Effects of Self-Selected and Imposed Intensity of Acute Exercise on the HPA-axis Response and Psychological Well-Being in Inactive Women with High Levels of Stress

DISSERTATION

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Abstract

An understanding of stress and coping are important to health promotion and disease prevention. Previous research suggested that exercise can be beneficial for people who experience psychological distress. Moreover, psychological benefits following acute exercise have been frequently documented. However, there are mixed results for inactive individuals. Specially, exercise intensity has been shown to moderate the psychological benefits of acute exercise in this population. In addition, the mechanisms responsible for improvements in affective states with acute exercise remain unclear.

The primary purpose of this study was to examine psychological responses to self-selected and imposed-intensity acute exercise in inactive women with high levels of stress. Women are more likely to be inactive than men, and women are at greater risk of depression, which has been associated with chronic stress. The secondary purpose of the study was to examine potential psychobiological mechanisms (i.e., HPA axis influences and self-efficacy) for changes in psychological states.

This study used a 2 factor within-subjects experimental design with 3 treadmill exercise conditions (self-selected intensity, 10% above and 10% below relative self-selected intensity). Affective responses and salivary cortisol were measured at 6 time points, including pre-, during, & post-exercise, and self-efficacy was measured at 3 time points.
The results showed that acute bouts of exercise at around and lower intensity than ventilatory threshold might generate positive affective responses during and after exercise in young low active women with high levels of stress. The total workload of 150 kcal from exercise is effective for generating positive affect. Self-selected intensity may be effective for eliciting more favorable experiences during and following acute bouts of exercise, and promote future intentions for exercise more than exercise intensities that are imposed by someone else. In addition, the results of the present study provide partial support for the hypothesis that self-efficacy during exercise may be a potential mechanism underlying the generation of positive affective responses at self-selected intensity. We cannot draw conclusion from our results as to whether the HPA axis activity is a plausible mechanism for changes in affective responses to exercise.

Our findings support the notion that positive affective responses and self-efficacy are important predictors for intentions for future exercise. Specifically, more affective variables were found to be strong predictors of intentions at the self-selected intensity condition. It may indicate that self-selected intensity exercise has a positive influence on future intentions.
This document is dedicated to my husband, Rob W. Wardwell
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Chapter 1: Introduction

An understanding of stress is important to health promotion and disease prevention because it has been documented that negative aspects of stress are associated with many risks of disease and illness. Stress is commonly defined as an imbalance of homeostasis and elicits physiological and behavioral responses to reestablish homeostasis. Hans Selye, an Austrian physician who introduced the concept of human stress, coined the terms “eustress” and “distress” (Selye, 1950). Eustress refers to good stress, in contrast to distress, which refers to bad stress. The consequences of eustress and distress are completely different. Eustress, which is brought by the appropriate level of stress, leads to positive adaptation and minimizes the potential harmful effects of stress in general on humans. Therefore, eustress enables humans to achieve optimal performance. Moreover, as Franks (1994) stated, if a person has the ability to deal with the situation and accurately perceives the match between situation and ability, then challenging situations foster growth and development.

Distress, wherein stress exceeds the individual’s adaptive abilities, is problematic. The harmful consequences of chronic stress have a deleterious influence upon health and can threaten our quality of life. Chronic stress can lead to psychobiological and behavioral maladaptations to stress and may contribute to illness directly through physiological effects or indirectly via maladaptive health behaviors. Stress is recognized
as a risk factor linked to mental disorders including depression and anxiety disorders (U.S. Department of Health and Human Services [USDHHS], 1999). Depression is the fourth leading cause of disease burden in the world, accounting for 4.4% of total disability-adjusted life years according to the Global Burden of Disease study published in 2000 (Üstün, Ayuso-Mateos, Chatterji, Mathers, & Murray, 2004). Furthermore, depression contributes the largest amount of non-fatal burden, accounting for almost 12% of all total years lived with disability worldwide (Üstün et al., 2004). Notably, the burden of depression is 50% greater for women than for men; women also have a higher burden from anxiety disorders (Lopez, Mathers, Ezzati, Jamison, & Murray, 2006).

Therefore, coping or managing stress is important to minimize the negative effects of stress on physical and psychological health. As Selye noted, although “Stress is the spice of life” (Selye, 1974, p. 83), the consequences of stress would be different depending on how people manage the stress in their daily lives.

The ways of coping with stress can have important influences on psychological and physical well-being. Exercise is often cited as an effective stress management technique (e.g., Berger, 1994). In a large population study of individuals ranging in age from 25 and 64 years, participants who exercised at least 2 or 3 times a week reported less perceived stress (Hassmén, Koivula, & Untela, 2000). Additionally, higher rates of positive moods have been reported during exercise days than non-exercise days (Steptoe, Kimbell, & Basford, 1998). Increases in cardiorespiratory fitness and habitual physical activity are also associated with greater emotional well-being (Galper, Trivedi, Barlow, Dunn, & Kampert, 2006). Exercise is associated with a reduction in stress-related
emotions, such as anxiety and depression. For example, a meta-analysis of the effects of exercise on anxiety revealed that acute bouts of aerobic exercise were consistently associated with reductions in state anxiety (Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991). In respect to depression, exercise has been associated with significant reductions in depressive symptoms (Bartholomew, Morrison, & Ciccolo, 2005; Craft & Landers, 1998; Dunn, Trivedi, Kampert, Clark, & Chambliss, 2005; North, McCullagh, & Tran, 1990).

Effects of acute exercise on psychological responses have received considerable attention in recent years. Numerous research studies have shown that acute exercise is associated with post-exercise improvements in a variety of psychological variables, such as mood, state anxiety, affective responses, and self-efficacy beliefs. Moreover, these improvements in psychological states typically emerge within 20 min of the cessation of activity (Cox, Thomas, & Davis, 2001; Raglin & Wilson, 1996; Reed, Berg, Latin, & La Voie, 1998), and can last up to several hours post-exercise (Raglin, 1997, Chapter 7).

Recent research examining the psychological responses to acute exercise has specifically focused on change in basic affect. Affect is defined as the most basic or elementary characteristic component of all valenced (positive or negative, pleasant or unpleasant) feeling states, including, but not limited to, emotions and moods (Ekkekakis, Hall, & Petruzzello, 2005b). Basic affect is frequently characterized as being primarily comprised of two independent bipolar dimensions: valence, which can range from pleasant to unpleasant and activation, which can range from calm to aroused. Although acute exercise has been consistently associated with improvements in affect, there are
mixed findings for this acute exercise-affect relationship in inactive individuals. Some researchers have observed that inactive individuals experienced less positive affect after acute bouts of exercise. For example, Focht, Knapp, Gauvin, Raedeke, and Hickner (2007) reported that a 20 min bout of stationary cycling at 65% VO\textsubscript{2peak} resulted in reductions in global ratings of pleasure and categorical affective states in both young and old sedentary adults. This finding is consistent with other previous studies demonstrating that inactive or low active individuals do not report improvements in psychological states following acute exercise (Blanchard, Rodgers, Spence, & Courneya, 2001; Gauvin, Rejeski, Norris, & Lutes, 1997; Reed et al., 1998). Taken collectively, these findings indicate that the psychological benefits frequently documented following acute exercise may not be as consistently observed within inactive individuals.

