 vs. REST and EX-40 vs. REST, respectively, but PA over time did not differ between EX-10 and EX-40. Additional analyses indicated that the intensity of positive affective responses after EX-40 also influenced subsequent caloric intake in an ad libitum eating task. Because both 10-minute and 40-minute bouts increased PA, both are viable options for improving PA and possibly increasing compliance for overweight and obese women within national activity recommendations.

Furthermore, preliminary findings indicate that improvement in PA after longer durations of exercise may favorably influence subsequent eating behavior.

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1.0 INTRODUCTION

Although participation in physical activity has multiple physical and psychological health benefits, many people continue to be inactive (Tucker, Welk, & Beyler, 2011). Promotion of physical activity is increasingly important as sedentary behavior is one of the leading preventable causes of death (Danaei, et al., 2009), and there is an inverse linear relationship between overall duration of physical activity and all-cause mortality (Andersen, Schnohr, Schroll, & Hein, 2000; Lee & Skerrett, 2001; U.S. Department of Health and Human Services, 2008). Moreover, engagement in sufficient doses of physical activity has been shown to reduce the risk of numerous chronic diseases including cardiovascular disease (Tanasescu, et al., 2002; Oguma & Shinoda-Tagawa, 2004), diabetes (Hu, et al., 1999; Jeon, Lokken, Hu, van Dam, 2006) and many forms of cancer (Friedenreich & Orenstein, 2002; Orsini, Mantzoros, & Wolk, 2008), while also providing psychological benefits and improvements in quality of life (Rejeski & Mihalko, 2001; Netz, Wu, Becker & Tenenbaum, 2005; Martinsen, 2008). Additionally, physical activity has been shown to be an important behavior for body weight regulation, contributing 1-3% weight loss beyond that achieved through dietary restriction alone (Donnelly, et al., 2009), as well as maintenance of weight loss and the prevention of weight regain (Sherwood, Jeffrey, French, Hannan, & Murray, 2000; Wing & Phelan, 2005; Jakicic, Marcus, Lang & Janney, 2008). Nevertheless, only 3.0-6.9% of overweight and obese individuals meet recommended activity guidelines for weight management (Bish, et al., 2005). Thus, it is important to understand factors that contribute to physical activity participation in this population.

Affect refers to the expression of an emotion or feeling (American Psychiatric Association [DSM-IV-TR], 2000). Negative affect associated with an exercise session has been linked with decreased future participation in physical activity; whereas, positive affect associated with exercise has been associated with increased participation in physical activity (M. Schneider, Dunn, & Cooper, 2009; Kwan & Bryan, 2010; Williams, et al., 2008; Williams, Dunsinger, Jennings, & Marcus, 2012). For normal weight adults, findings have suggested that an exercise session acutely increases positive affect and decreases negative affect across durations of physical activity, in general (Ekkakakis, Parfitt, & Petruzzello, 2011; Reed & Ones, 2006). For overweight and obese individuals, research has shown that negative affect increases as exercise intensity increases, and obese people may experience more negative affect throughout an exercise session as compared to their normal weight and overweight counterparts (Ekkekakis, Lind, & Vazou, 2010).

Little is known about how the duration of an exercise session influences affect in overweight or obese individuals. A recent study by Unick, Michael, & Jakicic (2012) showed that a session including an approximately 40-minute bout of moderate-intensity activity increased positive affect with no significant changes in negative affect compared to a session including a non-physical activity resting condition in overweight and obese women. Examination of the raw scores signaled that positive affect changes occurred from pre to post-exercise, although the pre-to-post-exercise change in positive affect was not significant. A related study by Schneider, Spring & Pagoto (2009) showed that negative affect responses varied between individuals in response to an exercise bout. Specifically, after a three-minute moderate-intensity exercise task, 37% of participants reported increased negative affect and 63% experienced no change or a decrease in negative affect. Data on positive affect in response to exercise was not reported. Thus, the two studies in this area used different methodologies and showed inconclusive findings regarding the effects of exercise on positive affect and negative affect for overweight and obese adults. In order to make exercise recommendations to overweight and obese adults that provide the most affective benefits and potentially increase compliance, more research is needed that examines affective responses to an exercise session for this population.

Of interest, accumulating bouts of 40 minutes of moderate-intensity physical activity for five or more days of the week appears to be consistent with the 200 to 300 minutes per week of physical activity recommended for overweight and obese adults desiring to lose and maintain weight loss (Jakicic & Otto, 2005; Donnelly et al., 2009). Although three-minute bouts are below the minimum duration level nationally recommended for physical activity, findings by K. Schneider et al. (2009) introduce the possibility that shorter bouts of activity may lead to a different affective response than longer bouts (i.e., 40 minutes) for overweight and obese adults. Activity bouts accumulated in 10-minute sessions are the minimal duration within the national guidelines for physical activity (U.S. Department of Health and Human Services, 2008), and findings by Jakicic, Wing, Butler & Robertson (1995) have demonstrated that overweight and obese adults choose to participate in shorter, 10-minute sessions as compared to longer bouts of activity. For normal weight adults, 10-15 minute walking sessions have been shown to result in improvements in affect (Ekkekakis, Hall, VanLanduyt, & Petruzzello, 2000). However, it is unknown whether there are similar improvements in affect after a shorter bout of physical activity (e.g., 10 minutes in duration) in an overweight and obese population. Moreover, although shorter bouts may be preferred by overweight and obese adults, it is unknown if improvements in affect resulting from a 10 minute bout of physical activity are greater than the improvements in affect resulting from a longer bout of physical activity (e.g., 40 minutes).

In summary, although overweight and obese individuals benefit from regular physical activity due to its physical and mental health benefits as well as its contribution to weight management, evidence indicates that few individuals meet recommendations for regular activity. Affect has been shown to be an important component of the exercise experience, and research suggests that affect associated with exercise may predict later behavior. Across durations of an exercise session, normal weight individuals have been shown to reduce negative affect and increase positive affect, in general. However, less research has been conducted that examines affective responses to varying durations of physical activity for overweight and obese adults. Of the two studies in this area, one found that there was variability in negative affect reported with approximately one-third of the sample having increased negative affect and approximately two-thirds of the sample having no change or a decrease in negative affect after a three-minute exercise bout. The other study showed that positive, but not negative, affect changed significantly over an exercise bout of approximately 40 minutes.

Taken together, there is a gap in the literature regarding the influence of an exercise session on positive and negative affect for overweight and obese individuals, and preliminary evidence suggests there may be differences in affective responses to exercise across initial BMI categories. Furthermore, because overweight and obese individuals may prefer shorter bouts of activity, there is a need for research to examine affective responses to shorter bouts (i.e., 10 minutes) as compared to longer bouts (i.e., 40 minutes), which are durations consistent with national recommendations. Therefore, the primary aim of this study is to compare the effects of varying durations of moderate-intensity physical activity (e.g., 10 minutes and 40 minutes) on affective response to physical activity compared to a non-activity resting condition in overweight and obese adults. The findings have practical implications on the recommended duration of exercise prescriptions for overweight and obese adults.

1.1 CLINICAL IMPLICATIONS FOR WEIGHT CONTROL

The investigation of affective responses to physical activity may reach beyond the influence on future physical activity for overweight and obese adults. There is some evidence that the affective response to a bout of physical activity may influence subsequent eating behavior. For example, recent data showed that 58% of overweight and obese women had a significant increase in positive affect after a bout of moderate intensity physical activity that was approximately 40 minutes in duration (Unick et al., 2012), with 42% of subjects having no change or a reduction in positive affect immediately following this bout of physical activity. When given access to a variety of foods following this bout of physical activity, those who increased positive affect showed a reduction in ad-libitum energy intake of 41 kilocalories (kcal) compared to a non-activity resting condition. Conversely, those who showed no increase or a decrease in positive affect following this bout of activity showed an increase in ad libitum energy intake of 63 kcal compared to a resting condition. K.L. Schneider et al. (2009) reported that 37% of overweight, sedentary individuals had increases in negative affect following a three-minute exercise bout, and this increase in negative affect post-exercise was associated with increased energy intake as compared to a resting control condition. However, it does not appear that any study has directly compared the influence of affective response to a short bout of physical activity (e.g., 10 minutes) to a longer bout of physical activity (e.g., 40 minutes) on ad libitum energy intake post-exercise in overweight and obese adults. More research is needed in order to understand how exercise at varying durations may lead to different affective responses, and subsequently, influence energy intake differently. Thus, a secondary aim of this proposed study is to replicate and extend prior findings by examining the influence of affective responses to a resting control (REST), and 10-minute (EX-10) and 40-minute (EX-40) moderate-intensity physical activity session on subsequent ad libitum energy intake in overweight and obese adults.

1.2 STUDY AIMS

This study proposed to examine the following primary aims:

1. Compare the effects of varying durations of moderate-intensity physical activity (e.g., EX-10 and EX-40) on positive affective response to physical activity when compared to a non-activity resting condition (REST) and across durations in overweight and obese adults.
    a. Hypothesis 1a. We hypothesized that participation in EX-10 would result in significantly greater increase in positive affect as compared to REST.
    b. Hypothesis 1b. We hypothesized that participation in EX-40 would result in significantly greater increase in positive affect as compared to REST.
    c. Hypothesis 1c.We hypothesized that participation in EX-10 would result in significantly greater increases in positive affect when compared to EX-40.

2. Compare the effects of varying durations of moderate-intensity physical activity (e.g., EX-10 and EX-40) on negative affective response to physical activity when compared to a non-activity resting condition (REST) and across durations in overweight and obese adults.
    a. Hypothesis 2a. We hypothesized that participation in EX-10 would result in significantly greater reduction in negative affect as compared to REST.
    b. Hypothesis 2b. We hypothesized that participation in EX-40 would result in significantly greater reduction in negative affect as compared to REST.
    c. Hypothesis 2c. We hypothesized that participation in EX-10 would result in significantly greater reduction in negative affect when compared to EX-40.

As a first step to the proposed examination of energy intake based on affective response to exercise, we first wanted to examine the main effect of experimental condition on energy intake. Therefore, a secondary aim of the proposed study was to:

3. Compare the effects of experimental session condition (EX-10, EX-40, REST) on energy intake in an ad libitum laboratory meal 1-2 hours after each session.
    a. Hypothesis 3a. We hypothesized that participation in EX-10 would result in a significant difference in energy intake in an ad libitum laboratory meal 1-2 hours post-exercise as compared to REST.
    b. Hypothesis 3b. We hypothesized that participation in EX-40 would result in a significant difference in energy intake in an ad libitum laboratory meal 1-2 hours post-exercise as compared to REST.

c. Hypothesis 3c. We hypothesized that EX-10 would result in a significant difference in energy intake in an ad libitum laboratory meal 1-2 hours post-exercise when compared to EX-40.

In order to replicate and extend prior findings, there was also interest in understanding how positive and negative affective change (an increase or decrease/no change in affect) post-exercise influences energy intake. Although we were unable to know the distribution of people with increases or decreases/no change in affect after exercise, we proposed the following a priori secondary aims in order to improve our understanding of this research area. Therefore, the secondary aims of the proposed study were also to:

4. Compare energy intake in an ad-libitum laboratory meal 1-2 hours after the experimental sessions between those who reported an increase in positive affect post-exercise and those who reported a decrease or no change in positive affect post-exercise, controlling for changes in positive affect after the resting condition.
    a. Hypothesis 4a. We hypothesized that those who increased positive affect after EX-10 would have a significant difference in energy intake after EX-10 as compared to those who had a decrease or no change in positive affect after EX-10.
    b. Hypothesis 4b. We hypothesized that those who increased positive affect after EX-40 would have a significant difference in energy intake after EX-40 as compared to those who had a decrease or no change in positive affect after EX-40.

5. Compare energy intake in an ad-libitum laboratory meal 1-2 hours after the experimental sessions between those who reported an increase in negative affect post-exercise and those who reported a decrease or no change in negative affect post-exercise, controlling for changes in negative affect after the resting condition.
    a. Hypothesis 5a. We hypothesized that those who increased negative affect after EX-10 would have a significant difference in energy intake after EX-10 as compared to those who had a decrease or no change in negative affect after EX-10.
    b. Hypothesis 5b. We hypothesized that those who increased negative affect after EX-40 would have a significant difference in energy intake after EX-40 as compared to those who had a decrease or no change in negative affect after EX-40.

Preliminary findings have suggested that initial body mass index (BMI) may influence the relationship between experimental condition and affective response to exercise (Ekkekakis et al., 2010; Unick, et al., 2012), but the direction of this relationship is unclear. Thus, the exploratory aim of the current study is to:

6. Examine initial BMI as a moderator of positive and negative affective change in response to each experimental condition.

2.0 LITERATURE REVIEW

2.1 AFFECT

Affect, emotion, and mood are terms that have been used interchangeably and inconsistently in relevant literature, and a clear definition of affect is needed in order to guide the current study. Emotion is a subjective state of feeling, and it can be manifested through mood or affect. Traditionally, psychiatric literature has distinguished mood and affect based on the degree to which the emotion is experienced vs. expressed and the temporal duration of the emotion. Specifically, mood has been defined as a sustained, internal experience of emotion, whereas affect is a fluctuating, external expression of emotion (American Psychiatric Association [DSM-IV-TR], 2000). Theory from the emotion literature, however, indicates that emotion (i.e., mood and affect) may be conveyed by various modes such as self-report, expressive behavior, physiological indices, and the context of a situation (Cohn, 2006). Thus, mood and affect may differ primarily on the temporal experience of the emotion, with mood being a longer lasting experience as compared to affect, which is sensitive to momentary changes. In the context of an exercise session, fluctuations in self-reported emotion have been shown throughout an exercise bout and even post-exercise (e.g., Backhouse, Ekkekakis, Biddle, Foskett, & Williams, 2007). Therefore, in conducting a study examining emotion in response to an exercise, affect is believed to be the appropriate construct to measure due to the sensitivity of affect to momentary changes.

Positive affect is defined as pleasurable engagement with the environment, such as happiness, joy, excitement, enthusiasm, and contentment (Clark, Watson, Leeka, 1989), whereas negative affect is a construct marked by various negative states including, but not limited to sadness, nervousness, tension, worry, anger, and self-dissatisfaction (Watson & Tellegen, 1985). Conceptually, affect is thought to exist on a circumplex that contains two orthogonal, overlapping dimensions. There are two different circumplex models of affect, and they differ based on the contentious issue of whether positive and negative affect are endpoints on the same dimension or separate dimensions completely. Russell (1980) proposed that there are two dimensions of affect, pleasure and activation, and affective states are formed from combinations of these dimensions. In this model, the pleasure dimension is bipolar and includes a range of positive and negative affective states, and the activation dimension reflects the valence of the affective state. On the other hand, Watson and Tellegen (1985) proposed that negative affect and positive affect are two separate dimensions, and activation is represented by intensity of the affect reported. Negative affect is believed to be independent of the experience of positive affect, and high negative affect does not necessarily imply a lack of happiness, joy, or other positive emotions (Watson & Clark, 1984). Furthermore, as mutually independent influences, negative affect is believed to impact behavior independently from positive affect. This conceptualization is supported by evidence that the processes of affect are bivariate, and both positive and negative affect may be activated simultaneously (Larsen, McGraw, & Cacioppo, 2001).

2.1.1 Timing and Measurement of Affect

The present study will examine *state affect*, which is thought to be an "in the moment" situational account of affect and is distinguished from *trait affect*, which is believed to be a more enduring tendency to have a certain affective response (Watson & Clark, 1984). State affect is typically measured by having individuals report affect during a particular time frame using a questionnaire or a palmtop computer for "real-time" data collection. However, there is variation in the assessments of negative and positive affect given the various conceptualizations of this construct. For instance, positive and negative affect have been viewed as constructs that include the frequent experience of positive emotions (e.g., happiness and joy) and negative emotions (e.g., sadness and anger), respectively. In these cases, affect is measured by examining the frequency with which people experience certain affective states, and typical measures include the Positive Affect and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) or the Profile of Mood States (POMS; McNair, Lorr, & Droppelman, 1971). Measures have also been used that examine specific negative affective states such anxiety or depression, but less research has been conducted examining changes in specific positive affective states. In the physical activity context, measures such as the Subjective Exercise Experiences Scale (SEES; McCauley & Courneya, 1993) and Exercise-Induced Feeling Inventory (EFI; Gauvin & Rejeski, 1993) have been developed to examine the degree to which people endorse affective states believed to be specific to exercise. Generally, the use of self-reported adjectives to represent affect has had good validity. For instance, Sandvik, Diener, & Seidlitz (1993) found convergence between a self-report questionnaire, interview ratings, peer reports, average daily mood ratings, and memory for pleasant events subtracted from unpleasant events.

2.2 AFFECT AND PHYSICAL ACTIVITY

Participation in exercise has been shown to influence positive and negative affect, and affective responses to an exercise session may influence later physical activity behavior. In general, an acute bout of exercise has been shown to increase state positive affect and decrease state negative affect post-exercise, and these effects have been shown to vary across intensity and duration of the exercise session (see review by Ekkekakis et al., 2011). Additionally, research has shown that more favorable affective responses associated with an exercise session may increase exercise adherence in the short term (i.e., 7 days; M. Schneider et al., 2009) and the long term (i.e., 3-12 months; Kwan & Bryan, 2010; Williams et al., 2009; Williams et al., 2012), and these effects are consistent across measures. Specifically, the Feeling Scale (Rejeski, Best, Griffith, & Kenney, 1987), which is a bi-polar (i.e., negative to positive) rating scale, was used by 3 of the studies (M. Schneider et al., 2009; Williams et al., 2009; Williams et al., 2012), and the Physical Activity Affect Scale (Lox, Jackson, Tuholski, Wasley, & Treasure, 2000), in which individuals are asked to rate the intensity of both positive and negative affective states, was used by one study (Kwan & Bryan, 2010).

Less information is known about changes in positive and negative affect throughout exercise for overweight and obese women, and more work is needed because it is possible that affective responses to exercise may influence later activity behavior. Sedentary and overweight women have been shown to prefer to exercise at a moderate-vigorous intensity level (Ekkekakis

& Lind, 2006; Lind, Joens-Matre, & Ekkekakis, 2005), and exercising at a self-selected intensity has been shown to promote positive affective responses (Ekkekakis & Lind, 2006; Lind, Ekkekakis, & Vazou, 2008; Parfitt, Rose, & Burgess, 2006). Thus, it is believed that more variability, and thus more opportunity for intervention, may occur regarding duration of an exercise. The next section will review the current literature on exercise duration and affect for normal weight as well as overweight and obese individuals.

2.2.1 Exercise Duration and Affect

2.2.1.1 Findings for Normal Weight Individuals

Initial research examining shorter bouts of exercise (i.e., < 20 minutes) and affective response produced null findings (Morgan, Roberts, & Feinerman, 1971; Sime, 1977), yet these studies contained methodological limitations in their measurement of affect. Namely, in the study by Morgan et al., (1971), affect was rated post-exercise in the absence of pre-session measurement, which does not allow for the examinations of changes in affect. In the other reported study by Sime (1977), affect ratings were delayed until after the exercise recovery period, and due to the labile nature of affect, these findings may overlook the acute and immediate responses of post-exercise affect.

More recent research examining affective responses to exercise has typically shown that improvements in affect are possible after 10-15 minute bouts of exercise, although there are differential reported effects for positive and negative affect. Two studies have shown that moderate intensity running for durations across 10 to 40 minutes have increased positive affect and decreased negative affect for mostly active undergraduate age students (Rudolph, Butki, &

Blake, 1998; Blanchard, Rodgers, & Gauvin, 2004). In the absence of positive affect measures, reductions in negative affect have also been shown after a 10-minute or 20-minute exercise bout, as compared to a 20-minute resting control condition for moderately active undergraduate students (Butki & Rudolph, 1997; Rudolph, Butki, & Blake, 1998). Additionally, using four samples of healthy, mostly active, undergraduate students and a bipolar measure of positive and negative affect, Ekkekakis et al. (2000) demonstrated that affect consistently improved after 10-15 minute bouts of exercise.

Larger scale reviews have also shown that both short and long bouts of exercise performed by normal weight individuals have similar effects on positive and negative affective response for durations up to 60 minutes of exercise (e.g., Reed & Ones, 2006; Landers & Arent, 2007). However, few studies have specifically compared affective responses to longer and shorter bouts using the same sample. Two studies have examined affective responses to exercise among normal weight women using a within-subjects, counterbalanced design. Daley & Welch (2004) showed that participants demonstrated improvements in positive affect and reductions in negative affect across exercise conditions, and there were no significant differences in affective responses after participation in a 15-minute bout as compared to a 30-minute bout. In comparison to a 30-minute resting condition, Hansen, Stevens, & Coast (2001) examined affective responses to exercise sessions lasting 10, 20, and 30 minutes. Overall, exercising for 10 minutes was sufficient for increasing positive affect, decreasing fatigue, and decreasing total negative mood state as compared to the resting condition. Increasing the duration of exercise bouts also resulted in improvements in affective states as compared to the resting condition, and the affective benefits did not increase significantly as duration increased. Thus, the limited research in this area suggests that improvements in affect are possible for short bouts and longer bouts of physical activity. However, further research needed to understand if affective responses to activity differ across durations of activity and if these effects are different for overweight and obese individuals.

2.2.1.2 Findings in Overweight and Obese Individuals

Two studies have examined affective responses to moderate-intensity exercise for overweight and obese adults. After an exercise session of approximately 40 minutes, Unick, et al. (2012) showed that 58% of overweight and obese women had increases in positive affect post-exercise, and negative affect did not change as compared to a resting condition. In contrast, K.L. Schneider et al. (2009) had overweight men and women participate in a stair-stepping task for three minutes, and results showed that participants demonstrated decreases in negative affect post-exercise, as compared to a resting condition. Taken together, there is initial evidence that a session of moderate-intensity activity may influence positive and negative affect for overweight and obese adults, and the effects on affect may differ when comparing shorter bouts (i.e., three minutes) and longer bouts of activity (i.e., 40 minutes). However, in order to directly compare the effects of varying durations of activity, further research is needed that compares the affective responses to exercise for shorter and longer bouts of activity for overweight and obese adults within the same sample. Of note, a 40-minute exercise session, if utilized on five or more days of the week, is consistent with national recommendations for physical activity for weight management for overweight and obese adults; a three-minute session is not. Thus, it is reasonable for research to examine 40-minutes as longer bouts of physical activity, but future research examining exercise sessions comparing shorter bouts of activity should be consistent with national recommendations for physical activity for exercise (i.e., $\geq$ 10 minutes).

2.2.1.3 Exercise Duration and Affect Summary

There is evidence for normal weight individuals that positive affect consistently increases and negative affect decreases across durations of exercise sessions lasting 60 minutes or less, yet further research is needed to specifically compare affective responses to exercise at varying durations. Of two studies that measured negative and positive affect in overweight and obese adults, one study showed that positive affect increased post-exercise and negative affect did not change, and one study showed that negative affect decreased post-exercise and positive affect was not reported. These findings were demonstrated in separate studies with exercise sessions lasting 3 minutes and 40 minutes, respectively. Additional work is needed to compare affective responses to exercise at varying durations of physical activity for overweight and obese adults using exercise bouts that are consistent with national recommendations.

2.2.2 Affect and Physical Activity: Experimental Framework

Moderate-intensity exercise consistent with national recommendations for physical activity has been shown to produce affective benefits for overweight and obese individuals. Less is known about the acute affective responses to exercise for this population. Initial findings have shown that across durations of activity, positive affect increases (Unick, et al., 2012) and negative affect decreases (K.L. Schneider et al., 2009). Thus, we hypothesized that in response to moderate-intensity exercise, overweight and obese people will experience increases in positive affect and decreases in negative affect post-exercise across durations of activity.

There is evidence that overweight and obese people prefer shorter bouts of activity as compared to longer bouts. Specifically, over the course of a 20-week exercise intervention, Jakicic et al. (1995) demonstrated that women assigned to exercise in short bouts reported exercising for significantly more days (mean = 87.3 days) and for a greater duration (223.8 minutes/week) as compared to those assigned to exercise in one continuous bout (mean days = 69.1; mean duration = 188.2 minutes). One possible explanation for this effect is that short bouts lead overweight and obese people to "feel better," or have a more profound effect in increasing positive affect and decreasing negative affect, as compared to longer bouts of activity. Based on initial findings, we hypothesized that increases in positive affect and decreases in negative affect will be greater after a short bout than a long bout of exercise.

2.3 ACUTE AFFECT AND EXERCISE: CLINICAL IMPLICATIONS FOR WEIGHT CONTROL

Investigating the influence of exercise on acute affect may reach beyond the effects on exercise adherence and also have clinical implications for weight control. Research has shown that affective responses to an exercise session influence subsequent energy intake within hours post-exercise for overweight and obese adults (Unick et al., 2012; K.L. Schneider et al., 2009). Specifically, findings have shown that individuals who report evidence of improved affect after an exercise session consume less than those who indicate feeling worse after exercise. Of relevance to this research area, there is also evidence that certain individuals respond to increasing levels of physical activity by increasing overall energy intake post-exercise whereas others do not (e.g., Blundell et al., 2003). Namely, individuals are distinguished by their choice of whether or not they "compensate" for the energy deficit caused by an exercise session by subsequently increasing their eating. This section will review the evidence suggesting that affect may be a link connecting exercise sessions and acute energy intake.

2.3.1 The Role of Exercise in the Weight Loss Context

Body weight is controlled by energy intake (EI) and energy expenditure (EE). When EI and EE are equal, weight is stable, or in a state of energy balance. When EE is greater than EI, weight loss occurs, and when EI is greater than EE, weight gain occurs. Exercise, which contributes to energy expenditure, has been indicated as a modest independent contributor to weight loss (average loss = 1-3% of body weight) when used at nationally recommended levels (Donnelly, et al., 2009; U.S. Department of Health and Human Services, 2008). Although frequently masked by research reporting average weight losses, there is individual variability in weight loss outcomes for those adopting exercise in the absence of dietary intervention (King, Hopkins, Caudwell, Stubbs, & Blundell, 2008).

One explanation for why some individuals gain or maintain their weight in the context of an exercise intervention is that they engage in compensatory eating behaviors that offset the energy deficit caused by exercise (Blundell, Stubbs, Hughes, Whybrow, & King, 2003). Research by King, et al. (2008) examined the influence of regularly scheduled, supervised exercise sessions over 12 weeks on energy intake for overweight and obese, sedentary individuals. Results showed that the average body weight significantly decreased over time. Further examination showed that subjects could be grouped as "compensators" and "non-compensators" based on their different behavioral compensatory responses to the exercise program. "Compensators" lost less than the predicted weight loss or actually gained weight, and "non-compensators" lost equal to or more than the predicted weight loss. Specifically, "compensators" showed average increases in energy intake of 268.2 kcal/day, whereas "non-compensators" showed average decreases in energy intake of 130 kcal/day. Taken together, there is suggestive evidence that certain individuals increase energy intake in response to exercise and other individuals may not.

2.3.2 Physiological Evidence for Exercise and Acute Energy Intake

Changes in factors related to appetite regulation have been targeted as one possible reason why exercise sessions may influence energy intake in overweight and obese adults, although there are few studies in this area. Adam & Westerterp-Plantenga (2004) showed that an appetite-regulating hormone, glucagon-like peptide-1 (GLP-1), did not change after an exercise session in obese individuals, although it increased for normal weight individuals, which is indicative of appetite suppression. Marzullo et al. (2008) found that after a maximal exercise test, both normal weight and obese subjects had decreases in ghrelin, a hormone with an appetite suppression effect, and the effect was attenuated in obese subjects. Across both studies, the results suggest that overweight and obese subjects may have different physiological responses to exercise as compared to normal weight individuals.

In order to examine this effect in relation to energy intake for overweight and obese adults, Unick et al. (2010) investigated the acute effect of moderate-intensity walking on appetite-regulating hormones and hunger and subsequent energy intake in an ad libitum eating session. Results showed that acylated ghrelin, GLP-1, and reported hunger did not change after an approximately 40-minute walking task. Furthermore, acylated ghrelin, GLP-1, and reported hunger were not associated with subsequent energy intake in the laboratory meal. Taken together, although research in this area is limited, the few studies examining physiological factors have not provided a decisive link between exercise and energy intake in overweight and obese adults.

2.3.3 Psychological Evidence for Exercise and Acute Energy Intake

Emotion has consistently been associated with eating behavior (e.g., Macht, 2008), and one plausible link between exercise and energy intake is that affective responses to exercise may influence subsequent energy intake for overweight and obese individuals. Research has shown that the relationship between emotion and eating is exceedingly complex, with individual variability in dietary restraint, intensity of the emotion, and available food choices being three of many factors related to energy intake (Macht, 2008). However, on a basic level, experimental evidence shows that many people use eating as a way to regulate negative emotions, and these effects have been shown across normal weight individuals, and anecdotally and experimentally among overweight, obese (Eldredge & Agras, 1996; Gluck, Geliebter, Hung, & Yahav, 2004; Macht, Haupt, & Ellgring, 2005). In contrast, experiencing positive emotions may lead eaters to choose more healthy foods and perceive food as being more pleasant (Lyman, 1982; Macht, 1999; Macht, Roth & Ellgring, 2002).

There is suggestive evidence that psychological factors may also provide a link between an acute exercise bout and subsequent energy intake. In a sample of normal weight women, Finlayson, Bryant, Blundell, & King (2009) examined the influence of hedonic wanting for food on energy intake in an ad libitum laboratory meal following a 50-minute exercise session and a

50-minute resting condition. Findings showed a distinction between "non-compensators," who ate approximately the same or less after exercise as compared to rest and "compensators" who ate more after exercise as compared to rest. Results showed that participating in exercise led to reported increases in hedonic ratings of food for compensators but not for non-compensators. Specifically, compensators rated the test meal as less pleasant after the sedentary condition as compared to non-compensators, and there were no group differences in pleasure ratings after the exercise condition. The authors concluded that there may be "reward-based" mechanisms for those with a tendency to compensate by eating post-exercise.

Research in overweight and obese adults suggests that affective responses to exercise may be a plausible link between exercise and energy intake. As outlined previously, K.L. Schneider et al. (2009) found that after a three-minute stair stepping task, participants demonstrated decreases in negative affect post-exercise, but positive affect did not change, as compared to a resting condition. Interestingly, those with increases in negative affect post-exercise consumed significantly more at an ad libitum laboratory meal, as compared to those with a decrease or no change in negative affect post-exercise. In contrast, Unick et al. (2012) showed that 58% of women had increases in positive affect after an approximately 40 minute moderate-intensity walking bout, and negative affect did not change as compared to a resting condition. There was a non-significant trend (p = 0.08) that those who increased positive affect post-exercise ate less than those who had a decrease or no change in positive affect post-exercise. Of note, this was the same sample of individuals in Unick et al. (2010) in which changes in physiological factors (i.e., ghrelin, GLP-1, hunger) were found to be unrelated to energy intake. Thus, there are preliminary data, which suggest affective changes, rather than physiological changes, may provide the link between exercise and energy intake.