Despite evidence linking acute exercise with improvements in affective states, the mechanisms responsible for this relationship remain unclear. However, several psychosocial and psychobiological mechanisms have been proposed. Perception of control represents one plausible psychosocial mechanism for the affective benefits of acute exercise (McAuley & Blissmer, 2000). Self-efficacy, the central motivational construct of the Social Cognitive Theory (Bandura, 1986), is defined as control beliefs regarding one’s capability to successfully satisfy specific situational demands (Bandura, 1997). McAuley and Blissmer (2000) have proposed that self-efficacy is related to affective responses to acute exercise, with higher self-efficacy beliefs being associated with more positive psychological outcomes and less psychological distress, and several studies have shown that higher self-efficacy beliefs were associated with more positive
psychological responses to acute exercise (McAuley & Courneya, 1992; Bozoian, Rejeski, & McAuley, 1994; Jerome, Marquez, McAuley, Canaklisova, Snook, & Vickers, 2002).

The relationships between pre exercise self-efficacy, in-task affective responses, and post exercise self-efficacy have been investigated. The studies that examined the link between pre exercise self-efficacy and affective states during exercise have shown conflicting results. For instance, some studies reported that this relationship was stronger when exercising at higher intensity (McAuley & Courneya, 1992; Treasure & Newbery, 1998). Contrary, Tate, Petruzzello, and Lox (1995) demonstrated that pre exercise self-efficacy was related to affect during 30 min of cycling exercise at 55% VO$_{2\text{max}}$, but not at 70% VO$_{2\text{max}}$. Focht and colleagues (2007) reported no significant correlations at 65% VO$_{2\text{max}}$.

On the other hand, the stronger association between in-task affective responses and post exercise self-efficacy has been consistently reported (McAuley & Courneya, 1992; Treasure & Newbery, 1998; Focht et al., 2007). For example, low levels of physical exhaustion and elevated feeling states during exercise predicted high post exercise self-efficacy in sedentary college students (Treasure & Newbery, 1998).

Recent studies reported the association between self-efficacy measured during exercise and affective responses during exercise, such as in a study with low active women where self-efficacy was a strong predictor of affect during a 30 min cycling exercise at 90% of the ventilatory threshold (Welch, Hulley, & Beauchamp, 2010).
Another plausible mechanism for effects of exercise on the response to stress is actions of the hypothalamic pituitary adrenal (HPA) axis as a consequence of exercise. The hypothalamic pituitary adrenal axis is activated in response to stress and adaptations in the HPA axis have been proposed as a physiological mechanism underlying the psychological benefits associated with acute exercise. The HPA axis is activated in response to physical or psychological stress. When exposed to stress, corticotrophin-releasing hormone (CRH) is secreted from the paraventricular nucleus of the hypothalamus. Following secretion of CRH, the posterior pituitary is stimulated and secretes vasopressin. The anterior pituitary is also stimulated and secretes adrenocorticotropic hormone (ACTH), prolactin, and β-endorphin. Adrenocorticotropic hormone activates the adrenal cortex to secrete cortisol, which plays an important role in the stress response, such as stimulation of gluconeogenesis and lipolysis for energy requirement during stress, and suppression of growth, reproductive, and immune responses. These responses occur fairly quickly and are aimed to maintain homeostasis. Dysregulation of the HPA axis can lead to hypercortisolism, which has been associated with depression (Gold, Loriaux, Roy, Kling, Calabrese, & Kellner, 1986).

Previous research has shown the effects of exercise on cortisol, noting cortisol levels are linearly associated with exercise intensity and duration (Davis, Gass, & Bassett, 1981; Scavo, Barletta, Vagiri, & Letizia, 1991). Rudolph and McAuley (1998) also reported that increased cortisol levels were related to increases in negative affect in inactive individuals during 30 min of treadmill exercise at 60% VO2max intensity.
Moreover, at 30 min post exercise, the participants who reported positive affect demonstrated lower cortisol levels (Rudolph & McAuley, 1998).

There are critical issues that need to be addressed regarding the beneficial psychological effects of acute exercise. First, exercise intensity has been shown to influence psychological responses to acute exercise, but the effects vary according to level of intensity and sample. Many studies showed that low to moderate intensity exercise sessions were consistently associated with post exercise improvements in psychological states (Ekkekakis, Hall, Van Landuyt, & Petruzzello, 2000; Raglin & Wilson, 1996; Steptoe & Cox, 1988; Steptoe & Bolton, 1988), while there is evidence that for inactive individuals, high intensity exercise bouts can result in negative post exercise psychological responses. For example, compared to inactive individuals, only trained individuals showed positive affect following a 90% VO$_{2\text{max}}$ workload (Parfitt & Markland, 1994), after a 100W cycle bout (Steptoe & Bolton, 1988), and after moderate and high intensity aerobic exercise (Boutcher & McAuley, 1997). Some other studies found negative affective responses following high intensity exercise even in fit individuals. After 15 min of high intensity cycling (100W), tension and anxiety increased immediately for both highly fit and moderately fit female college students, although highly fit individuals reported greater mental vigor and exhilaration than moderately fit participants (Steptoe & Bolton, 1988).

Second, as stated earlier previous studies have focused exclusively on changes in psychological states pre to post exercise. Only recent studies have described a systematic investigation of the affective responses during a bout of exercise. This is very important
for understanding the temporal dynamics associated with affective responses to acute exercise. Results of studies in which psychological responses during exercise were examined suggest that there may be considerable heterogeneity in these responses. Bixby, Spalding, Bradley, and Hatfield (2001) revealed that pleasure-displeasure were not significantly different before and after bouts of cycling exercise at a low intensity. However, low intensity exercise led to a significant increase in pleasure during exercise, which was maintained 20 min following exercise. A bout of high intensity exercise led to a significant decrease during exercise, but pleasure increased to a level above the baseline following exercise. Van Landuyt, Ekkekakis, Hall, & Petruzzello (2000) reported that almost half of their participants experienced progressive improvement in affective valence, whereas the other half experienced progressive deterioration during a 30-min cycling exercise at 60% VO$_{2\text{max}}$.

The results from these studies have addressed the temporal dynamics of affective responses to exercise and have shown that higher intensity exercise is associated with displeasure or discomfort during exercise. It is speculated that these negative affective responses may reduce the intrinsic motivation for physical activity, which could lead to decreased adherence and increased risk of dropout (Backhouse, Ekkekakis, Biddle, Foskett, & Williams, 2007; Ekkekakis et al., 2005). Accordingly, it is important to examine the exercise intensity-affect-adherence link. A recent study showed that inactive participants who reported more positive affective responses to a single bout of moderate intensity exercise at baseline reported more minutes of physical activity both 6 and 12 months later (Williams, Dunsiger, Ciccolo, Lewis, Albrecht, & Marcus, 2008).
The recent recommendation for physical activity is to exercise 30-min at a moderate intensity 5 days a week, 20-min at a high intensity 3 days a week, or some combination of moderate and high intensity exercise (Haskell, Lee, Pate, Powell, Blair, & Franklin, 2007). The recent guidelines for physical activity have encouraged self-selected or self-paced exercise as one way to enhance the likelihood of positive psychological responses and future adherence. Although there is good evidence for the beneficial effects of regular, moderate intensity exercise, research examining the psychological benefits of self-selected acute exercise is limited. In addition, there are only a few studies that have examined what intensity people of different exercise histories or current fitness levels select, and the average reported self-selected walking intensity varies across studies. For example, the mean self-selected walking intensity on a treadmill was 51.5% VO$_{2max}$ among 29 adult female habitual walkers (Spelman, Pate, Macera, & Ward, 1993). In another study, both high and low active groups selected a mean intensity of 60% VO$_{2max}$ for a 20-min cycling bout (Dishman, Farquhar, & Cureton, 1994).