2.3.4 Acute Affect and Exercise: Clinical Implications Summary

Physical activity has been shown to be a modest contributor to weight loss when adopted in the absence of dietary intervention. Research has shown that one possible reason for this effect is that individuals "compensate" for energy deficits caused by exercise by increasing subsequent energy intake. Although there is limited research in this area, physiological factors involved with appetite regulation have not been shown to link exercise and acute energy intake, and preliminary evidence suggests that psychological factors may be involved in this process. Namely, two studies have demonstrated that affective responses to an acute bout of exercise influence subsequent energy intake, but the studies showed conflicting findings concerning the role of positive and negative affect, respectively. Further research is needed in order to investigate affective responses to exercise as a possible link between an exercise session and energy intake "compensation."

2.3.5 Affect, Exercise, and Energy Intake: Experimental Framework

Research has shown that participation in acute bouts of exercise is related to later energy intake. Research on appetite regulating hormones has not provided a decisive link between exercise and energy intake in overweight and obese adults. Rather, there is preliminary suggestive evidence that affective responses to an exercise session influence subsequent energy intake within hours post-exercise for overweight and obese adults (Unick et al., 2012; K.L. Schneider et al., 2009).

In the current study, we expect a pattern by which certain individuals do not have expected affective responses to an acute exercise session (i.e., increases in positive affect and decreases in negative affect). Rather, some individuals may experience decreases or no change in positive affect and increases/no change in negative affect post-exercise. For both short and long exercise bouts, we hypothesized that people who increase in positive affect post-exercise will have a significant difference in energy intake as compared to those who have a decrease or no change in positive affect post-exercise. Similarly, we hypothesized that for both short and long exercise bouts, those with decreased negative affect post-exercise will have a significant difference in energy intake as compared to those who have an increase or no change in negative affect post-exercise.

2.4 SUMMARY OF LITERATURE REVIEW

Overweight and obese individuals may benefit from regular physical activity due to its physical and mental health improvements as well as its contribution to weight management, yet evidence indicates that only a small proportion of overweight and obese people meet recommendations for regular activity. Previous research has shown that affect associated with exercise may predict subsequent physical activity behavior (M. Schneider et al., 2009; Kwan & Bryan, 2010; Williams, et al., 2008; Williams et al., 2012). Further research is needed that examines affective responses to exercise for overweight and obese individuals, as these findings may have clinical implications for exercise prescription for this population.

Of two studies that measured affective responses to exercise for overweight and obese adults, one study showed that positive affect increased after an exercise bout and negative affect did not change after a 40-minute bout, and one study showed that there was individual variability in negative affect responses after a three-minute bout. In order to make exercise prescriptions that produce the most affective benefit and that may maximally increase adherence, more research is needed to compare affective responses to exercise at shorter and longer durations of physical activity for overweight and obese adults. Evidence indicates that overweight and obese individuals prefer shorter bouts of physical activity as compared to longer bouts, and it is hypothesized that shorter bouts may yield more affective benefit for this population than longer bouts of activity.

In addition to the implications for physical activity adherence, the importance of studying affective responses to physical activity among overweight and obese adults also has clinical implications for weight control. Research has shown that overweight and obese individuals may "compensate" for energy deficits caused by exercise by increasing subsequent energy intake. Preliminary research examining physiological factors involved with appetite regulation has not been shown to link exercise and acute energy intake, yet there is evidence that psychological factors may be involved in this process. Namely, two studies have demonstrated that affective responses to an acute bout of exercise influence subsequent energy intake. However, the studies showed conflicting findings concerning the role of positive and negative affect, respectively. Further research is needed in order to investigate affective responses to exercise as a possible link between an exercise session and acute energy intake.

3.0 METHODOLOGY

3.1 SUBJECTS

Thirty pre-menopausal, sedentary, overweight and obese women were recruited to participate in this study. Inclusion criteria were: female, between the ages of 18 and 45, BMI > 25.0 kg/m^2 and < 40 kg/m^2, and participating in an average of < 90 minutes per week of moderate to vigorous intensity physical activity during the previous six months. All participants provided informed consent, and signed consent forms were approved by the University of Pittsburgh Institutional Review Board. In order to study a distribution of women across the range of BMI classifications, an effort was made to equally recruit individuals across the overweight (25.0-29.9 kg/m^2), Class I obese (30.0 – 34.9 kg/m^2), and Class II obese (35.0 – 39.9 kg/m^2) BMI categories. Subjects were excluded based on factors that contraindicated for participation in an exercise bout or influenced energy intake and affective response in ways other than the experimental session. The exclusion criteria for the study and the rationale for exclusion are listed below:

1) Presence of any condition that may limit ability to exercise (i.e., orthopedic limitations or severe arthritis)
    - Rationale: Women with these conditions may not safely participate in the exercise sessions proposed in the study without experiencing pain or discomfort.

2) Having uncontrolled hypertension (non-medicated resting systolic blood pressure ≥ 140mmHg or non-medicated diastolic blood pressure ≥ 90mmHg) or currently taking medication that would alter blood pressure, heart rate (e.g. beta blockers)

    - Rationale: Having hypertension or taking medication that affects heart rate or blood pressure is contraindicated for participation in the exercise sessions designed for the current study (ACSM, 2009).

3) Presence of any medical condition that may alter metabolism (i.e., thyroid disease) or taking medication that may alter metabolism (e.g., synthroid).

    - Rationale: Participants with medical conditions that affect metabolism or those who take medications that affect metabolism were excluded because these factors may influence energy needs and energy intake (e.g., Leibel, Rosenbaum, & Hirsch, 1995).

4) Weight loss of ≥ 10 pounds within the previous 6 months

    - Rationale: Participants with a recent weight loss (≥ 10 pounds in the past 6 months) were excluded because they may have experienced an alterations in their metabolism, which influence energy needs and energy intake (e.g., Leibel, Rosenbaum, & Hirsch, 1995).

5) Currently menopausal, post-menopausal, or reporting irregular menstrual cycles (<25 days or >35 days between cycles) as obtained by self-report

    - Rationale: Hormone concentrations may be affected by menopausal, post-menopausal, or having irregular menstrual cycles. Because research has shown that differences in hormone concentrations may influence energy intake (e.g., Poehlman, Toth, & Gardner, 1995; Wei, Schmidt, Dwyer, Norman, & Venn, 2009), as well as affect (e.g., Joffe & Cohen, 1998), individuals with these characteristics were excluded.

6) Currently pregnant, pregnant during the previous six months, or planning to become pregnant in the next two months as obtained by self-report

   - Rationale: It is not clear if participation in moderate intensity exercise in the current protocol is contraindicated for pregnant women, and for this reason, pregnant women were excluded. Hormone concentrations may be affected by a recent pregnancy, and because research has shown that differences in hormone concentrations due to pregnancy may influence energy intake (e.g., Ladyman, Augustine, & Grattan, 2010), individuals who were recently pregnant were excluded. Furthermore, women were asked to complete the experimental sessions within 1-2 months of beginning the protocol. Therefore, because women who were planning to become pregnant in the next two months may become pregnant, they were excluded from the study.

7) Currently smokes cigarettes

   - Rationale: Because regular cigarette smoking has been shown to influence energy intake (e.g., de Castro & Taylor, 2008) and weight (Kleges, Meyers, Kleges, LaVaque, 1989), and abstinence from smoking has been shown to influence affect (e.g., Kassel, Stroud, & Paronis, 2003), smokers were excluded from the current study.

8) Currently being treated for any psychological disorder or taking any psychotropic medications as obtained by self-report

- Rationale: Individuals with psychological disorders were excluded due to the fact that symptoms may include disruptions in affect, appetite, and possible subsequent energy intake, as these characteristics are evident within the criteria for common mental disorders (DSM-IV-TR, 2000). Furthermore, because medications for psychological illness are designed to modify affective responses and may also influence appetite and energy intake (e.g., Samanin & Garattini, 1990), those taking psychotropic medications were also excluded.

9) Getting an average of < 6 hours of sleep per night as obtained by self-report
    - Rationale: Due to suggestive evidence that short duration of sleep is inversely related to upregulation of appetite and energy intake (e.g., Knutson, Spiegel, Penev, Van Cauter, 2007), individuals classified as short sleepers (< 6 hours per night) were excluded from the current study.

3.2 RECRUITMENT AND SCREENING

3.2.1 Recruitment Methods

Several methods of recruitment were used for this study. Specifically, advertisements were delivered through various media outlets (e.g., internet, flyers) in Pittsburgh and the greater Pittsburgh area. All advertisements instructed individuals to call the Physical Activity and Weight Management Research Center (PAWMRC). Interested callers were informed about the study procedures, and if they provided verbal informed consent, they underwent a brief phone screening with a staff member. If a woman was deemed potentially eligible for the study, she was mailed an information packet with pre-test guidelines and was scheduled for an orientation session.

3.2.2 Initial Orientation Session

All women determined to be potentially eligible after the phone screening were invited to the laboratory for an orientation session. At this time, the study was explained in complete detail and interested individuals were given the opportunity to ask questions about the study prior to signing consent forms. Once written informed consent was obtained, subjects were asked to complete the Physical Activity Readiness Questionnaire (PAR-Q; Blair, et al., 1985) to ensure that they had no contraindications to engaging in moderate-to-vigorous intensity physical activity. The PAR-Q contains seven items, and individuals were asked to check a box indicating "yes" or "no" in response to statements that may influence their ability to participate in physical activity. A staff member reviewed the form, and if a "yes" response was indicated for any of these items, the individual was not eligible to participate in this study.

3.2.3 Screening Visit

Individuals who appeared to be eligible after completion of the orientation session were scheduled for additional screening visit to confirm eligibility prior to participation in experimental sessions. Prior to the screening visit, individuals were instructed to fast for at least four hours prior to the visit, avoid consumption of over-the-counter medications for 24 hours prior to the visit, abstain from all vigorous physical activity for 24 hours prior to the visit, and transport themselves to the laboratory in a method that did not allow for excessive physical exertion (i.e., by car or bus). Individuals were required to self-report their compliance to these directives. The screening visits occurred between 7 AM and 5 PM and included the following measures to confirm eligibility for this study.

Body Weight: Body weight was measured to the nearest 0.1 pounds using a calibrated digital scale. Subjects were weighed in a lightweight, cloth, hospital gown with their shoes removed.

Height: Height was assessed to the nearest 0.1 cm using a wall-mounted stadiometer. Subjects were asked to remove their shoes for the measurement.

Body Mass Index (BMI): Measurements of height and body weight were used calculate BMI, which is represented as kg/m^2. BMI was used to confirm that each subject met the inclusion criteria for this study.

Resting Blood Pressure: Resting blood pressure was measured following a 5-minute seated resting period. Blood pressure was measured in duplicate, with 30 seconds elapsing between these measurements. If necessary, additional measures were performed until two measures that met the criteria of systolic blood pressure differing by $\leq$10 mmHg and diastolic blood pressure differing by $\leq$6 mmHg. The average of the two measures were used to represent resting blood pressure, which was used to confirm that the subject met the inclusion criteria.

Cardiorespiratory Fitness: A submaximal graded exercise test (GXT) on a motorized treadmill was used to confirm that there were no contraindications to participation in moderate-intensity physical activity as well as provide an estimate of fitness by measuring maximal oxygen consumption ($V0_2$; L/min). The speed of the treadmill was held constant at 80.4 m/sec

(3.0 mph). Grade (elevation) of the treadmill was initiated at 0% and increased by 1% at 1-minute intervals until the subject achieved 85% of age-predicted maximal heart rate, with age-predicted maximal heart rate computed as 220 minus age. Heart rate was measured using a 12-lead electrocardiogram (ECG) during the last 10 seconds of each minute, with blood pressure measured during the final 45 seconds of each even-number exercise stage (e.g., 2nd, 4th, 6th, etc.). Heart rate and blood pressure were measured at the point of test termination and throughout the 5 to 10 minute recovery period. The test was terminated prior to achieving 85% of age-predicted maximal heart rate if any of the test termination criteria outlined the American College of Sports Medicine be achieved (ACSM, 2009). A cardiologist reviewed the ECG results from the exercise test, and only those subjects receiving medical clearance based on this test were eligible for further participation in this study.

3.3 EXPERIMENTAL DESIGN AND MEASURES

Subjects who remained eligible following the completion of all screening procedures participated in all three experimental sessions. These included: 1) a 30-minute rest period followed by a 10-minute exercise session (EX-10); 2) a 40-minute exercise session (EX-40); and 3) a 40-minute resting session (REST). Participants were randomized using a counterbalanced design, and each participant completed all of the three experimental sessions. Experimental sessions occurred in the morning and were separated by at least 2 days. In addition, as conducted in previous research (K.L. Schneider et al., 2009; Unick et al., 2012), experimental sessions were scheduled between days 7 and 21 of each woman's menstrual cycle, as determined by self-report, to minimize the effect of hormone concentrations on outcome measures. In order to limit time passed across all of the visits, participants were given two months to complete the experimental sessions after being randomized.

Prior to each experimental session subjects were instructed to adhere to the following guidelines: 1) abstain from exercise for 2 days prior to the experimental session, 2) keep a detailed food record for 2 days prior to the experimental session, 3) get at least 6 hours of sleep on the 3 nights prior to the experimental session, 4) consume a preload meal 2 hours prior to the session, as described below, and 5) abstain from all other food and drink besides water on the morning of the experimental session. These guidelines are consistent with the methods used by Unick et al. (2012). Compliance to these directions was verified via self-report prior to each experimental session.

3.3.1 Preload Meal

Prior to each experimental session the subjects were instructed to consume a preload meal in the form of a commercially available shake. The shake was provided to the subject by the investigator. The energy content of the preload meal was equivalent to 15% of estimated resting metabolic rate, with resting metabolic rate estimated using the Mifflin-St. Joer equation (Mifflin et al., 1990). Compliance to consuming the preload meal was verified via self-report prior to each experimental session.

3.3.2 Measurement of Heart Rate during Experimental Sessions

During each of the experimental sessions, minute-by-minute heart rate and energy expenditure was assessed. Heart rate was assessed using a Polar Heart Rate Monitor, which required the subject to wear a chest strap that was fitted prior to each experimental session.

3.3.3 Experimental Sessions

Upon arriving for each experimental session, participants were asked to verify their compliance with pre-session directions. The subject was then fitted with the Polar Heart Rate Monitor, which was worn during the 40-minute experimental condition and then removed. Subjects then underwent a five-minute seated resting condition to acclimate to the laboratory surroundings, which was followed by completion of the affect questionnaires described below. The subject completed the 40-minute experimental condition (REST, EX-10, EX-40), followed by the completion of the affect questionnaires. Subjects then participated in a one-hour seated resting condition, followed by a one-hour period in which ad-libitum food intake was assessed. The flow of the experimental sessions is illustrated in Appendix A, with details of REST, EX-10, and EX-40 described below.

REST Experimental Session: Subjects were instructed to rest quietly in a seated, upright position for a 40-minute period, and heart rate was monitored. During this time, they were permitted to watch videos or read magazines that were provided by the investigator. The inclusion of videos and magazines in the control condition were chosen in order to simulate possible sedentary activities integrated into a person's daily life.

EX-40 Experimental Session: During this session, the subject walked on a treadmill at 3.0 mph and at a grade that induced a heart rate between 70% to 75% of age-predicted maximal heart rate. The initial grade was determined based on the data available from the graded exercise test completed during the screening visit. Heart rate was monitored at each minute, and the average of the final two minutes during each 5-minute period of walking was used to determine if the grade of the treadmill needed to be adjusted. The following criteria were used regarding adjustment of the treadmill: 1) If the heart rate was within the range of 70% to 75% of age-predicted maximal heart rate, the grade was not changed; 2) If the heart rate was below the range of 70% to 75% of age-predicted maximal heart rate, the grade was increased by 1%; 3) If the heart rate was above the range of 70% to 75% of age-predicted maximal heart rate, the grade was decreased by 1%. If the grade of treadmill could not be reduced to lower heart rate within the target range, the speed of the treadmill was reduced 0.2 mph. The exercise session was terminated after 40 minutes of walking.

EX-10 Experimental Session: During this session, the subject participated in a 30-minute resting condition as described above for REST. The resting period was followed by a 10-minute walking period on a treadmill at 3.0 mph and at a grade that induced a heart rate between 70% to 75% of age-predicted maximal heart rate. The initial grade was determined based on the data available from the graded exercise test completed during the screening visit. Heart rate was monitored at each minute, and the average of the final two minutes during each 5-minute period of walking was used to determine if the grade of the treadmill needed to be adjusted according to the same criteria outlined for EX-40. The exercise session was terminated after 10 minutes of walking.

3.3.4 Measurement of Affect

Positive and negative affect was 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 rate the degree to which they have experienced each of the adjectives. The responses cluster into 10-item subscales for positive and negative affect, respectively. The directions instructed participants to rate how they were feeling "right now." Ratings were made on a 5-point Likert-type scale ranging from "Not at all" to "Extremely." For the EX-10 condition, the questionnaire was administered at the 0-minute (prior to the pre-test resting period), 30-minute (immediately pre-test), and 40-minute (immediately post-test) time points. For the EX-40 and REST conditions, the questionnaire was administered at the 0-minute (immediately pre-test) and 40-minute (immediately post-test) time points.

Positive and negative affect was also measured using the positive well-being (PWB) and psychological distress (PD) subscales of the Subjective Experience of Exercise Scale (SEES; McAuley & Courneya, 1994). Although the PWB and PD subscales have been shown to be moderately correlated with positive affect and negative affect subscales of the PANAS, respectively, PWB and PD were included because they are thought to capture unique variance in affective responses specific to the stimulus properties of exercise (McAuley & Courneya, 1994). The SEES lists 12 adjectives and asks participants to rate how they feel "right now" based on a seven-point Likert-type scale. The responses cluster into 3 subscales of positive well-being, psychological distress, and fatigue. For the EX-10 condition, this questionnaire was administered at the 0-minute (prior to the pre-test resting period), 30-minute (immediately pre-test), and 40-minute (immediately post-test) time points. For the EX-40 and REST conditions, this questionnaire was administered at the 0-minute (immediately pre-test) and 40-minute (immediately post-test) time points.

In order to measure affect throughout an exercise session, positive and negative affect were also measured during each experimental condition using two 10-point scales designed by the investigators. The positive affect scale ranged from 0, labeled, "No positive emotion" to 10, labeled, "Very intense positive emotion." The negative affect scale was structured similarly and also ranged from 0 (No negative emotion) to 10 (Very intense negative emotion). Participants were asked to rate the intensity of their positive and negative emotions every 5 minutes throughout the first 40 minutes of each experimental condition (i.e., EX-40, EX-10, REST). Prior to beginning each experimental condition, participants were educated about the possibility of simultaneously experiencing both positive and negative emotions (adapted from Watson & Tellegen, 1985). Verbal indicators used in the PANAS were provided to give participants semantic references to describe the different numerical intensities.

3.3.5 Measurement of Ad Libitum Energy Intake

Upon completion of each experimental condition, the subjects completed the affect questionnaires. They were then instructed to remain in a seated position for one hour during which they had access to videos. Next, they underwent another one-hour resting period with access to a buffet of food and magazines. Based on food preference survey data completed by Unick et al. (2010), popular breakfast foods were provided. Examples of the food include: mixed fruit, yogurt, bagels, cream cheese, butter, donuts, cereal, and milk. Participants were instructed to help themselves while they waited for additional affect measurements to be collected over time. Participants were not told that their food intake was monitored.

Energy intake was measured by calculating individual food consumption during the hour of ad libitum food access for each experimental condition. All food was weighed in grams prior to giving the subject access to the buffet (time 1) and again after the subject left the laboratory (time 2). The difference in weight of each food from time 1 to time 2 was calculated in order to measure grams consumed. Grams consumed of each food was then be multiplied by the ratio of kilocalories/gram of the specific food (available on nutrition labels) in order to calculate the total calories consumed of each food choice. This calculation was performed separately for each available food and then aggregated in order to calculate total calories consumed.

3.3.6 Additional Measures Following the Final Experimental Session

At the completion of the third experimental session, the subject rated the likability of all food items offered at the post-exercise ad libitum laboratory meal. The ratings were made using a 5-point Likert scale, with a rating of 1 corresponding to "not at all" and a rating of 5 corresponding to "really liked it." Additionally, to determine if the subject remained blinded to the research hypotheses, the subject was asked to record if she believed that food intake was being monitored.

3.3.7 Subject Compensation

Upon completion of all study procedures each subject received an honorarium of $300, which was in the form of a debit card using the University of Pittsburgh WePay system. The subject did not receive partial payment if she did not complete all study procedures and experimental sessions.

3.4 STATISTICAL ANALYSES

Statistical analyses were completed using SPSS, version 19. Before testing the hypotheses, the distributions and correlations of all variables were examined to evaluate normality and associations between descriptive and outcome variables. If descriptive variables were significantly correlated with study outcome variables and theoretically relevant to the analyses, they were controlled in analyses with the respective outcome variable. Descriptive analyses were also conducted for participants' likeability of food and awareness of the monitoring of energy intake during the ad libitum meal. These data were used to evaluate factors that could influence study outcomes.

Mean affect scores were calculated at each of the time points measured for the experimental sessions. Additionally, total energy intake for each of the experimental conditions was calculated. Calculations for affect outcomes were conducted for positive affect from the PANAS and positive well being from the SEES, respectively, and separate analyses were conducted for each as the positive affect outcome variable. Similarly, calculations were conducted for negative affect from the PANAS and psychological distress from the SEES, respectively, and separate analyses were conducted for each as the negative affect outcome variable. For the ease of reporting, the terms positive affect and positive well-being as well as negative affect and psychological distress are used interchangeably in the current study.

Effect sizes were reported using partial-eta squared (η_p^2) to describe the magnitude of effects for factors within an ANOVA, and Cohen's *d* was used to describe the magnitude of effects for comparisons between two means. For all within-subjects analyses, sphericity was examined using Mauchly's test. If sphericity is detected, the Huynh-Feldt correction was used if sphericity is greater than or equal to 0.75 or the Greenhouse-Geisser correction was used if sphericity is less than 0.75. Below are the analyses for each of the study aims.

<u>Primary Aim 1</u>. Compare the effects of varying durations of moderate-intensity physical activity (e.g., EX-10 and EX-40) on positive affective response to physical activity to a non-activity resting condition (REST) in overweight and obese adults.

A 2 x 3 repeated measures analysis of variance (ANOVA) was conducted with time (pre-test and post-test) as one factor and experimental condition as the second factor (EX-10, EX-40, REST) in order to examine main effects or interaction effects with positive affect as the outcome variable. In order to examine the proposed comparisons of the experimental conditions, a repeated measures ANOVA using planned contrasts was conducted.

<u>Primary Aim 2.</u> Compare the effects of varying durations of moderate-intensity physical activity (e.g., EX-10 and EX-40) on negative affective response to physical activity compared to a non-activity resting condition (REST) in overweight and obese adults.

As outlined in Primary Aim 1, a 2 x 3 repeated measures ANOVA was conducted with time (pre-test and post-test) as one factor and experimental condition as the second factor (EX-10, EX-40, REST) in order to examine main effects and interaction effects with negative affect as the outcome variable. A repeated measures ANOVA using planned contrasts was conducted to examine the proposed comparisons of the experimental conditions.

Secondary Aim 1. Compare the effects of experimental condition (EX-10, EX-40, REST) on energy intake in an ad libitum laboratory meal 1-2 hours after each session.

In order to investigate Secondary Aim 1, a repeated measures ANOVA using planned contrasts was conducted. Energy intake was entered as the outcome variable and experimental condition was entered as a factor with three levels (EX-10, EX-40, and REST).

Secondary Aim 2. Compare energy intake in an ad-libitum laboratory meal 1-2 hours after the experimental sessions between those who reported an increase in positive affect post-exercise and those who reported a decrease or no change in positive affect post-exercise, controlling for changes in positive affect after the resting condition.

For Secondary Aim 2, subjects were first separated into groups of those who reported an increase in positive affect post-exercise and those who reported a decrease or no change in positive affect post-exercise. Separate calculations were completed for the EX-10 and EX-40 sessions. Positive affective change calculations were conducted for positive affect from the PANAS and positive well being from the SEES, respectively, and separate analyses were conducted for each as the outcome variable.

A 2 x 3 ANOVA was conducted with positive affective change as one factor (increased, decreased/no change) and experimental condition (EX-10 vs. REST when analyses were based on EX-10; EX-40 vs. REST when analyses were based on EX-40) as the second factor. Planned contrasts were conducted to examine the proposed comparisons of the experimental conditions.

Secondary Aim 3. Compare energy intake in an ad-libitum laboratory meal 1-2 hours after the experimental sessions between those who reported an increase in negative affect post-exercise and those who reported a decrease or no change in negative affect post-exercise, controlling for changes in negative affect after the resting condition.

For Secondary Aim 3, subjects were first separated into groups of those who reported an increase in negative affect post-exercise and those who reported a decrease or no change in negative affect post-exercise. Separate calculations were completed for the EX-10 and EX-40 sessions. Negative affective change calculations were conducted for negative affect from the PANAS and psychological distress from the SEES, respectively, and separate analyses were conducted for each as the outcome variable.

A 2 x 3 ANOVA was conducted with negative affective change as one factor (increased, decreased/no change) and experimental condition (EX-10 vs. REST when analyses were based on EX-10; EX-40 vs. REST when analyses were based on EX-40) as the second factor. Then, an ANOVA using planned contrasts was conducted to examine the proposed comparisons of the experimental conditions.

Exploratory Aim 1. Examine initial BMI as a moderator of positive and negative affective change in response to each experimental condition.

For exploratory aim 1, two 3 x 3 x 2 mixed design analyses of variance (ANOVAs) were used to determine if measurements of positive affective responses and negative affective responses, respectively, across experimental conditions (EX-10, EX-40, REST) were significantly different among BMI classifications (overweight, class I obese, and class II obese) over time (pre-test, post-test). Main effects of experimental condition, BMI classification, and time as well as interaction effects were examined.

3.5 POWER ANALYSES

The primary aim of the proposed study was to measure affective responses to a 10-minute bout and 40-minute bout of exercise as compared to a resting condition. An a priori power analysis was conducted using G*Power 3 software (Faul, F., Erdfelder, E., Lang, A.G. & Buchner, A., 2007) to provide an estimate of sample size needed to detect statistically significant effects for the primary aims only. Based on the findings of Unick et al. (2012) examining the time (pre-session and post-session) and condition (exercise and rest) interaction effect on positive and negative affective responses to exercise, an effect size of $d = 0.60$ appeared to be a reasonable estimate to examine the primary aims of the current study. Using a power level of 0.80 and an alpha of 0.05, 9 subjects were needed to detect an effect size of 0.60 for the primary outcomes of the study. Because recruitment targeted women in 3 different BMI classifications, 27 women were needed for the present study. In addition, due to the possibility for subjects to have incomplete data, as evidenced in Unick et al. (2010), 3 additional subjects were recruited. Thus, a total of 30 subjects were recruited for this study.

4.0 RESULTS

The purpose of this study was to examine affective responses and subsequent energy intake after varying durations of physical activity for sedentary, overweight and obese women. The study used a randomized, counterbalanced, within-subjects design, and the results are presented below.

4.1 SAMPLE

Thirty women were recruited to complete the present study. All participants completed the assessment visit; however, after the initial visit, two women were unable to complete the experimental sessions and were removed from the study. One woman was unable to complete the study due to a health concern, and the other participant did not attend any sessions within the two-month time frame for testing. Thus, only the complete data obtained from 28 women are reported below. Demographic information describing the sample (n = 28) is provided in Table 1. Based on BMI, 10 participants were classified as overweight (BMI: 25-29.9 kg/m^2), 8 participants as Class I obese (BMI: 30-34.9 kg/m^2), and 10 participants as Class II obese (BMI: 35-39.9 kg/m^2). The sample was ethnically mixed with participants who were white (n=15; 53.6%), black (n=8; 28.6%), and bi-racial (n=5; 17.9%). All participants were randomly assigned to complete each of the three experimental conditions in a counterbalanced order. A post-hoc analysis confirmed that there were not any order effects based on the assignment of conditions.

All of the study variables were normally distributed with the exception of negative affect from the PANAS and psychological distress from the SEES at all measured time points. To correct the positive skew, the non-normal data were adjusted using a log transformation. Correlations were examined between relevant participant parameters, such as fitness, and outcome variables. Because there were no significant correlations for the background variables of interest and the outcomes, none were considered in the study analyses. Positive affect and negative affect correlations at each time point were also examined in order to consider the utility of including both positive and negative affect in the same analyses. There were not significant correlations between positive and negative affect, and no further analyses were conducted.

Data was collected regarding the likability of food and knowledge about food intake monitoring during the ad libitum eating task. Results showed that the food presented as part of the eating task was rated as generally likable by the sample. Specifically, on a scale from 1, corresponding to “not at all,” to 5 corresponding to “really liked it,” the food was rated as a 3.5, on average, by all participants. After all experimental conditions were completed, 50% of the sample reported via questionnaire that they suspected that their food intake was monitored. Analyses showed that calorie intake for each condition did not differ between those who suspected food intake was monitored and those who did not.

Table 1. Baseline Characteristics of the Sample and by BMI Category

	Total Sample (*n* = 28)	Overweight (*n* = 10)	Class I Obese (*n* = 8)	Class II Obese (*n* = 10)	p-value across weight groups
Age (years)	27.18 (7.78)	28.50 (8.78)	25.75 (5.20)	27.00 (8.92)	0.77
Height (cm)	165.59 (7.76)	165.38 (8.95)	167.10 (6.33)	164.59 (8.12)	0.80
Weight (lbs.)	197.15 (31.32)	166.80 (19.24)[a,b]	203.88 (16.66)[a]	222.14 (24.49)[b]	**<0.01**
Weight (kg)	89.43 (14.21)	75.66 (8.73)[a,b]	92.48 (7.56)[a]	100.76 (11.11)[b]	**<0.01**
BMI (kg/m^2)	32.59 (4.25)	27.73 (1.42)[a,b,c]	33.08 (1.41)[a,b,c]	37.05 (1.48)[a,b,c]	**<0.01**

Note. Data presented as mean (standard deviation);
Groups with same superscript across a row are significantly different at $p \leq 0.05$

4.2 PRIMARY AIMS

The results of the data analysis for the primary aims are presented below. Time 1 was defined as the 0-minute time-point for EX-40 and REST. Time 1 for EX-10 was the 30-minute time-point in order to measure affect immediately prior to the exercise session. Time 2 was defined as the 40-minute time-point for EX-40, EX-10, and REST. See Appendix A for an illustration of time points across the experimental conditions.

4.2.1 Effect of REST, EX-10, and EX-40 on Positive Affect

4.2.1.1 Results from the PANAS

Data from the PANAS positive affect scale are presented in Table 2. The Time X Condition interaction effect was statistically significant for positive affect response, $F(2, 54) = 10.23$, $p < 0.01$, $\eta_p^2 = 0.28$, with positive affect changing by -0.75±4.54 for REST, 3.42±4.92 for EX-10, and 4.97±6.70 for EX-40. Planned contrasts showed a significant difference in positive affect between EX-10 and REST, and the mean difference was 4.18 points, $F(1, 27) = 12.18$, $p < 0.01$, $d = 0.88$, 95% CI [1.72, 6.64]. The mean difference in positive affect between EX-40 and REST was 5.71 points, which also indicated a significant difference, $F(1, 27) = 12.07$, $p < 0.01$, $d = 1.00$, 95% CI [2.34, 9.09]. The mean difference in positive affective change between EX-40 and EX-10 was 1.54, and the comparison between the two conditions was not significantly different, $F(1, 27) = 2.38$, $p = 0.13$, $d = 0.26$, 95% CI [-0.51, 3.58].