Participant characteristics and exercise mode can also affect selected intensity. Female college students with high social physique anxiety self-selected a mean intensity of 63.5% HR$_{max}$ (approximately 40% VO$_{2max}$) for a bout on a cycle ergometer (Focht & Hausenblas, 2003), and active college students selected a mean intensity of 71% VO$_{2max}$ for an exercise bout on a treadmill (Parfitt, Rose, & Markland, 2000).

As shown, findings from these studies were inconsistent. Some recent studies used metabolic landmarks (i.e., ventilatory threshold and lactate threshold, the point of transition from aerobic to anaerobic metabolism) instead of using percent of oxygen
uptake to mark intensity, as in the study by Lind, Joens-Matre, and Ekkekakis (2005). They found that previously sedentary women tended to choose intensities proximal to the ventilatory threshold. Additionally, affect was positive and stable throughout the self-selected intensity of exercise. Similar to these findings, Rose and Parfitt (2007) observed the most positive affective responses in an at-lactate threshold condition in sedentary women and a below-lactate threshold condition in sedentary men (Parfitt, Rose, & Burgess, 2006). In summary, self-selected or self-paced intensity may aid in improving the quality of acute exercise experiences, facilitate more favorable psychological responses during and following acute exercise, and consequently could positively impact motivation for future exercise participation in inactive individuals.

The Purpose of Study

To date, there have been few studies comparing the psychological responses to self-selected and imposed-intensity acute exercise in inactive individuals. Additionally, knowledge of the psychobiological mechanisms responsible for the psychological benefits of acute exercise remains under-examined. In order to promote exercise in inactive individuals, investigation of these issues addressed above is potentially very important.

The primary purpose of this study was to examine psychological responses to self-selected and imposed-intensity acute exercise in inactive women reporting high levels of stress. The secondary purpose was to examine potential psychobiological
mechanisms, specifically HPA axis activity (salivary cortisol levels) and self-efficacy (mastery) associated with changes in psychological states.

To accomplish these purposes, we had three research questions. The first question was whether exercising at self-selected intensity results in more positive affective responses than exercising at imposed intensity (higher or lower) in inactive women, when equating for total energy expenditure.

**Hypotheses tested:**

1. Affective responses will become more positive pre to post exercise, irrespective of exercise intensity.

2. Global and categorical assessments of affective valence (pleasure), assessed with the Self-Assessment Manikin (SAM) and the Exercise Feeling Inventory (EFI) will be higher at the self-selected intensity exercise than at the imposed exercise intensity conditions during exercise and 10 and 30 min post exercise.

3. Dominance, a variable of the SAM will be higher during exercise at the self-selected intensity exercise than during the imposed exercise intensity conditions.

4. Arousal, a variable of the SAM will be highest during exercise at 10% above the self-selected intensity exercise.

The second research question addressed the role of the HPA axis (operationalized as levels of salivary cortisol) as a contributing mechanism to changes in affective responses during and after acute bouts of exercise.
Hypotheses tested:

5. Cortisol levels at imposed intensities (10% above and 10% below the relative intensity at the self-selected exercise) will be associated with less positive affective response during exercise.

6. Positive affect and cortisol response will be inversely related 10 and 30 min post exercise.

The third question was whether in-task self-efficacy is related to affect and cortisol level.

Hypotheses tested:

7. At the self-selected intensity, exercise self-efficacy will be significantly higher than during exercise of imposed intensities.

8. Self-efficacy during exercise will be inversely related to cortisol levels post exercise.

9. Higher self-efficacy will be strongly related to more favorable affective responses during the self-selected intensity exercise and 10% below the relative self-selected intensity exercise compared to 10% above the relative self-selected intensity exercise.

Definitions

**Acute exercise**

A single session of exercise; lasting from minutes to 1 hour in duration.
Affect

Affect is the most basic characteristic component of all valenced (positive or negative, pleasant or unpleasant) responses, including, but not limited to, emotions and moods. Valence and activation are orthogonal dimensions of the affect model. The valence and arousal dimensions of basic affect were defined as the response to the Self-Assessment Manikin (SAM; arousal, dominance, pleasure) as well as more discrete categorical affective responses defined using the Exercise Feeling Inventory (EFI).

Arousal

Arousal or activation is a unidimensional state of physiological activation that can range from sleep to wakefulness or excitement. Arousal was defined as the response to this SAM subscale.

Body Mass Index (BMI)

Body mass index is a function of weight and height that is used to determine degree of obesity. BMI was calculated by dividing the body weight in kilograms by the height in meters squared.

Cortisol

Cortisol is the main glucocorticoid steroid hormone secreted by the adrenal cortex and it regulates various organic metabolisms. Salivary cortisol was used for this study.

Dominance

Dominance is a continuum feeling state ranging from being controlled or submissive to in-control or empowered. Dominance was defined as responses to this
SAM subscale and subjects’ confidence in performing exercise to expend 150 kcal at each exercise conditions.

*Exercise*

Exercise is a subset of physical activity that is planned, structured, repetitive bodily movements with the purposive sense of improvement or maintenance of one or more components of physical fitness. In this study, exercise was defined as walking on the treadmill at self-selected and imposed intensities and durations in order to expend 150 kcal.

*Exercise prescription*

A recommendation for a course of exercise to meet desirable individual goals or fitness level, including activity types, duration, intensity, and frequency of exercise.

*Hypothalamic Pituitary Adrenal axis (HPA axis)*

Hypothalamic Pituitary Adrenal axis is a term for organs that secrete multiple hormones involved in the regulation of a wide range of physiological and behavioral responses to stress. One of the end products of HPA axis activation is cortisol secretion in humans.

*Intensity*

Exercise intensity refers to how much work is performed during exercise. In this study, exercise intensity was expressed as relative to maximal capacity (e.g., 50% of \( \text{VO}_2\text{max} \)). Intensities for acute exercise bouts were chosen by the participants (self-selected intensity), and prescribed by the investigator to be 10% above and 10% below the relative intensity at the self-selected intensity.
**Perceived exertion**

Perceived exertion is how hard one feels his or her body is working during physical activity. It is a subjective experience based on physical sensation and helps determine the intensity of activity.

**Physical Activity**

Any bodily movement produced by skeletal muscles that result in energy expenditure.

**Pleasure**

Pleasure is the mental state that humans experience as positive, enjoyable, and/or happy. Pleasure was defined as responses to SAM subscale pleasure and EFI.

**Sedentary**

Sedentary is defined as physically inactive. In this study, sedentary was defined as “no aerobic exercise” or “exercise less than 3 times per week and less than 20 minutes per session and weekly energy expenditure from exercise less than 500 kcal”.