Table 2. Comparison of the Acute Effects of REST, EX-10, and EX-40 on Positive Affect

		Condition			p-values		
Measure	*Time Point*	REST	EX-10	EX-40	Time Effect	Condition Effect	Time X Condition Effect
PANAS PA	Time 1	24.00±9.50	24.79±8.69	24.39±7.35	$\boldsymbol{p < 0.01}$	$\boldsymbol{p < 0.01}$	$\boldsymbol{p < 0.01}$
	Time 2	23.25±8.96	28.21±7.45	29.36±7.37			
	Change	-0.75±4.54[a,b]	3.42±4.93[b]	4.97±6.70[a]			
SEES PWB	Time 1	13.64±6.24	13.29±5.35	13.50±4.72	$\boldsymbol{p=0.02}$	$p=0.13$	$\boldsymbol{p < 0.01}$
	Time 2	12.82±5.70	15.18±4.91	16.11±5.63			
	Change	-0.82±2.99[a,b]	1.89 ±2.91[b]	2.61±4.59[a]			

Note. PANAS PA: Positive and Negative Affect Schedule, Positive Affect Subscale; SEES PWB: Subjective Experience of Exercise Scale, Positive Well Being Subscale; Time 1 was 0 minutes for EX-40 and REST and 30 minutes for EX-10; Groups with the same superscript across a row are significantly different at $p \leq 0.05$

4.2.1.2 Results from the SEES

Data from the SEES positive well being scale are also presented in Table 2. Analysis showed a significant Time X Condition interaction effect on positive affective response, $F(2, 54) = 9.51$, $p < 0.01$, $\eta_p^2 = 0.26$. Change from Time 1 to Time 2 was -0.82±2.99 for REST, 1.89±2.91 for EX-10, and 2.61±4.59 for EX-40. Planned contrasts showed a significant difference in positive affect between EX-10 and REST with a mean difference of 2.71 points, $F(1, 27)= 14.98$, $p < 0.01$, $d= 0.92$, 95% CI [1.28, 4.15]. There was also a significant difference in positive affect between EX-40 and REST with a mean difference of 3.43 points, $F(1, 27)= 11.50$, $p < 0.01$, $d = 0.88$, 95% CI [1.35, 5.50]. The mean difference in positive affective change between EX-40 and EX-10 was 0.71 points, and the comparison was not statistically significant, $F(1, 27)= 0.93$, $p = 0.34$, $d=0.19$, 95% CI [-0.81, 2.24].

4.2.2 Effect of REST, EX-10, and EX-40 on Negative Affect

4.2.2.1 Results from the PANAS

Data obtained from the PANAS negative affect scale prior to log transformation are presented in Table 3. Log-transformation was needed to normalize the distribution of the data, with log-transformed negative affect data from the PANAS shown in Table 4. There were no significant effects of time, condition, or Time X Condition on negative affective response measured using the PANAS.

Table 3. Mean Ratings of PANAS Negative Affect and SEES Distress Raw Scores

		Condition		
Measure	*Time Point*	REST	EX-10	EX-40
PANAS NA	Time 1	12.11±4.39	11.21±2.28	12.14±3.11
	Time 2	11.71±4.38	11.25±2.76	11.96±2.70
	Change	-0.39±1.45	0.04±1.58	-0.18±2.80
SEES Distress	Time 1	6.43±3.91	5.71±3.15	5.64±3.19
	Time 2	5.89±3.89	5.36±3.25	5.18±2.25
	Change	-0.54±1.77	-0.36±1.75	-0.46±2.91

Note. PANAS NA: Positive and Negative Affect Schedule, Negative Affect Subscale;
SEES Distress: Subjective Experience of Exercise Scale, Distress Subscale;
Time 1 was 0 minutes for EX-40 and REST and 30 minutes for EX-10

4.2.2.2 Results from the SEES

The SEES psychological distress data prior to log transformation are presented in Table 3. Log-transformation was needed to normalize the distribution of the data, with log-transformed data from the SEES for psychological distress also presented in Table 4. Analyses showed that the Time X Condition interaction effect was not significant. There was a significant main effect of time, $F(1, 27) = 5.98$, $p = 0.02$, $\eta_p^2 = 0.18$, and condition, $F(2, 54) = 122.49$, $p < 0.01$, $\eta_p^2 = 0.90$, on negative affective response.

Table 4. Comparison of the Acute Effects of REST, EX-10, and EX-40 on Negative Affect

		Condition			p-values		
Measure	*Time Point*	REST	EX-10	EX-40	Time Effect	Condition Effect	Time X Condition Effect
Log PANAS NA	Time 1	1.07±0.11	1.04±0.08	1.07±0.10	p=0.39	p=0.10	p=0.62
	Time 2	1.05±0.12	1.04±0.08	1.07±0.09			
	Change	-0.02±0.04	0±0.04	0±0.09			
Log SEES Distress	Time 1	2.45±0.68	0.72±0.18	0.71±0.18	**p=0.02**	**$p < 0.01$**	p=0.35
	Time 2	2.34±0.65	0.68±0.18	0.69±0.15			
	Change	-0.10±0.33	-0.03±0.09	-0.02±0.16			

Note. PANAS NA: Positive and Negative Affect Schedule, Negative Affect Subscale; SEES Distress: Subjective Experience of Exercise Scale, Distress Subscale; Log: Indicates data are log-transformed; Time 1 was 0 minutes for EX-40 and REST and 30 minutes for EX-10

4.3 SECONDARY AIMS

4.3.1 Effect of REST, EX-10, and EX-40 on Energy Intake

Data for energy intake during the ad libitum eating period are presented in Table 5. The main effect of condition on energy intake was statistically significant, $F(2, 54) = 3.72$, $p = 0.02$, $\eta_p^2 = 0.22$), and observation of the raw data shows that subjects consumed the most calories during EX-10 followed by EX-40 and REST, respectively. Planned contrasts showed a significant difference in energy intake between the EX-10 and REST conditions with a mean difference of 188.32 kcal, $F(1, 27) = 7.68$, $p = 0.01$, $d = 0.38$, 95% CI [48.92, 327.72]. The mean difference in energy intake between EX-40 and REST was 117.06 kcal, and the comparison demonstrated a non-significant trend, $F(1, 27) = 3.37$, $p = 0.08$, $d = 0.26$, 95% CI [-13.82, 247.94]. The mean difference in energy intake between EX-40 and EX-10 was -71.26 kcal, and the comparison between conditions was not statistically significant, $F(1, 27) = 3.72$, $p = 0.24$, $d = -0.13$, 95% CI [-191.80, 49.28].

Table 5. Main Effect of Condition on Energy Intake

	Condition			
	REST	EX-10	EX-40	Condition Effect
Energy Intake in kilocalories	754.31±417.49[a]^	942.63±567.79[a]	841.37±486.78^	***p*= 0.02**
[a]Groups are significantly different at $p \leq 0.05$ ^Group difference shows a non-significant trend at $p = 0.08$				

4.3.2 Influence of Condition and Change in Positive Affect on Energy Intake

Additional analyses were performed in order to further understand the difference in energy intake across the exercise and resting conditions. Specifically, reported differences in positive affective responses to exercise using the PANAS and SEES, respectively, were examined as a factor influencing energy intake. Change in positive affect during REST was used as a control variable in order to examine changes in positive affect specific to exercise, and marginal means and standard deviations are reported.

4.3.2.1 EX-10 vs. REST and Positive Affective Change Group on Energy Intake

Subjects were grouped by whether there was an increase in PANAS positive affect following the 10-minute exercise session (EX-10↑PA) or whether there was no change or a decrease in positive affect (EX-10↓PA). Affective change groups by condition are shown in Table 6. Analyses of the EX-10 individual data showed that 68% of participants were in the EX-10↑PA group with a mean change in positive affect from pre-exercise to post-exercise of 6.16±3.27 points and a magnitude of change of 1 to 12 points. Thirty-two percent of participants were in the EX-10↓PA group with a mean change in PANAS positive affect from pre-exercise to post-exercise of -2.33±1.66 points and a magnitude of change ranging from -5 to 0 points.

Table 6. Participants (*n*) listed by PANAS Affective Change and Exercise Condition

	PANAS Affective Change Category			
Condition	Positive Affect Increase	Positive Affect Decrease/No change	Negative Affect Increase	Negative Affect Decrease/No change
EX-10	19	9	3	25
EX-40	22	6	9	19

Data describing energy intake for condition and PANAS positive affect groups after the 10-minute exercise session are shown in Figure 1. The Affective Change Group X Condition interaction effect on energy intake was not significant. Consistent with previously reported findings, there was a significant effect of condition on energy intake, $F(1, 25)$, $p = 0.01$, $\eta_p^2 = 0.27$. Participants grouped as EX-10↑PA consumed 834.08±566.06 kilocalories after exercise and 718.75±427.28 kilocalories after resting. On average, participants grouped as EX-10↓PA consumed 1171.78±565.92 kilocalories after exercise and 829.37±427.17 kilocalories after resting.

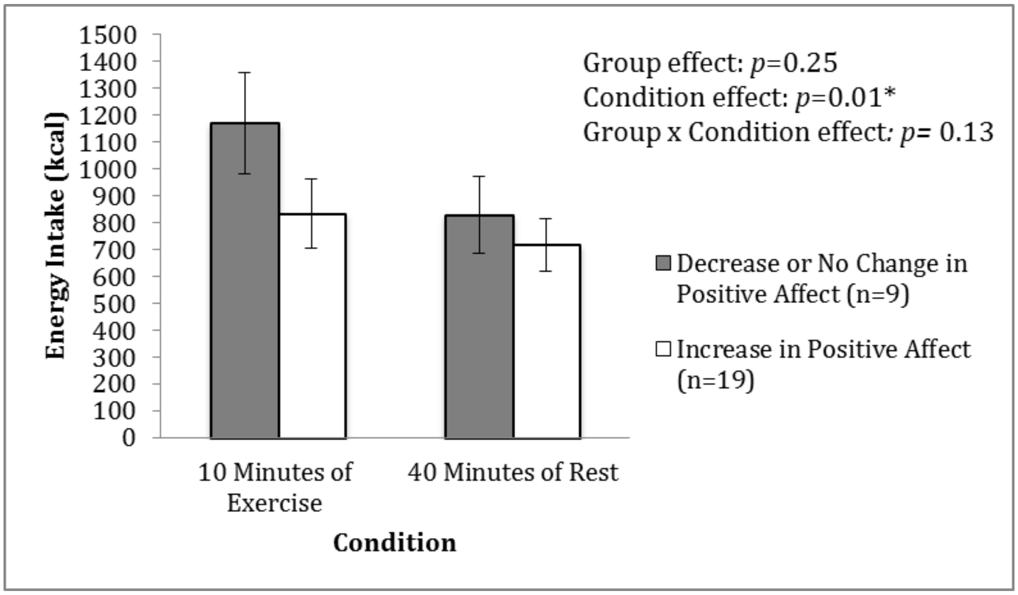

Figure 1. Comparison of energy intake (kcal) following the 10-minute exercise and 40-minute rest conditions based on PANAS positive affective change post-exercise

Subjects were also classified by whether or not there was increase in SEES positive affect following the 10-minute exercise session (EX-10↑PWB) or whether there was no change or a decrease in positive affect (EX-10↓PWB). Affective change groups by condition for the SEES data is displayed in Table 7. Analyses of the individual EX-10 data showed that 61% of participants were in the EX-10↑PWB group and showed a mean change in SEES positive affect of 3.59±2.43 points from pre-exercise to post-exercise and a magnitude of change ranging from 1 to 11 points. Additionally, 39% of participants were in the EX-10↓PWB group and showed a mean change in SEES positive affect from pre-exercise to post-exercise of -0.73±1.00 points and a magnitude of change ranging from -3 to 0 points.

Table 7. Participants (*n*) listed by SEES Affective Change and Exercise Condition

	SEES Affective Change Category			
Condition	Positive Affect Increase	Positive Affect Decrease/No change	Negative Affect Increase	Negative Affect Decrease/No change
EX-10	17	11	1	27
EX-40	16	12	3	25

Data describing energy intake for condition and SEES positive well being change groups after the 10-minute exercise session are shown in Figure 2. The Affective Change Group X Condition effect on energy intake was not statistically significant. Similar to the findings from the PANAS, there was a significant effect of condition on energy intake, $F(1, 25)$, $p = 0.01, \eta_p^2 = 0.27$. Individuals in the EX-10↑PWB group consumed 793.96±585.45 kilocalories after exercise and 693.03±442.16 kilocalories after resting. Participants in the EX-10↓PWB group consumed 1172.39±600.62 kilocalories after exercise and 849.02±453.61 kilocalories after resting.

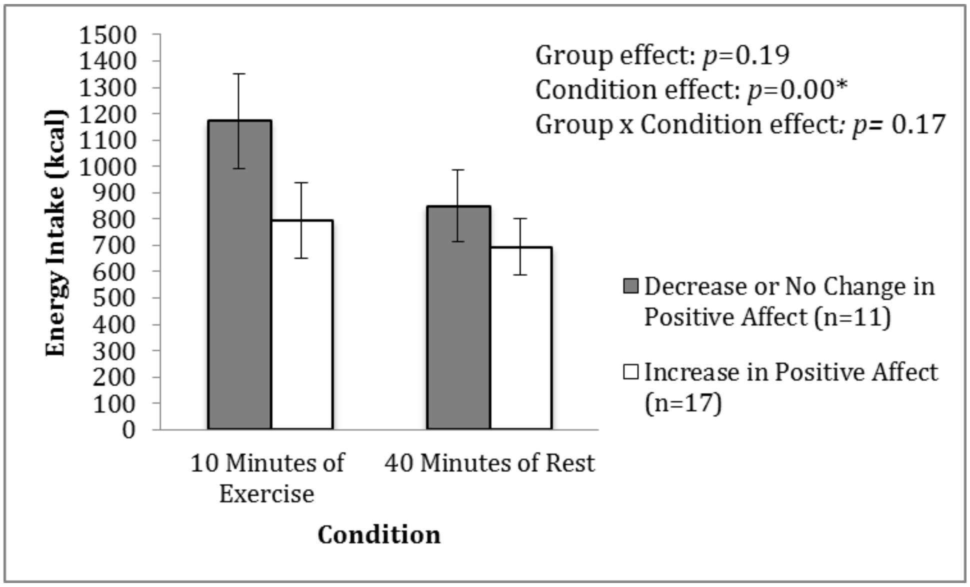

Figure 2. Comparison of energy intake (kcal) following the 10-minute exercise and 40-minute rest conditions based on SEES positive affective change post-exercise

4.3.2.2 EX-40 vs. REST and Positive Affective Change Group on Energy Intake

Subjects were grouped by whether there was increase in PANAS positive affect following the 40-minute exercise session (EX-40↑PA) or whether there was no change or a decrease in positive affect (EX-40↓PA). Overall, 79% of subjects were in the EX-40↑PA group with a mean change from pre-exercise to post-exercise of 7.41± 4.83 points and a magnitude of change ranging from 1 to 24 points. Twenty-one percent of subjects were in the EX-40↓PA group with a mean change from pre-exercise to post-exercise of -4.00± 4.65 points and a magnitude of change ranging from -13 to 0 points. Affective change groups by condition are displayed in Table 6. Of note, 86% of the subjects in the EX-40↑PA group were also in the EX-10↑PA group.