**Stress**

Any circumstance that causes imbalance of homeostasis that activates physiological and psychological responses to restore homeostasis.

**Ventilatory threshold**

Ventilatory threshold is the point at which pulmonary ventilation increases disproportionately with oxygen consumption without a concomitant increase in pulmonary ventilation for carbon dioxide during exercise.
**Assumptions and Delimitations**

The sample population in this study was limited to women in the central Ohio area, between the ages of 18 and 40. Participants should have been experiencing higher perceived stress, but were not clinically diagnosed with any mental conditions. It was also assumed that the participants’ personal life events did not influence individual responses to the exercise bouts.

The participants were asked to perform walking exercise on a treadmill. It was assumed that the participants would be able to expend the 150 kcal at the self-selected intensity, 10% above and 10% below of the relative intensity at the self-selected intensity. We assumed that the participants understood and responded honestly to questions that were administrated before, during, and after each exercise condition.
Chapter 2: Literature Review

Historical Perspective of Stress

For many years, balance or harmony has been recognized as a necessary condition for the survival or good health of human beings. In the 19th century, Claude Bernard, a French physician and physiologist, first put forth the idea of a constant internal *milieu interior*, which means the principle of a dynamic internal physiological equilibrium for good health. Later, the concept was refined by the American physiologist, Walter Cannon, who coined the term *homeostasis*. He also described the “fight or flight” response, which is necessary as the first defense against external challenge. In the 1930’s, Hans Selye, an Austrian physician used the term “stress” from physics and set it to mean the mutual actions of forces that take place across the body. Later he defined stress as the “nonspecific response of the body to any demand” (Selye, 1974, p. 14). He also described “stressors” to refer to anything in the environment that caused a stress response (Selye, 1956). When a stressor disturbs homeostasis, it results in the activation of the stress response, which is managed through the hypothalamic-pituitary-adrenocortical (HPA) axis to restore homeostasis (Selye, 1974). Further, Selye coined the terms “eustress” and “distress,” which reflected the notion that not all states of stress (i.e., threatened homeostasis) were noxious (Selye, 1950). Hence, he believed that mild, brief, and
controllable challenges could actually be perceived as pleasant or exciting and could be positive stimuli to emotional and intellectual growth and development.

Selye also emphasized the connection between stress and diseases systems of the body. Stress was associated with the so-called “diseases of adaptation,” which are due principally to an imperfect adjustment to stress (Selye, 1955). According to his “general adaptation syndrome,” the initial response to stress, which is called the alarm reaction (e.g., increase in heart rate and blood pressure) is followed by the adaptation stage, which includes the successful activation of the appropriate response systems and reestablishment of homeostasis. If stress becomes chronic or is repeated frequently, the exhaustion phase sets in and increases susceptibility to diseases (Selye, 1956).

In a more recent view of stress, Chrousos and Gold (1992) defined stress as a state of disharmony that threatens homeostasis, which is an immensely complex dynamic and harmonious equilibrium that is constantly challenged or threatened by intrinsic and extrinsic stressors.

Some researchers suggested that the concept of stress is multidimensional. It has been suggested that living organisms develop adaptive responses to stress at two levels; one level is cognitive-behavioral and the other is the physiological processes through which the organism attempts to reestablish homeostasis. These adaptations include such behavioral changes as increased arousal, cognition, vigilance, focused attention, and appropriate aggression accompanied by suppression of feeding and reproductive behavior. Physiological changes aim at a conservation of energy by directing oxygen and nutrients to the central nervous system and increasing cardiovascular activity, blood
pressure, heart rate, respiratory rate, gluconeogenesis, and lipolysis in conjunction with suppression of growth and reproductive and immune systems. These responses occur relatively quickly and in the short term appear to be beneficial to the organism in its attempt to regain homeostasis and survive (Plowman, 1994).

Chronic stress or maladaptive responses to stress may be linked to illness as Selye noticed a long time ago. The adaptive responses can be specific to the stressor or nonspecific; and the latter occurs only if the magnitude of the threat to homeostasis exceeds a certain threshold (Chrousos & Gold, 1992). The harmful consequences of chronic stress have influence on our health and even threaten our quality of life. Chronic stress elevates stress hormones, such as cortisol. Constant elevation of cortisol makes a person more susceptible to infection. Moreover, prolonged elevated cortisol levels produce structural changes in the brain and lead to neuronal damage. Some behavioral responses, for example aggression, hyperactivity, withdrawal, or eating disorders and drug addiction are associated with high cortisol levels. In this regard, maladaptation to stress may lead to pathological changes and become a link to illness, such as cardiovascular disease, hypertension, cancer, mental illness, and so forth.

In the interactional view, psychologists emphasize that a stress response is a result of the relationship between a person and the environment (Cohen, 2000), especially an individual’s perceptions and cognitions in respect to stressors (Gill, 1994). For example, individual characteristics, including perceptions, expectations, experiences, moods, personality traits, appraisal skills, coping resources, vulnerabilities, risk factors, and
behavioral dispositions would determine how the stress is perceived (Franks, 1994; Plowman, 1994).

The current working definition of stress can be summarized as a state of threatened homeostasis, which causes an imbalance of the physiological systems and elicits physiological and behavioral responses. In addition, it has been suggested that two major physiological pathways are involved in the stress responses, that is, the HPA axis and the locus coerules norepinephrine (LC-NE) system/autonomic nervous system, which provide additional support to actions of the neurological axis by increasing cardiac output, blood pressure, and contraction of skeletal muscles.

In our modern society, we have to deal with stress daily. In a college student population, for example, 75% reported moderate stress and 12% reported high stress when surveyed during a class (Pierceall & Keim, 2007). Female students have higher perceived stress than male students (Abouserie, 1994; Pierceall & Keim, 2007). Moreover, students under greater stress exhibit lower levels of self-esteem and reduced perceptions of their health status (Hudd et al., 2000).

The consequences of stress can be positive in some cases if the stress is short-term, milder, and perceived as controllable, or negative if long-term, more severe, and perceived as out of the person’s control. Hence, to maintain an optimal level of stress, people need to regulate the amount of stress in their daily lives and to manage their stress responses (Berger, 1994).
Affective Responses to Acute Exercise

Positive effect of exercise on psychological well-being.

Accumulating evidence suggests that acute bouts of exercise are associated with post exercise improvements in a variety of psychological responses, such as mood, state anxiety, affective valence (pleasure), categorical affective states (more discrete states, such as revitalization and physical exhaustion), and self-efficacy beliefs. For example, after sub-maximal exercise on a cycle ergometer, state anxiety diminished in female college students (Felts & Vaccaro, 1988). Mood was improved following acute exercise in older people (Pierce & Pate, 1994). In both frequent exercisers and infrequent exercisers, mood was improved to the same degree after an aerobic exercise class (Choi, Van Horn, Picker, & Roberts, 1993). Lox, Martin, and Petruzzello (2003) summarized that exercise seems to increase positive mood states, produce an energizing effect, and reduce negative mood states, such as tension, anger, confusion, and fatigue.

Furthermore, these psychological improvements were reported to persist from 20 min to several hours after exercise. Reed et al. (1998) reported that positive affective responses were maintained 20 min after 24 min of cycle ergometer exercise at 50% $\text{VO}_2\text{max}$ intensity. The participants were 41 active and sedentary college students between the ages of 19 and 33; and both groups were similar in affect at 20 min post exercise. Cox et al. (2001) showed that 24 physically active male college students with an average age of 28.3 years maintained positive well-being and decreased fatigue and psychological distress 60 min post 30 min of treadmill exercise at both 50 and 75% predicted $\text{VO}_2\text{max}$. In a study with 15 young adults, state anxiety was assessed at 5, 60, and 120 min.
following 20 min of cycle ergometer exercise at 40, 60, and 70% \( \text{VO}_{2\text{peak}} \) intensity (Raglin & Wilson, 1996). The reduction in state anxiety was observed at 120 min post exercise with a similar reduction for all exercise conditions. In a recent meta-analysis, Reed and Ones (2006) summarized that the effect of aerobic exercise on affect lasted for at least 30 min after exercise.

Previous studies of affective responses to exercise extensively focused on examining distinct variables, such as mood states and state anxiety. However recent studies have focused more on basic or global affect. Basic affect is commonly defined by both valence (positive or negative, pleasant or unpleasant) and activation responses (calm to aroused), including, but not limited to, emotions and mood (Ekkekakis et al., 2005b).

Positive valence (e.g., pleasure) elicited by exercise has been recognized as an important consequence of exercise and has been highlighted by physical activity recommendations to enhance health status. The Healthy People 2010 health promotion program states that “each person should recognize that starting out slowly with an activity that is enjoyable and gradually increasing the frequency and duration of the activity are central to the adaptation and maintenance of physical activity behavior” (USDHHS, 2000, P22-4). In respect to this support for engaging in enjoyable activities, Ekkekakis, Hall and Petruzzello (2004) suggested that affect should be used as a guide in physical activity prescriptions.
**Findings from previous studies.**

Researchers have attempted to draw conclusions about the optimal exercise dose (intensity and duration) to generate positive affective responses, but results from their studies have been mixed.

**The dose of exercise intensity.**

Ekkekakis and Petruzzello (1999) evaluated 31 studies published between 1971 and 1998 that compared the effects of exercise intensity on affect. The most often cited assumption in these early studies was the inverted-U shape of the dose response relationship between the intensity of physical activity and affect. The inverted-U indicates that low intensity exercise is insufficient to produce significant changes in affect and that high intensity is either ineffective or experienced as aversive while midrange intensities are optimal (Kirkcaldy & Shephard, 1990; Ojanen, 1994). Berger and Motl (2000) suggested that optimal benefits occur following moderate, but not low or high intensity exercise.

The results of early work by Farrel, Gustafson, Morgan, and Pert (1987) indicated a threshold effect for intensity of physical activity to provoke psychological benefits. They reported that tension and anxiety reductions were similar following acute treadmill running at both 60 and 80% of VO\(_{2\text{max}}\), but affect was not affected after running at 40% of VO\(_{2\text{max}}\). On the other hand, Raglin & Wilson (1996) observed that a 20 min cycle ergometer exercise resulted in significant reductions in state anxiety at all post exercise assessments in the 40% VO\(_{2\text{peak}}\) condition as well as the 60% VO\(_{2\text{peak}}\) condition. Several
studies have shown that other forms of low intensity exercise, such as walking, are also effective for acute psychological benefits (e.g., Ekkekakis et al., 2000). Ekkekakis and Petruzzello (1999) concluded that a threshold assumption for low intensity of exercise was not supported.

Likewise, high intensity exercise has produced mixed results. Several researchers reported that high intensity exercise was related to significant elevations in state anxiety and should be avoided to ensure psychological benefits (Raglin, 1997, chap. 7). For example, Steptoe and Bolton (1988) found that tension and anxiety were elevated following high intensity stationary leg cycling exercise, whereas these levels were significantly reduced following low intensity cycling. High intensity exercise increased fatigue among collegiate swimmers (Berger & Owen, 1992) and resulted in a more negative mood for middle aged men who participated in a marathon race (Hassmen & Blomstrand, 1991). Raglin and Wilson (1996) found that state anxiety increased immediately following 20 min of leg cycling performed at 70% VO_2peak, whereas reductions were observed immediately after exercise at 40 and 60% VO_2peak.

Conversely, it has been reported that high intensity exercise (e.g., 80% VO_2max) brought about significant affective benefits in some individuals. Maximal exercise in women appeared to increase self-esteem and decrease tension in a study by Pronk, Crouse, and Rohack (1995). In another study, 22 young and fit volunteers participated in 3 randomly assigned conditions, including no exercise, 30 min cycling exercise at 50% VO_2max or 70% VO_2max (Tate & Petruzzello, 1995). Exercising at an intensity of 70% VO_2max resulted in significant increases in positive affect and decreases in state anxiety
and led to longer lasting increases in energetic arousal post-exercise (Tate & Petruzzello, 1995).

Training status or fitness seems to be a significant moderator of affective responses at higher intensities (Ekkekakis & Petruzzello, 1999). During the high intensity condition, some fit individuals showed a more positive affective response, whereas unfit individuals experienced negative affective responses. For example, psychological distress significantly increased for the unfit group in the 80% of maximal heart rate reserve condition, but there was no difference between the fit and unfit groups at 50% HRR condition (Blanchard et al., 2001). Steptoe and Bolton (1988) found that only highly fit individuals showed increases in vigor and exhilaration following 100W cycling bout (a high intensity condition). Similarly, in a study of 80 college students, including 40 men and 40 women, the inactive students had significantly less positive affect than their active counterparts in the last 30s of and 5 min after exercise at 90% of their maximal workload on a cycle ergometer (Parfitt & Markland, 1994). Trained participants exhibited an increase in positive affect during running at an intensity that was rated as moderate and hard (Boutcher & McAuley, 1997), whereas untrained participants had decreased positive affect after moderate and hard intensity exercise. Reed et al. (1998) reported that active subjects were significantly more positive than the inactive group during exercise on a cycle ergometer at 50% VO$_{2\text{max}}$ (moderate intensity) and at 5 min post exercise.

Although negative affective responses were generated immediate after high intensity exercise for some individuals, some studies observed improved affective responses at 60 min and longer post exercise. Raglin and Wilson (1996) demonstrated
that similar reduction in state anxiety occurred for 40, 60, and 70% VO$_{2\text{peak}}$ conditions 60 and 120 min following 20 min stationary leg cycling. Especially, in the 70% of VO$_{2\text{peak}}$ condition, state anxiety was elevated at 5 min post exercise, and decreased below baseline at 60 and 120 min post exercise to a degree not different from 40 and 60% of VO$_{2\text{peak}}$ conditions. Similar results were reported by Steptoe and Bolton (1988) with 40 fit and moderately fit female volunteers. The results indicated that tension and anxiety were reduced significantly following low intensity (25W) cycling exercise, whereas these levels were elevated following high intensity (100W) cycling exercise. However, tension and anxiety reductions with similar magnitude to low intensity exercise were observed 15 min following the high intensity condition. Raglin (1997, chap.7) explained that these results indicated that psychological improvement may be delayed following high intensity exercise.