Dietary intake post-exercise and post-rest was compared between EX-40↑PA and EX-40↓PA, with data shown in Figure 3. The Affective Change Group X Condition interaction effect on energy intake was not statistically significant. There was a significant effect of affective change group on energy intake, $F(1, 25)= 5.58$, $p = 0.03$, $\eta_p^2 = .0.18$, and the EX-40↓PA group consumed more calories, on average, than the EX-40↑PA group. Participants in the EX-40↑PA group consumed 775.66±468.86 kilocalories following EX-40 and 663.88±392.04 kilocalories following REST. Those in the EX-40↓PA group consumed 1222.28±472.78 kilocalories during EX-40 and 1085.88±395.31 kilocalories during REST.

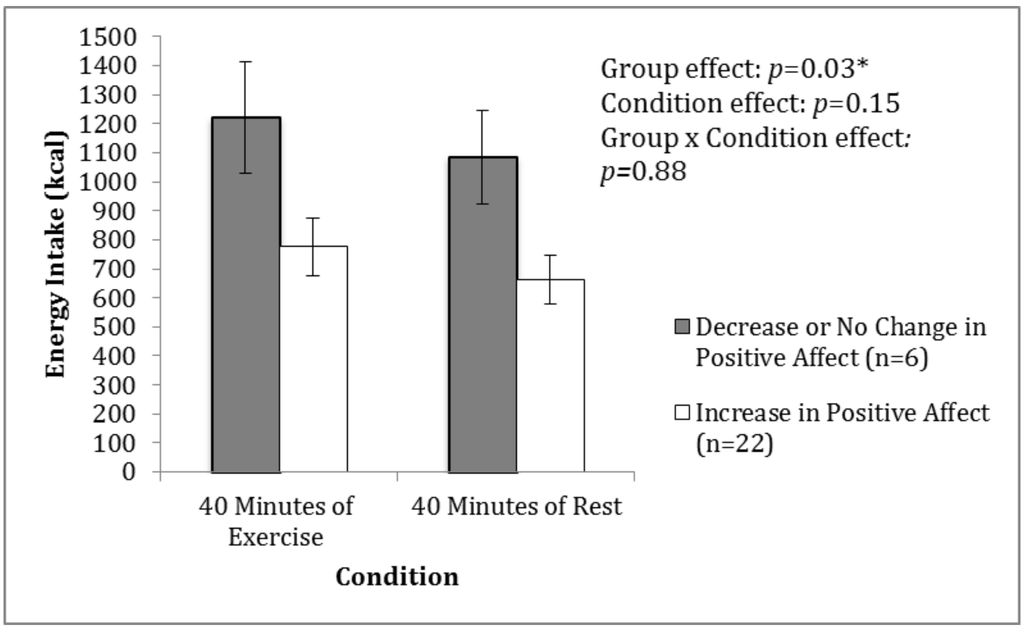

Figure 3. Comparison of energy intake (kcal) following the 40-minute exercise and rest conditions based on PANAS positive affective change post-exercise

According to the SEES data, 57% of participants reported an increase in SEES positive affect post-exercise (EX-40↑PWB), and 43% reported a decrease or no change in positive affect post-exercise (EX-40↓PWB). Affective change groups by condition for the SEES data is displayed in Table 7. During EX-40, those in the EX-40↑PWB group reported an increase in SEES PA from pre-exercise to post-exercise with a mean change of 5.63± 3.63 points and a magnitude of change ranging from 1 to 14 points. Furthermore, subjects in the EX-40↓PWB group reported a decrease or no change in SEES positive affect from pre- to post-exercise with a mean change of -1.42±1.68 points and a magnitude of change ranging from -5 to 0 points. Analyses showed that 75% of the subjects in the EX-40↑PWB group were also in the EX-10↑PWB group.

Data describing energy intake for condition and SEES positive well being change groups after the 40-minute exercise session are shown in Figure 4. The Affective Change Group X Condition interaction effect on energy intake was significant, $F(1, 25)= 4.50$, $p = 0.04$, $\eta_p^2 = 0.15$. As compared to the EX-40↑PWB group, participants in the EX-40↓PWB group ate significantly more calories after 40 minutes of exercise but not after 40 minutes of resting. Participants in the EX-40↑PWB group ate 711.93±468.16 kilocalories after 40 minutes of exercise and 704.53±425.08 kilocalories after 40 minutes of resting. Those in the EX-40↓PWB group ate 1083.95±467.97 kilocalories after 40 minutes of exercise and 820.67±424.89 kilocalories after 40 minutes of resting. The effect of condition on energy intake demonstrated a non-significant trend, $F(1, 25)= 3.54$, $p = 0.07$, $\eta_p^2 = .0.12$, such that subjects ate more after the 40-minute exercise condition as compared to the 40-minute resting condition. The effect of affective change group on energy intake was not significant.

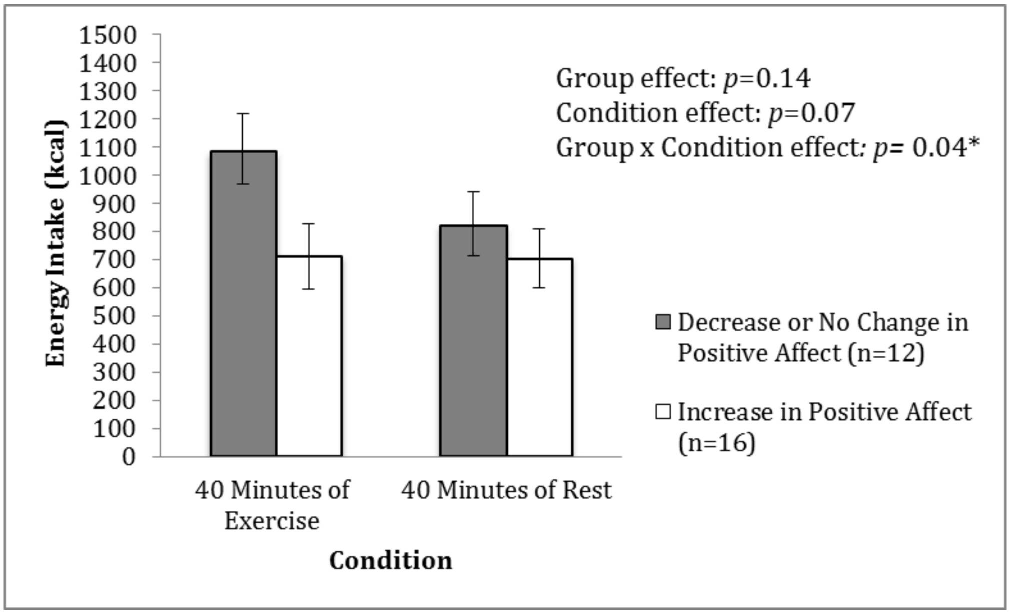

Figure 4. Comparison of energy intake (kcal) following the 40-minute exercise and rest conditions based on SEES positive affective change post-exercise

4.3.3 Influence of Condition and Change in Negative Affect on Energy Intake

Differences in negative affective responses to exercise using the PANAS and SEES, respectively, were also examined as a factor influencing energy intake. Change in negative affect during REST was used as a control variable in order to examine changes in positive affect specific to exercise, and marginal means and standard deviations are reported.

4.3.3.1 EX-10 vs. REST and Negative Affective Change Group on Energy Intake

Analyses of the EX-10 individual data prior to log transformation showed that 11% of subjects (n = 3) reported an increase in PANAS negative affect (mean change = 3.00±3.46 points) from pre-to post-exercise with a magnitude of change of 1 to 7 points. Furthermore, 89% of participants (n = 25) reported a decrease or no change in negative affect from pre-to post-exercise (mean change = -0.32±3.46 points) with a magnitude of change ranging from -3 to 0 points.

Analyses of the EX-10 individual data prior to log transformation showed that 4% of subjects (n = 1) reported an increase in SEES negative affect (individual change = +7 points) from pre-exercise to post-exercise. Furthermore, 96% of participants reported a decrease or no change in negative affect from pre-to post-exercise (mean change = -0.63±1.00 points) with a magnitude of change ranging from -3 to 0 points.

Analyses examining energy intake for condition and both PANAS and SEES negative affective change groups after the 10-minute exercise session were not conducted because the sample sizes of the affective change groups were considered too small to run the proposed analyses.

4.3.3.2 EX-40 vs. REST and Negative Affective Change Group on Energy Intake

Participants were grouped by whether they had an increase in negative affect (EX-40↑NA) or a decrease or no change in negative affect (EX-40↓NA) from pre-exercise to post-exercise. Nine participants (32%) were in the EX-40↑NA group with a mean change in negative affect from pre-exercise to post-exercise of 2.44±1.67 points with a magnitude of change ranging from 1 to 6 points. Nineteen participants (68%) were in the EX-40↓NA group with a mean change in negative affect from pre-exercise to post-exercise of -1.42±2.34 points and a magnitude of change ranging from -9 to 0 points.

Data describing energy intake for condition and PANAS negative affective change groups after the 40-minute exercise session are shown in Figure 5. The interaction effect of

Affective Change Group X Condition on energy intake was not significant. The effect of condition on energy intake demonstrated a non-significant trend $F(1, 25) = 3.54$, $p = 0.07$, $\eta_p^2 = 0.12$, such that participants consumed more calories after 10 minutes of exercise than after resting. On average, the EX-40↑NA group consumed 856.04±508.2 kilocalories after 40 minutes of exercise and 662.40±430.74 kilocalories after 40 minutes of resting. Average energy intake for the EX-40↓NA group was 878.63±506.63 kilocalories after 40 minutes of exercise and 797.84±429.42 kilocalories after 40 minutes of resting.

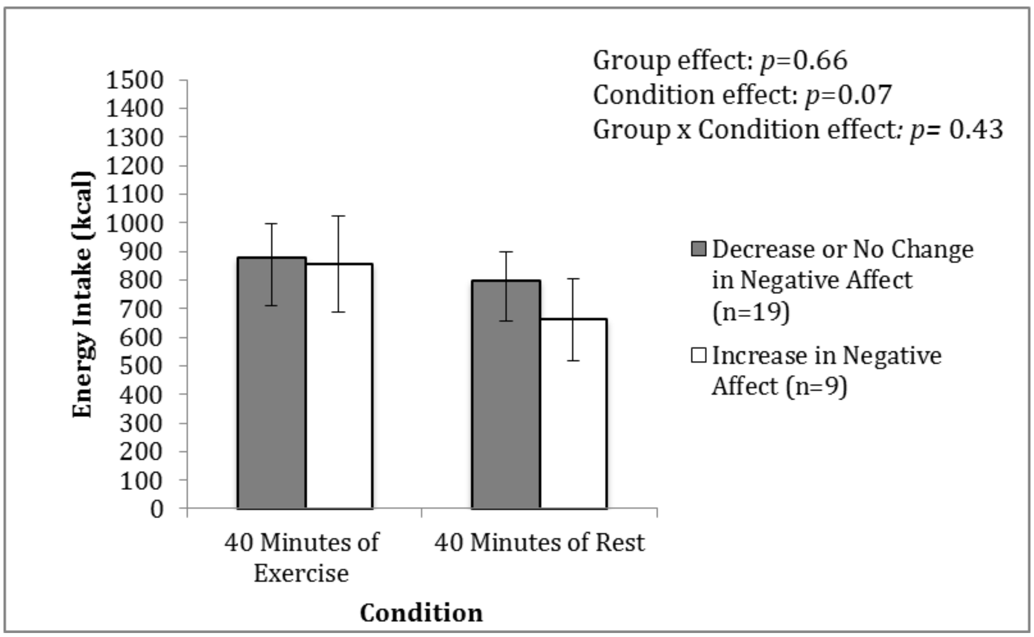

Figure 5. Comparison of energy intake (kcal) following the 40-minute exercise and 40-minute rest conditions based on PANAS negative affective change post-exercise

During the EX-40 condition, participants were also grouped by whether they had an increase in negative affect (EX-40↑Dist) or a decrease or no change in negative affect (EX-40↓Dist) from pre-exercise to post-exercise. Examination of the data prior to log transformation indicated that 11% of participants (n = 3) were in the EX-40↑Dist group with a mean change in negative affect from pre-exercise to post-exercise of 4.67±2.31 points and a magnitude of change ranging from 2 to 6 points. Conversely, 89% of participants (n = 25) were in the EX-40↓Dist group with a mean change of -1.08±2.33 points and a magnitude of change ranging from -9 to 0 points. Analyses examining energy intake for condition and SEES negative affective change groups after the 40-minute exercise session were not conducted because the sample sizes of the affective change groups were considered too small to run the proposed analyses.

4.4 EXPLORATORY ANALYSES

4.4.1 Explore Initial BMI as a Moderator of Positive and Negative Affective Change

In light of research that showed that individuals in different weight categories might have different responses to exercise, initial BMI was explored as a moderator of the effect of time and condition affective change. Using the positive affect data from the PANAS and the SEES, respectively, BMI was not a significant moderator of the time, condition, or the Time X Condition interaction effects on positive affective response. Similarly, BMI was not a significant moderator of the time, condition, or the Time X Condition interaction effects on negative affective response using the data from the PANAS and SEES, respectively.

4.4.2 PANAS and SEES Data Throughout the Experimental Sessions

Additional analyses were conducted in order to examine positive and negative affect ratings throughout each experimental session. Appendix B shows the data on positive affect using the PANAS and SEES throughout the experimental period. Analyses of the data across all time points showed there was a Time X Condition effect, $F(6, 162) = 4.12$, $p < 0.01$, $\eta_p^2 = 0.15$, on PANAS positive affect. There was also a Time X Condition effect, $F(6, 162) = 4.03$, $p < 0.01$, $\eta_p^2 = 0.13$, on SEES positive affect across all time points.

Within-condition analyses were also performed in order to further understand changes in affect throughout experimental conditions. Evaluation of the PANAS positive affect data showed that there was a significant difference in positive affect across time points for EX-10, $F(4, 108) = 4.67$, $p < 0.01$, $\eta_p^2 = 0.15$, and EX-40, $F(3, 81) = 4.91$, $p < 0.01$, $\eta_p^2 = 0.26$, but not for REST. Analyses of SEES positive affect data also showed that there was a significant difference in positive affect across time points for EX-10, $F(4, 108) = 3.04$, $p = 0.02$, $\eta_p^2 = 0.10$, and EX-40, $F(3, 81) = 4.21$, $p = 0.01$, $\eta_p^2 = 0.14$, but not for REST. Examination of positive affect raw scores during the exercise sessions showed a tendency for PANAS and SEES positive affect ratings to decrease from the 40-minute to 100-minute time period. In order to investigate the magnitude of change in positive affect at the 100-minute time period, paired-samples t-tests with Bonferroni corrections were performed comparing 100-minute ratings to baseline ratings of positive affect. Results showed that positive affect ratings at 100 minutes were not significantly different from baseline ratings during EX-40 (i.e., 0 minutes) or baseline ratings during EX-10 (i.e., 30 minutes) for the PANAS and SEES positive affect data, respectively. Taken together, these results suggest an average decline in positive affect to baseline levels prior to the eating task.

Appendix C displays the PANAS and SEES negative affect data prior to log transformation and Appendix D displays the PANAS and SEES log-transformed negative affect data. Consistent with the previously reported results from the pre-session to post-session periods, there were no significant Time X Condition effects for the PANAS and SEES negative affect data, respectively. Examination of data from the PANAS negative affect scale shows a minimal but significant decline in scores throughout REST, EX-10, and EX-40, respectively. Negative affect data from the SEES shows a minimal but significant decline in scores during both REST and EX-10 but not EX-40.

4.4.3 Ten-Point Scale Data During the Experimental Sessions

Analyses were conducted using data from the 10-point positive and negative affect scales to evaluate the possibility that there may be differences in affective responses throughout exercise and resting periods. On average, the data showed that participants reported minimal change in positive affect over the first 30 minutes of each condition. Positive affect increased a very small amount from 30 minutes to 40 minutes for each condition and subsequently remained relatively consistent for the remainder of the session. There were minimal changes in negative affect throughout the first 30 minutes of all sessions. Negative affect then declined slightly from 30 to 40 minutes across all sessions and declined minimally at 100 minutes and 160 minutes. Taken together, an exploratory examination of the data showed nominal changes in positive and negative affect across conditions and minimal fluctuations within conditions. In turn, no further analyses were conducted.

5.0 DISCUSSION

Sedentary behavior has been associated with increased disease and mortality risk, and interventions are needed to increase physical activity adoption. Promotion of increased physical activity levels may be especially important for overweight and obese individuals due to the influence on body weight regulation and related chronic disease risk. Previous research has shown that affective responses to exercise may predict future exercise behavior. The present study examined affective responses to varying durations of physical activity for overweight and obese women. Additionally, the influence of affective responses to physical activity on subsequent energy intake was examined.

The major finding from the present study was that both 10-minute and 40-minute bouts of exercise produced improvements in positive affect compared to resting quietly. Participants tended to consume more calories after 10 minutes of exercise as compared to after resting, and there was a trend-level finding that 40 minutes of exercise led to greater caloric intake than resting quietly. Additionally, those who had positive affective responses to exercise after 40 minutes consumed fewer calories after exercise than those who did not have positive affective responses to a 40-minute exercise bout. Positive affective responses to 10 minutes of exercise did not predict calorie intake as compared to resting. In fact, on average, all participants consumed more calories after 10 minutes of exercise as compared to resting. The findings are discussed further below in the context of existing research, and a review of implications, study strengths and limitations, and suggestions for future research are also presented.

5.1 REVIEW OF FINDINGS

5.1.1 Positive Affective Responses to Physical Activity

As hypothesized, participation in 10 minutes of moderate-intensity physical activity led to improvements in positive affect as measured by the PANAS and SEES that were significantly greater than after a resting period, which is consistent with most findings in normal weight samples (Rudolph, Butki, & Blake, 1998; Ekkekakis et al., 2000; Blanchard, Rodgers, & Gauvin, 2004). There are several reasons that the current finding that 10 minutes of exercise is affectively rewarding is clinically relevant. First, although there are not known markers of clinically significant positive affective change on the PANAS and SEES, the robust effect sizes provide evidence that there is a strong relationship between participating in 10 minutes of exercise and experiencing an improvement in positive affect. Second, a majority of women reported positive affect improvements after 10 minutes of exercise (i.e., 68% based on PANAS ratings, 61% based on SEES rating), which is promising for exercise intervention. Specifically, if considering inactivity, individuals adopting an exercise routine may benefit from reminders that it is likely that they will experience the affective benefits of exercise even after a short bout. Furthermore, in the context of an exercise intervention, the prospect of completing 10 minutes of exercise may be perceived as less daunting than a longer bout of exercise for sedentary, overweight individuals. One of the most frequently reported barriers to exercise is lack of time (Reichert, Barros, Domingues, & Hallal, 2007; Sequeira, Cruz, Pinto, Santos, & Marques, 2011), and separating exercise into multiple shorter bouts that are potentially more convenient may increase adherence to an exercise protocol.

Although a short, 10-minute exercise bout may produce a transient “dose” of positive affect, it is possible that the accumulation of multiple short exercise bouts may provide additive, sustained mood benefits. There is a strong body of research that suggests that participation in regular physical activity is associated with improvements in mental health outcomes for both healthy and psychiatric samples (Rejeski & Mihalko, 2001; Netz, Wu, Becker & Tenenbaum, 2005; Martinsen, 2008). However, less is known about the emotion-based mechanisms by which participation in multiple bouts of exercise leads to improvements in mood. For individuals with low positive affect, such as those with depressed mood, further understanding of the influence of repeated short durations of exercise on positive affect will be beneficial. Recent research by Mata et al. (2012) showed that individuals with depression experienced improvements in positive affect post-exercise regardless of duration, and participation in a long bout of exercise was associated with greater acute improvements in positive affect than participation in a short bout of exercise. Although long duration exercise bouts may yield greater increases in positive affect than shorter bouts, preliminary findings from the current study suggest that the affective improvement may be short lived. Thus, it is possible that participation in multiple 10-minute bouts of exercise may lead to the accumulation of multiple periods of positive affect improvement, and potentially, an improvement in overall mood. Within the design of the current study, only one 10-minute bout of activity was examined, which limits the ability to extrapolate these findings across multiple bouts of activity that may be performed within a single day. Further work is needed in order to understand if multiple 10-minute bouts of physical activity would have an additive effect on daily positive affect as well as overall mood in both depressed and non-depressed samples.

Consistent with our hypothesis, 40-minute bouts of physical activity also led to improvements in positive affect as compared to resting. Similar to the findings after 10 minutes of exercise, there was a robust effect of 40 minutes of exercise on positive affective change. These findings are consistent with research conducted on long durations of exercise and affect in normal weight samples (Reed & Ones, 2006; Landers & Arent, 2007) as well as suggestive findings from study conducted in an overweight and obese sample (Unick et al., 2012). Individual analysis of the data showed that the majority of sedentary, overweight or obese women experienced positive affect in response to 40 minutes of exercise. Specifically, after 40 minutes of exercise, 79% (PANAS rating) and 57% (SEES rating) of participants increased positive affect as compared to baseline. These findings are promising in the context of exercise prescription for affective benefits because it shows that most women will experience the mood enhancing properties of a long duration of exercise.

As compared to the findings of Unick et al. (2012), in which 58% of participants reported an increase in PANAS positive affect after exercise, more participants in the current study had positive affective responses and a greater magnitude of positive affective response to 40 minutes of exercise. One possible explanation for the increased frequency and magnitude of positive affect increase in the present study may be due to different methodologies used in each study. The methods used by Unick et al. (2012) were part of a parent study that measured physiological markers of hunger. Throughout the study, and specifically prior to exercising, participants had blood drawn. Additionally, the exercise session in the Unick et al. (2012) study was completed while wearing a mask attached to a portable metabolic cart. Thus, the multiple blood draws and use of the metabolic cart during exercise may have led to discomfort for the participants as compared to the procedures of the present study in which neither of the procedures were utilized. Thus, the current study may have simulated an exercise session that more closely matches the type of exercise that may be performed outside of a laboratory-based setting when compared to the methods of Unick et al. (2012).

Contrary to our hypothesis, participation in 10-minute exercise bouts did not yield significantly greater improvements in positive affect as compared to 40 minutes of exercise, which is consistent with research in normal weight individuals (Hansen, Stevens, & Coast, 2001). Of note, the effect sizes of this comparison indicated small effects, and the current study did not have a sufficient sample size or power for the analyses. If future adequately powered analyses support the idea that there are no differences in positive affect change after exercise of 10 and 40 minutes, one possibility is that the maximal affective benefits of exercise may occur after approximately 10 minutes and there is an attenuated positive affective response after that time. For example, findings from Backhouse et al. (2007) showed that positive affective responses reached a peak within first 15 minutes of exercise and subsequently declined over time in a sample of active men. In the current study, additional exploratory analyses were used to examine the potential peak in positive affect after 10 minutes of exercise and during the first 10 minutes of the 40-minute bout. Results showed that positive affect during exercise showed very minimal variability as compared to positive affect during a resting session.

Although the current exploratory analyses deserve consideration, it should also be noted that the present study was not designed with adequate power to specifically examine affect during exercise. Additionally, different samples and scales were used between studies. Unlike the scale used in the Backhouse et al. (2007) study, the 10-point scales were administered every 5 minutes throughout the experimental session in the present study. As discussed by Sharpe and Gilbert (1998), it is possible that there may be methodological limitations to administering the same affective questionnaire multiple times throughout testing. Because the investigators for the current study designed the 10-point scale, further information about the psychometric properties of the scale is needed in order to make a meaningful interpretation of the results. Taken together, in order to understand more about the time course of positive affect improvements in response to exercise, further research is needed to examine positive and negative affective responses during exercise for overweight and obese women.

In the current sample, it is also important to note that a majority of women who experienced affective improvements after 40 minutes of exercise also reported affective improvements after 10 minutes of exercise. These findings introduce the possibility of background characteristics that lead to positive affect improvements in exercise regardless of duration. For example, greater positive affect responses to exercise have been shown for individuals without a history of depression (Wichers, et al., 2011) and individuals who are more active (Welch, Hulley, Ferguson, & Beauchamp, 2007) as compared to those who do not have those characteristics. Although the design of the current study does not allow for these comparisons, future work is needed to examine background variables that may predict positive affect improvements in response to acute exercise.

5.1.2 Negative Affective Responses to Physical Activity

In the current study, it was hypothesized that both 10-minute and 40-minute exercise sessions would lead to a reduction in negative affect as compared to 40 minutes of resting, and the results were not consistent with the hypothesis. Overall, there were low ratings of negative affect in response to both the exercise and resting sessions. Although some research among normal weight samples has shown that reductions in negative affect are possible after exercise of various durations (Butki & Rudolph, 1997; Rudolph, Butki, & Blake, 1998; Blanchard, Rodgers, & Gauvin, 2004), there is a growing literature that suggests that negative affect may not be significantly changed after exercise as compared to resting. For example, Barnes, Coombes, Armstrong, Higgins, & Janelle (2010) detected minimal changes in negative affect across time and condition in a sample of individuals who completed a 30-minute exercise session. Additionally, Mata et al. (2012) investigated changes in self-reported positive and negative affect post-exercise in a sample of depressed and never-depressed controls. For both groups, self-initiated physical activity led to an increase in positive affect and no significant change in negative affect. The present findings are also consistent with results from Unick et al. (2012) that showed that negative affective change after approximately 40 minutes of exercise was not significantly different than negative affective change after a resting session in overweight and obese individuals.

One possible implication of the current findings is that the process of exercise may not influence overweight and obese people in a negative way. Rather, completion of exercise may result in various intensities of positive affective responses ranging from feeling very positive to the reduction of a positive affect. Interestingly, although there is research that shows negative affect may not significantly change in response to exercise, negative affect has been shown to interfere with participation in physical activity (e.g. Strine et al., 2008). For example, among both clinically depressed and non-clinical samples, individuals with greater negative mood symptoms have been shown to participate in less physical activity than those with fewer negative mood symptoms (Roshanaei-Moghaddam, Katon, & Russo, 2009; Koopmans et al., 2009). The present findings may be especially important when negative affect may be a barrier to participation in the context of an exercise intervention. Specifically, individuals may benefit from knowing that participation in exercise will likely not intensify negative affect; rather, exercising is more likely to lead to some degree of improvement in positive affect.

5.1.3 Body Mass Index and Affective Responses to Exercise

Because previous research by Ekkekakis et al. (2010) and Unick et al. (2012) showed that individuals in different weight categories may have variable affective responses to exercise, initial BMI was explored as a moderator of the effect of time and condition on affective change from pre-exercise to post-exercise. The results showed that body mass index was not a significant moderator of the effect of an acute bout of physical activity on positive or negative affective response across 10-minute and 40-minute durations of exercise, respectively. Thus, across weight classifications, it is possible that sedentary women may have similar affective responses to exercise and resting sessions.

5.1.4 Duration of Physical Activity and Energy Intake

As hypothesized, there was a significant difference in energy intake across the experimental conditions. Specifically, there was a tendency for participants to consume more calories following exercise sessions as compared to the resting period. Energy intake after the 10-minute exercise condition was significantly greater than after the 40-minute resting condition, and there was a non-significant trend that energy intake after the 40-minute exercise condition was greater than the 40-minute resting condition. Contrary to our hypothesis, energy intake was not significantly different between the different durations of exercise.

The current study was not adequately powered to examine the secondary aims, and the current finding requires replication with adequate power to detect effects before making any definitive conclusions about energy intake after various durations of exercise. That being said, the magnitude of difference in energy intake for EX-10 vs. REST (+188 kcal), EX-40 vs. REST (+117 kcal), and EX-40 vs. EX-10 (-71 kcal) is noteworthy due to the possible effects on weight. Research has shown that even minor changes in diet (i.e., 100 calories/day) may significantly influence long-term weight management (Hill, 2009). As such, it may be prudent to help individuals seeking weight management to monitor how participation in exercise at varying durations may subsequently influence energy intake.

Based on assumptions of energy balance alone, one may have expected that participants may have consumed more calories after 40 minutes of exercise than after 10 minutes of exercise because energy expenditure after a long bout of exercise would be greater than energy expenditure after a short bout of exercise. However, because energy intake after a short bout and a long bout of exercise were not significantly different in the present study, it may be possible that additional factors influence caloric intake post-exercise as compared to post-resting. In light of research that has shown that acute affective responses to exercise may influence energy intake (Unick et al., 2012), further analyses were conducted to explore the relationship between exercise, affect, and eating behavior.

5.1.5 Affective Responses to Physical Activity and Energy Intake

5.1.5.1 Positive affective responses to exercise for 10 minutes of exercise and 40 minutes of resting

In the current study, we hypothesized that there would be a significant difference in energy intake for those who showed improvements in positive affect in response to 10 minutes of exercise as compared to those with who did not show improvements in positive affect after 10 minutes of exercise. Contrary to the hypothesis, the results showed that both groups of those who did and did not have improvements in positive affect in response to 10 minutes of exercise had similar caloric intake across experimental conditions. Regardless of their affective responses to exercise, all subjects consumed significantly more calories after 10 minutes of exercise than after 40 minutes of rest. Of note, examination of the PANAS and SEES raw scores shows that those who did not have significant increases in positive affect after 10 minutes of exercise consumed the most calories as compared to other groups or conditions. Although the effect was not significant, it is possible that future research specifically designed to examine this question and with adequate power to detect effects may yield findings to confirm or refute the hypothesis.

5.1.5.2 Positive affective responses to exercise for 40 minutes of exercise and 40 minutes of resting

We hypothesized that there would be a significant difference in energy intake for those who showed improvements in positive affect in response to 40 minutes of exercise as compared to those with who did not show improvements in positive affect after exercise. Based on previous research by Blundell et al. (2003), the current study also explored the possibility that certain individuals may engage in compensatory eating after exercise by consuming more calories after exercise than after resting. The results showed varying findings across the PANAS and SEES measures. Data from the PANAS positive affect scale does not support the idea of compensatory eating after exercise. Rather, those who did not have positive affect improvements after 40 minutes of exercise consumed more calories after both exercise and resting as compared to those who did have positive affect improvements. Data from the SEES positive affect scale supports the existence of a compensatory eating post-exercise. As compared to those who did have positive affective improvements post-exercise, those who did not have positive affect improvements post-exercise consumed significantly more calories after exercise but similar calories post-resting.

Although there are different findings regarding the possible existence of compensatory eating post-exercise, findings from both the PANAS and SEES showed that those who felt better (i.e., increased positive affect) after 40 minutes of exercise ate fewer calories post-exercise as compared to those who did not experience positive affective improvement after exercise. Thus, experiencing the affect enhancing properties of exercise was helpful in controlling calorie intake post-exercise. This finding gives initial insight into predicting who will have positive changes in a weight management intervention. Specifically, the current findings provide preliminary evidence that promoting exercise sessions that lead to improvements in positive affect may be helpful in weight management. With further support of this finding, individuals seeking weight management may benefit from finding ways to enhance positive affect after long durations of exercise. Moreover, if exercise is not known increase positive affect for individuals, it is possible that they may benefit from choosing to participate in long durations of exercise that do not precede meal times or situations when food is readily available.