Gauvin et al. (1997) attempted to find the dose-response relationship between different intensities (30, 50, 70% of HRR) of acute aerobic exercise and feeling states in 72 sedentary men and women. However, they did not find either a strong dose response relationship or mood enhancing effects of acute exercise. The authors discussed that these results might be influenced by individual characteristics and circumstances. For example, the study participants were inactive and were not used to exercising, and environmental condition, such as exercising in a supervised laboratory setting could have also influenced the results.

Taken together, the inverted-U model has limitations for describing the relationship between exercise intensity and positive affective responses. Moreover,
previous studies did not provide strong evidence of a dose-response effect on affective responses. Considering the relatively small number of studies and sample sizes, and their methodological differences and limitations, especially a lack of systematic and theoretical foundations, Ekkekakis and Petruzzello (1999) summarized that “any definitive conclusion would be imprudent.”

However, low to moderate intensity exercise is consistently associated with positive affect. In particular, moderate intensity exercise is understood to be safe, and produces positive affective changes in all or most individuals. Morgan (1997, chap.1) claimed that it is “possible to defend a single exercise prescription for all individuals (e.g., 70% of VO\textsubscript{2max})” (p. 11). Lox et al. (2003) provided the general recommendation for the optimal dose of exercise to achieve psychological benefits: at least 20-30 min duration and intensities in a moderate range (e.g., 70% VO\textsubscript{2max}).

Ekkekakis and his colleagues (2005b) claimed that physical activity must be considered from an evolutionary and adaptational perspective. According to the authors, “physical activity is unique among survival-critical activities, as it can induce bidirectional changes in affect [i.e., pleasure or displeasure” (p. 481)] and they stated pleasure and displeasure are tied to the maintenance of homeostasis. Therefore, different levels of physical activity may entail either utility or danger. Moderate intensity activity can be maintained for a long time period at a physiological steady state. Ekkekakis et al. (2005b) supported the position that the pleasure associated with moderate intensity
Physical activity is the psychological mechanism that evolved to reward (e.g., Sher, 1998), and therefore, to promote such activity.

**The dose of exercise duration.**

Some researchers have made a general recommendation for thresholds of exercise duration to show psychological benefits. Berger (1994) proposed that at least 20-30 min of exercise is required for psychological benefits. Dishman (1986) stated that exercise must be at least of moderate intensity and last for a minimum of 20 min. According to Petruzzello et al.’s (1991) meta-analysis, exercise of at least 21 minutes seemed necessary to achieve reductions in state and trait anxiety.

Contrary to these recommendations, some other studies have indicated that short bouts of exercise can improve affective responses. In an early study, 10 min of brisk walking significantly elevated feelings of energy for 18 college students between 19 and 38 years of age (Thayer, 1987). Rudolph and Butki (1998) investigated the effects of 10, 15, and 20 min bouts of treadmill running in moderately active female college students. Their results showed increased positive well-being and decreased psychological distress in all three conditions (10, 15, and 20 min bouts of exercise) from baseline to 20 min after exercise. Ekkekakis et al. (2000) showed that 10-15 min bouts of walking performed in both outdoor and laboratory settings were associated with more positive affective valence. Likewise, more recent studies, Ekkekakis, Backhouse, Gray, and Lind (2008) and Focht (2009) also confirmed improvements in affective responses after 10-15 min brief walks in both outdoor and laboratory environments.
Few studies have compared the effects of duration on affective responses to exercise (Lox et al., 2003). In one of these studies, Rejeski, Gauvin, Hobson and Norris (1995) attempted to find the optimal dose of acute exercise duration on feeling states. Eighty moderately fit female college students were divided into four groups, including a 10 min attention control group and three groups who exercised for 10, 25 and 40 min at an intensity of 70% of age predicted heart rate reserve. The participants in all three exercise groups reported a greater feeling of revitalization than the control group. After controlling for the influence of baseline feeling states, the participants who had low to moderate revitalization scores before exercise gained the most benefit from acute exercise when they performed exercise for 10 or 25 min. The results of this study are in line with Ekkekakis and Petruzzello (1999) who stated that “there is no evidence that the threshold assumption has some basis in fact” (p. 354). In addition, Ekkekakis and Petruzzello (1999) pointed out a measurement issue. Post exercise assessments of affect were made several minutes following the termination of the exercise bout, such that waiting for relatively long recovery periods before conducting the post exercise assessment might have allowed any duration effects to dissipate. In a more recent study, Blanchard, Rodgers, and Gauvin (2004) attempted to replicate Rejeski and colleagues’ study from 1995, but used a non-laboratory environment (i.e., indoor running track) instead of a laboratory environment (Rejeski et al., 1995). Blanchard et al. (2004) examined the influence of exercise duration (25 and 40 min of exercise at 70% of HRR) on feeling states with 69 physically active young women, which was a similar sample to Rejeski et al.’s (1995). The results of Blanchard’s study revealed that positive
engagement and revitalization significantly increased from pre to post exercise regardless of exercise duration. The changes in physical exhaustion in the two exercise conditions were similar in magnitude. Interestingly, the participants in the 40 min running condition reported a significant reduction in physical exhaustion from pre to post exercise in comparison to the changes in the control condition. Only the participants in the 25 min running condition experienced an increase in tranquility. These results were in line with previous studies conducted in laboratory environments (Rejeski et al., 1995). Furthermore, the authors found the decrease in physical exhaustion from pre to post exercise (both 25 and 40 min), whereas Rejeski et al.’s did not find this decrease.

Another study compared the effects of 15 and 30 min cycle ergometer exercise among physically active participants (Daley & Welch, 2004). The results showed that no significant differences were noted between the 15 and 30 min exercise conditions. In a meta-analysis, Reed and Ones (2006) reported that there were no differential effects of exercise duration on post exercise positive affect; however the results demonstrated that effects were positive for exercise duration up to 35 min.

One recent study supported the dose-response relationship between exercise duration and affective responses. Woo, S. Kim, J. Kim, Petruzzello, and Hartfield (2009) compared 15, 30, and 45 min of treadmill exercise at 60% of VO$_{2\text{max}}$, identified as the workload just below ventilatory threshold among non-active female college students. The results showed psychological vigor and frontal EEG asymmetry were higher following 30 min of exercise than other exercise durations. Their results partially supported previous
findings, but highlighted that a shorter or longer duration of exercise was not as effective as 30 min of exercise.

**Critical methodological issues.**

Some reviews and empirical research published in the 1990’s and later (e.g., Backhouse et al., 2007; Ekkekakis & Petruzzello, 1999; Ekkekakis, 2009b; Welch, Hulley, Ferguson, & Beauchamp, 2007) described several methodological issues in previous studies that influenced results regarding affective responses to acute exercise.

**The timing of affect assessments (“during” exercise).**

The first critical methodological issue is the timing of affect assessments. The vast majority of the studies conducted before the 1990’s and many conducted since, reported assessments of affect before and at various time points after the exercise bout, but not during the exercise (e.g., Backhouse et al., 2007). The affective responses only before and after the exercise reflect the assumption that any interim changes taking place would be linear (e.g. Backhouse et al., 2007; Ekkekakis, 2009b). This assumption provides a limited and potentially misleading perspective on the true effects of different exercise bout durations on affective response (Ekkekakis & Petruzzello, 1999). Measuring affect during exercise, so called “in-task” affective responses would be very important in capturing the dynamic nature of affective changes.