Because the current study design has limited power to detect effects, definitive conclusions cannot be made, and additional research is needed to examine the link among exercise, affect, and eating behavior. If results show that individuals across affective change groups eat more after both exercise and resting, as exhibited in the PANAS data for the current study, it is possible that those who do not receive the affective benefits of exercise may have a trait-like quality in which they receive minimal or no pleasure from exercise but do receive pleasure from consuming food. As such, regardless of whether they exercise or not, energy intake is generally greater than those who do receive affective benefits from exercise. Findings consistent with the SEES data from the current study as well as the “compensation” literature supports the idea individuals who did not receive the affective benefits of exercise may seek out food as a pleasurable experience when exercise does not increase positive affect. Future research that specifically recruits “compensators” and “non-compensators” and examines affective responses to exercise will provide further information about the role of affective responses to exercise on eating behavior.

5.1.5.3 Negative affective responses to exercise across 40 minutes of exercise, 10 minutes of exercise, and 40 minutes of resting

We hypothesized that women who increased negative affect after 10 minutes of exercise would have a significant difference in energy intake as compared to those who had a decrease or no change in negative affect after 10 minutes of exercise. Examination of the PANAS and SEES data showed that a large majority of participants did not have increases in negative affect after 10 minutes of exercise. Consequently, the affective change groups were considered too small to run the proposed analyses. Although there is no standard practice for how unequal groups may be to analyze and interpret the data, Keppel and Wickens (2004) caution that studies with small, unequal samples may be more likely to violate the heterogeneity of variance assumption and yield ambiguous results.

We also hypothesized that women who increased negative affect after 40 minutes of exercise would have a significant difference in energy intake as compared to those who had a decrease or no change in negative affect after 40 minutes of exercise. Contrary to the hypothesis, there was no difference in energy intake between those who increased NA after 40 minutes of exercise and those who had a decrease or no change in NA after 40 minutes of exercise using the PANAS data. Regardless of affective responses to exercise, there was a suggestive trend that all subjects ate more after 40 minutes of exercise as compared to 40 minutes of resting. Examination of data from the SEES data showed that a majority of individuals did not have increases in negative affect post-exercise. Thus, further analyses were not conducted. The inability to separate individuals by negative affective change group further supports the idea that exercise may not have a significant effect on negative affect for most sedentary, overweight women.

5.2 IMPLICATIONS FOR WEIGHT CONTROL

Short and long bouts of acute exercise have both been shown to produce improvements in positive affect for sedentary, overweight and obese women. In the context of a weight loss program, individuals seeking the mood-enhancing benefits of exercise will likely receive positive affective benefits by participating in either 10 minutes of exercise or 40 minutes of exercise. Thus, participation in multiple 10-minute bouts in accordance with national recommendations is an excellent option for sedentary, overweight individuals because most exercisers will gain improvements in positive affect post-exercise as well as gain the physical health benefits of exercise (Jakicic et al., 1995). Additionally, participation in 10-minute bouts may be perceived as more convenient and less daunting than participation in longer bouts of activity. Across 10-minute and 40-minute bouts of exercise, negative affect did not significantly change, which suggests that overweight and obese women may not have negative responses to exercise. Instead, exercise may be viewed as a modality that has the potential to make individuals feel better but not necessarily feel worse.

Participation in exercise may influence subsequent energy intake. The current study showed that caloric intake was greater after 10 minutes of exercise than after a resting session, and there was a suggestive trend-level finding that intake was greater after 40 minutes of exercise than a resting session. Thus, in the context of weight management efforts involving physical activity, participants should be cautioned about the likelihood to increase energy intake after exercise. Also, careful attention should be given to individual variability in affective responses to exercise and subsequent energy intake. Some individuals may have a particular tendency to increase energy intake post-exercise, and this pattern may negatively influence weight management efforts.

5.3 STRENGTHS

The current study is the first known study to examine affective responses to exercise of varying durations for overweight and obese women. Strengths of the current study include the use of a within-subjects, randomized, counterbalanced experimental design that allows for the minimization of between-subjects variability, experimental error, and order effects. The study also had a well-controlled methodology to minimize subject variability across participants. Specifically, the recruitment criteria and assessment visit were helpful to ensure participant safety as well as minimize the presence of comorbid health issues or behaviors that may have affected outcome variables. Another strength was the use of guidelines prior to each session, such as the consumption of a preload shake, in order to maximize participant consistency across all sessions.

The design of the experimental session also had several strengths. The study was adequately powered and yielded robust effects for the primary aims. Additionally, there was good consistency and control across all experimental sessions. Specifically, the food and type of magazines and movies available in the resting periods were the same across all participants. For the exercise sessions, the starting grade and speed of the treadmill was estimated based on each individual’s graded exercise test during her assessment visit. In turn, the majority of participants easily began each exercise session at a moderate intensity. Furthermore, trained staff monitored all exercise sessions. Specifically, each participant's heart rate was monitored throughout the exercise sessions in order to ensure safety and that exercise remained at a moderate intensity.

5.4 LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

The current findings should be interpreted within the context of several limitations. The current study investigated a specific sample of healthy, overweight and obese women. Because only women ages 18-45 were eligible to participate in the study, the findings may not generalize to men, or individuals in other age or BMI ranges who may have different subjective experiences of exercise. Although there is information that can be learned from the current study regarding weight management, participants in the current study were not required to have an interest in losing weight. As such, the results should be interpreted with the understanding that they may not generalize to all individuals seeking weight management intervention. Additionally, as part of the experimental design of the study, study staff monitored participants during the exercise sessions to ensure safety and record affect ratings. Although this design was necessary to complete the current study, the exercise prescribed in the study may differ from an individual's self-chosen exercise modality, duration, or intensity. Because self-chosen exercise may influence affect differently than imposed exercise (Ekkekakis & Lind, 2006), future research may benefit from using ambulatory monitoring of affect during self-selected exercise sessions.

Other limitations of the current study involve the interpretation of meaningful affective change points and the psychometrics of the 10-point affect scales. Because the PANAS and

SEES do not have criteria for the magnitude of change that is considered clinically meaningful, effect sizes were included in the current study in order to demonstrate the strength of current effects. Future research may benefit from examining clinically relevant criteria for meaningful changes in affect based on the influence on subsequent behavior. For example, additional research is needed in order to know what degree of affective change may influence eating behavior over the course of a day. Furthermore, the investigators created the 10-point affective scales used in the study as a way to simultaneously measure positive and negative affect during exercise and resting sessions. The scales were designed to collect pilot data because it is the first known measure to examine both acute positive and negative affect during an exercise session. Further information is needed regarding the psychometric properties of the affective scale.

The presentation of food during the ad libitum eating period one-hour post-exercise also presents limitations regarding the generalizability of findings. The current design is consistent with previous research examining exercise, affect, and eating (Unick et al., 2012). However, this design limits the ability to understand eating behavior more proximal to the exercise session. For example, when food was presented immediately after exercise, Oh & Taylor (2011) found that normal weight individuals consumed fewer calories after 15 minutes of exercise as compared to when the food was presented immediately after a resting session. It is unclear if energy intake would have been different in the current study if food was presented immediately after the initial exercise or rest period. Additional research will benefit from presenting food immediately after initial exercise or resting periods in order to understand how a one-hour resting period may influence energy intake.

The current study provides initial evidence that experiencing positive affect improvements after long durations of exercise may positively influence eating behavior;

however, the current design presents limitations regarding affect post-exercise as the only possible influence on eating. There can be multiple influences on affective responses to exercise, including: the participants' psychological and physiological characteristics, the physiological demands of exercise, the physical and social environment, and situational appraisals (Backhouse et al., 2007). Thus, as an extension of the current findings regarding affect and exercise, future research may benefit from collecting additional information regarding unique and shared contribution of physiological and cognitive responses to an exercise session. For example, King et al. (2012) proposed that there may be exercise-induced physiological changes in gastric emptying and gut physiology, appetite peptides, and substrate oxidation that all contribute to individual variability in energy intake after exercise. Attentional bias, which is a cognitive tendency to focus one's attention in a certain manner, also has been shown influence affective responses to exercise (Barnes et al., 2010). Furthermore, Bahrke & Morgan (1978) introduced a "distraction hypothesis" in which exercise serves as a distraction, or a mental "time out," that frees a person from negative, worrisome thoughts. Thus, because changes in physiological and cognitive variables post-exercise may possibly influence how individuals act regarding food choices, it may be useful to measure such factors over the course of the experimental period in future research.

It is also important to note that the presentation of food post-exercise may have influenced caloric consumption. In general, people have been shown to increase food intake when food is readily available in their environment (Murakami, Sasaki, Takahashi, Uenishi, 2009; Hickson et al., 2011). Weight control interventions, in fact, typically teach stimulus control, or the ability to minimize unhealthy eating and exercise cues while maximizing healthy ones. By presenting participants in the current study with foods that may be considered both healthy and unhealthy options, it introduced another factor that may have directly or indirectly influenced calorie intake. In order to investigate individual food choices after exercise, future research may benefit from collecting energy intake data via self-report for the full day after an exercise session.

Lastly, although the study was designed with sufficient statistical power to investigate the Primary Aims, it is important to also note that a priori power analyses were not conducted for the Secondary and Exploratory Aims. Due to the relationship found in the current study between exercise and subsequent energy intake as compared to a resting session, future research with an adequate a priori power analysis is recommended to examine the association between affect, exercise, and energy intake.

5.5 CONCLUSION

Affective responses to exercise have been widely investigated in normal weight populations, yet little is known about how overweight and obese individuals respond to exercise. The present study showed that most sedentary, overweight and obese women had positive affective responses to moderate intensity bouts of exercise at short and longer durations. In particular, 10-minute exercise bouts resulted in positive affective improvements that were not significantly different than improvements in positive affect after 40 minutes of exercise. Furthermore, on average, participation in exercise did not lead to increases in negative affect. Clinically, these findings are important because exercise accumulated in either short or long durations may be an attractive option for improving positive affect and increasing compliance to regular activity for sedentary, overweight and obese individuals. From research perspective, these findings encourage future research regarding the long-term affective benefits that may result from participation in multiple 10-minute exercise bouts throughout one's day.

The present study also showed that positive affective responses to exercise may influence subsequent energy intake. Findings supported the idea that there is individual variability in energy intake after exercise. Additionally, whether or not people experience positive affective responses to exercise may influence energy intake post-exercise. In the current study, individuals who did not have positive affect responses to long durations of exercise increased caloric consumption post-exercise. Because increased calorie consumption after exercise may influence weight management efforts, additional research is needed to examine relationship between affective response to exercise and subsequent energy intake.

APPENDIX A

STUDY DESIGN

EX-10

| Rest (VID, MAG) | Exercise | Rest (VID) | Ad-libitum eating task (MAG) |

0min	30min	40min	100min	160min
PANAS	PANAS	PANAS	PANAS	PANAS
SEES	SEES	SEES	SEES	SEES

EX-40

| Exercise | Rest (VID) | Ad-libitum eating task (MAG) |

0min	40min	100min	160min
PANAS	PANAS	PANAS	PANAS
SEES	SEES	SEES	SEES

REST

| Rest (VID, MAG) | Rest (VID) | Ad-libitum eating task (MAG) |

0min	40min	100min	160min
PANAS	PANAS	PANAS	PANAS
SEES	SEES	SEES	SEES

Key: min: elapsed session time in minutes; PANAS: Positive and Negative Affect Schedule administered; SEES: Subjective Experiences of Exercise Scale administered; VID: videos available; MAG: magazines available

Figure 6. Study Design of Experimental Sessions

APPENDIX B

POSITIVE AFFECT DATA AT ALL COLLECTED TIME POINTS

Table 8. PANAS Positive Affect and SEES Positive Well Being Data at All Collected Time Points

		Condition			p-values		
Measure	Time Point	REST	EX-10	EX-40	Time Effect	Condition Effect	Time X Condition Effect
PANAS PA	0 minutes	24.00±9.50	25.86±9.50*	24.39±7.35	**$p < 0.01$**	**$p < 0.01$**	**$p < 0.01$**
	30 minutes	-------	24.79±8.69	-------			
	40 minutes	23.25±8.96	28.21±7.45	29.36±7.37			
	100 minutes	23.29±10.18	24.43±8.33	25.11±7.86			
	160 minutes	23.04±8.78	24.79±8.62	24.82±7.96			
Within Condition p-values		p=0.69	p=0.00	p=0.00			
SEES PWB	0 minutes	13.64±6.24	14.32±4.63*	13.50±4.72	**p=0.04**	**p=0.01**	**$p < 0.01$**
	30 minutes	-------	13.29±5.35	-------			
	40 minutes	12.82±5.70	15.18±4.91	16.11±5.63			
	100 minutes	12.25±5.73	14.00±4.96	14.61±6.15			
	160 minutes	12.86±5.87	14.61±5.12	14.57±6.27			
Within Condition p-values		p=0.15	p=0.02	p=0.01			
*Excluded from ANOVA analysis and 30-minute time point was used as baseline							

APPENDIX C

RAW SCORES FOR NEGATIVE AFFECT DATA AT ALL COLLECTED TIME POINTS

Table 9. Raw Scores for PANAS Negative Affect and SEES Distress data at all Collected Time Points

		Condition		
Measure	Time Point	REST	EX-10	EX-40
PANAS NA	0 minutes	12.11±4.39	11.68±2.72	12.14±3.11
	30 minutes	-------	11.21±2.28	-------
	40 minutes	11.71±4.38	11.25±2.76	11.96±2.70
	100 minutes	11.61±4.31	10.96±1.93	10.89±1.77
	160 minutes	11.32±3.79	10.54±1.26	10.86±2.10
SEES Distress	0 minutes	6.43±3.91	5.39±2.51	5.64±3.19
	30 minutes	-------	5.71±3.15	-------
	40 minutes	5.89±3.89	5.36±3.25	5.18±2.25
	100 minutes	5.32±2.82	4.89±2.17	4.79±1.66
	160 minutes	5.29±3.38	4.54±1.60	4.75±2.21

APPENDIX D

LOG-TRANSFORMED NEGATIVE AFFECT DATA AT ALL COLLECTED TIME POINTS

Table 10. Log-Transformed PANAS Negative Affect and SEES Distress Data at All Collected Time Points

		Condition			p-values		
Measure	Time Point	REST	EX-10	EX-40	Time Effect	Condition Effect	Time X Condition Effect
Log PANAS NA	0 minutes	1.07±0.11	1.06±0.09*	1.07±0.10	$\boldsymbol{p < 0.01}$	p=0.26	p=0.19
	30 minutes	-------	1.04±0.08	-------			
	40 minutes	1.05±0.12	1.04±0.08	1.07±0.09			
	100 minutes	1.05±0.11	1.03±0.07	1.03±0.06			
	160 minutes	1.04±0.10	1.02±0.04	1.03±0.07			
Within condition p-values		***p*=0.03**	***p*=0.05**	***p*=0.00**			
Log SEES Distress	0 minutes	2.45±0.68	0.70±0.16*	0.71±0.18	$\boldsymbol{p < 0.01}$	$\boldsymbol{p < 0.01}$	p=0.07
	30 minutes	-------	0.72±0.18	-------			
	40 minutes	2.34±0.65	0.68±0.18	0.69±0.15			
	100 minutes	2.25±0.50	0.67±0.13	0.66±0.12			
	160 minutes	2.23±0.57	0.64±0.11	0.65±0.13			
Within condition p-values		***p*=0.00**	***p*=0.00**	*p*=0.17			
*Excluded from ANOVA analysis and 30-minute time point was used as baseline							

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