For example, Bixby et al. (2001) measured affective responses before, during, and following 30 min of exercise at low and high intensity. In the low intensity condition,
mood improved during exercise relative to baseline and remained elevated for 20 min following the exercise. In contrast, in the high intensity condition, mood was worse than the baseline levels during exercise, and improved to a level better than baseline following exercise. This study observed different pathways during exercise leading to a common affective outcome. Backhouse et al. (2007) examined affective valence in 90 min walk-run exercise (simulate sport-games) among recreationally active young men. The results demonstrated a significant decline in affective valence ratings during 90 min walk-run, whereas affective valence reported post exercise did not differ from pre-exercise level.

**Defining exercise intensity.**

Defining exercise intensity has been a challenging methodological issue. In most previous studies, exercise intensity was based on an individual’s percentage of maximum heart rate or VO\textsubscript{2max}. Many studies employed moderate intensity, such as 70\% VO\textsubscript{2max} to produce positive affective responses to acute bouts of exercise. However, 70\% VO\textsubscript{2max} could be above the anaerobic threshold for many individuals (Morgan, 1997, chap 1.). Therefore, the method was questioned because individuals exercising at the same workload would have different metabolic responses, that is, the same workload could produce aerobic metabolism for one individual, but anaerobic metabolism for the other even if they are of the same gender and have similar maximal aerobic capacity, age and health characteristics (Ekkekakis et al., 2005b; Katch, Weltman, Sady, & Freedson, 1978; Lox et al., 2003). Some researchers took these differential responses into account using intensity based on lactate or ventilatory threshold (Bixby et al., 2001; Hall, Ekkekakis, &
Petruzzello, 2002). Lactate accumulation during exercise can contribute to fatigue and perceived exertion. Lactate threshold (LT) is the lowest workload at which the rate of lactate accumulation in the blood starts to exceed the rate of removal. Ventilatory threshold (VT) is the point at which the ventilatory equivalent for oxygen continues to increase without a concomitant increase in the ventilatory equivalent for carbon dioxide. After these studies by Bixby et al. (2001) and Hall et al. (2002) in which intensity was based on participants’ LT or VT, Ekkekakis (2003) proposed “the dual-mode conceptual model.” Ekkekakis (2003) postulated that affective responses to exercise are the products of the continuous interplay between two general factors, both of which have access to the affective centers of the brain. These dual factors are: (a) relevant cognitive process originating primary in the prefrontal cortex and involving such processes as appraisals of the meaning of exercise, goals, self-perceptions including self-efficacy, attributions, and considerations of the social context of exercise and (b) interoceptive cues from a variety of receptors stimulated by exercise-induced physiological changes. The dual mode model also proposed to use metabolic landmarks (i.e., ventilatory and lactate thresholds). Using LT and VT was particularly informative for the examination of in-task affective responses and these metabolic landmarks could be a useful reference point for individualized exercise prescriptions (Ekkekakis et al., 2004).

**Exercise intensity and total work.**

Another methodological issue in relation to exercise intensity is that most previous studies manipulated exercise intensity while holding duration constant.
Kilpatrick, Kreamer, Batholomew, Acevedo, and Jarreau (2007) pointed that this clearly confounded exercise intensity and the total work. Few studies tested the relationship between exercise intensity and affective response when equating total work expenditure. In one of the few studies that did address this issue, Kilpatrick et al. (2007) compared affective responses for cycle ergometer exercises with 30 min at 85% of VT and an average of 24 min at 105% VT, but equal total work. Affective valence was significantly less positive during the higher intensity bout, but not the lower intensity bout. Their results demonstrated that the decline in the ratings of pleasure during higher intensity exercise was not dependent on differences in total caloric expenditure.

**Environment factors.**

Environmental factors may also influence psychological well-being during acute exercise. Focht and Hausenblas (2003) examined the state anxiety responses to self-selected and imposed intensity bouts of acute exercise for individuals with high social physique anxiety (SPA). They used two levels of evaluative threat environment; a laboratory environment was used as the less evaluative threat condition, and a naturalistic environment was used as a more evaluative threat condition, which could even induce an anxiogenic response. The results revealed that with high SPA, self-presentational (naturalistic environment) threat was more influential than the exercise stimulus in relation to the state anxiety response during exercise. Although state anxiety was reduced 5 min following both exercise conditions, the anxiolytic effect persisted through the 120 min assessment only following the less threatening environmental condition (laboratory).
The authors argued that intensity of exercise, which normally contributes to the reduction of the state anxiety score, was superseded by perceived self-presentational threat for women with high SPA (Focht & Hausenblas, 2003).

**Exercise-affect relationship: findings from recent studies.**

Studies published since 2000 have examined the exercise-affect relationship from a new methodological platform, such as using LT or VT to define exercise intensity and assessing affect at multiple time points, both during and after the exercise bout. These recent empirical studies revealed a clear dose-response pattern, as intensity increases above LT or VT, affect during exercise becomes less positive or more negative, thus supported the dual mode model (e.g., Bixby, et al., 2001; Hall et al., 2002; Ekkekakis et al., 2004; Ekkekakis, Hall, & Petruzzello, 2005a, 2008; Kilpatrick et al., 2007; Parfitt et al. 2006; Rose & Parfitt, 2007; Welch et al., 2007). For example, Hall et al. (2002) and Ekkekakis and colleagues (2004), (2005a), and (2008) showed that affective valence declined above VT during treadmill exercises in young healthy college students. Likewise, in a study of 37 college students with different fitness statuses, Kilpatrick et al. (2007) found a decline in ratings of pleasure during higher intensity cycle ergometer exercise (105% of VT), but not during lower intensity cycle ergometer exercise (85% of VT).

Other studies with inactive and older populations found results consistent with studies using young healthy populations. In middle-aged inactive adults, affect was the least positive during the above LT condition and most positive during the below LT
conditions during 20 min of treadmill exercise among 12 men (Parfitt et al., 2006) and among 19 women (Rose & Parfitt, 2007). Interestingly, Parfitt et al. (2006) revealed that there were no differences in affective responses between the above LT condition and the below LT condition post exercise. Ekkekakis and colleagues (2008, p.145) stated, “The VT appears to be a turning point toward reduced affective positivity.” At least one study, Welch et al. (2007) demonstrated that a mean decline in valence began before the VT among inactive young female college students. Thus, inactive or low active individuals may experience displeasure at intensities below but near the VT.

**Inter-individual variability.**

Gauvin et al. (1997) stated that acute exercise positively influences only *some* of the people, *some* of the time. Van Landuyt et al. (2000) assessed affect before, during, and after a session of moderate intensity (i.e., 60% VO2max) cycle ergometry among 80 university students. The authors found that 44.4% of the participants reported a gradual improvement in affective valence over the course of 30 min of cycling at 60% VO2max, whereas 41.3% reported a gradual decline. Ekkekakis et al. (2005b) stated that inter-individual variability is reduced when the intensity of exercise is either low or high, but is quite prevalent over a fairly broad range of intensities around moderate intensity.

Recent research has demonstrated a dose-response relationship between exercise intensity and affective responses. A decline in affective valence during exercise above LT or VT is homogeneous among individuals. On the other hand, there are substantial differences in affective responses below and around the LT and VT. Parfitt et al. (2006)
reported that inter-individual variability in Feeling Scale (FS) responses was greatest below the LT (58% increased, 25% decreased, 17% no change), while similar levels of variability were found in the self-selected (92% of participants increased in affective valence) and above lactate conditions (83% of participants decreased in affective valence). Later, Rose and Parfitt (2007) also found that individual differences were greatest at-LT condition (21% increased, 42% decreased, 37% no change or fluctuated) as well as in the below-LT condition (42% increased, 32% decreased, 26% no change of fluctuated).

The dual mode model (Ekkekakis, 2003) explained inter-individual variability. According to the model, interoceptive cues become the primary source of influence on affective responses as the exercise intensity exceeds the VT or LT and physiological steady state is threatened, thus affective valence declines. During high intensity exercise, the inter-individual variability of affective responses is likely to be limited. On the contrary, the cognitive factors, such as goals, self-efficacy, or attributions are dominant during exercise below or at the VT or LT, which vary from individual to individual. This contention of dual mode model would probably fit most individuals, especially inactive and low active people. Rose and Parfitt (2010) explored the cognitive factors that influence affective responses experienced during prescribed and self-selected intensity exercise in low active and high active middle-aged women. They found that pre-exercise affective state, perception of ability, anticipation of the end, focus of attention, and perception of control were related to affective responses in both groups. Although
perception of ability was particularly relevant for low active women, the authors reported no thematic differences emerged between high active and low active women.

**Affect-exercise-adherence link.**

Physical inactivity has been one of the greatest public health concerns for most industrialized countries. In fact, only 33% of adults 18 years of age and over engaged in leisure-time physical activity on a regular basis according to a study by Pleis, Lucas, and Ward (2009). In the same study, 36% of adults were considered inactive and 59% of adults never engaged in any period of vigorous leisure-time physical activity lasting 10 minutes or more per week.

Recent studies (e.g., Ekkekakis et al., 2003, 2004, 2008; Hall et al., 2002; Parfitt et al., 2006) have shown differences in affective responses over time; researchers have shown that higher intensity physical activity is associated with displeasure or discomfort during exercise and these negative affective responses may contribute to reduced adherence to regular exercise or increased risk of dropout.

In an aforementioned study, Ekkekakis et al. (2005b) explained the affective responses to acute exercise from an evolutionary and adaptational perspective. Physical activity is unique among survival-critical activities, as it can induce bidirectional changes in affect (i.e., pleasure and displeasure). Pleasure is considered to signify utility and displeasure to signify danger, thus pleasure and displeasure are related to the maintenance of homeostasis. Ekkekakis and colleagues (2005b) proposed that there is a genetically determined pleasure-based mechanism that has evolved to reward and promote physical
activity. Further, Ekkekakis and colleagues (2008) proposed the degree of pleasure may be a mediator the relationship between exercise intensity and adherence. Therefore, the implications of a causal link among exercise intensity, affective responses, and adherence need to be considered to address the critical public health problem of physical inactivity. However, affective responses as determinants of adoption and maintenance of physical activity behavior have not been fully examined (Williams, 2008).

One recent longitudinal study conducted by Williams et al. (2008) was designed to examine the relationship between acute affective responses during moderate intensity treadmill exercise (i.e., a graded submaximal exercise) and future physical activity participation among inactive adults ($N = 37$). The results demonstrated that inactive participants who reported more positive affective responses to a single bout of moderate intensity exercise at baseline reported more minutes of physical activity both 6 and 12 months later. However, no causal data can be drawn from this study due to the nature of correlational data. In addition, affect following exercise was not measured in this study, and thus the question of the utility of in-task versus post-exercise affective response to exercise on future physical activity still remains.

Several authors mentioned that affect plays an important role in the human-decision making process (e.g., Ekkekakis, 2009b). Affective responses are not included as key variables in any existing health decision-making theories, but they may be influential factors. Kiviniemi, Voss-Humke, & Seifert (2007) examined the role of affective associations in individuals’ physical activity behaviors and how the influence of
affective associations fit with the Health Belief Model (HBM) and Theory of Planned Behavior (TPB). Four hundred thirty-three adults participated in this study. Their study results revealed that more positive affective associations with activity significantly predicted greater activity behavior. Furthermore, the influence of the HBM and TPB constructs on activity behavior was mediated through affective associations, but affective associations were not mediated by these theories’ constructs (i.e., attitude, social norms, perceived behavioral control, and benefits and barriers) (Kiviniemi et al., 2007). These findings suggest a need for modifications to existing models or theories to include affect for predicting exercise behavior.

**Future intentions of exercise.**

Motivational correlates, for instance intention for future exercise participation have been examined in some recent studies. Kwan and Bryan (2010) investigated affective responses during a bout of moderate intensity exercise (i.e., 65% of VO$_{2\text{max}}$) and post exercise among 127 young adults. Their results revealed that increases in positive affect and decreases in fatigue during exercise were associated with more frequent exercise participation 3 months later. Also, greater positive affect and tranquility and less negative affect and fatigue at 15 min post exercise were associated with stronger intention-behavior relationships. The results of Kwan’s study are in line with another study in which affective responses were related to future intentions (e.g., Raedeke, Focht, & Scales, 2007). In a study by Focht (2009), affective responses, enjoyment and intention for future exercise participation were examined during and after brief walks in outdoor
and laboratory environments. Thirty-five physically active young female college students walked 10 min at a self-selected intensity. The participants reported higher ratings of intention for future participation following outdoor walking. However, affective responses were not consistently related to intention. Focht (2009) discussed the idea that increased positive affective states with brief walking led to enjoyment, which in turn, led to increased intention for future exercise.

**Self-selected vs. imposed intensity of exercise.**

Most of the studies presented used prescribed or imposed intensity of exercise and were not successful in generalizing the results. As shown earlier, higher intensity exercise is associated with a decline in affective valence during exercise, which may decrease future physical activity participation.

Physical activity guidelines forwarded by both Healthy People 2010 (USDHHS, 2000) and the American College of Sports Medicine (ACSM, 2006) advocate accruing 30 min of recommended daily physical activity by participating in multiple 10-min bouts of moderate-intensity walking. Efforts to promote participation in 10-min bouts of walking are based on the expectation that brief walks are more tolerable and enjoyable, and may foster motivation to engage in future physical activity participation. As introduced earlier, according to the Healthy People 2010 report, “Each person should recognize that starting out slowly with an activity that is enjoyable and gradually increasing the frequency and duration of the activity are central to the adoption and maintenance of physical activity behavior” (USDHHS, 2000, p. 22-24). The most recent physical activity guidelines state
that, “individuals have many choices about appropriate types and amounts of activity” (USDHHS, 2008, P4). In addition, the new guidelines recommend at least 150 minutes of moderate-intensity physical activity, such as brisk walking, to achieve substantial health benefits for low active people (USDHHS, 2008). The guidelines also include the choice of vigorous activity or a combination of moderate and vigorous intensities to meet the recommended amount of regular physical activity. Therefore, self-selected or self-paced exercise has been encouraged as one way to enhance the likelihood of positive psychological responses and future adherence.

Previous studies showed that having the opportunity to select one’s preferred mode of exercise was associated with improved affective responses (e.g., Miller, Bartholomew, & Springer, 2005). However, affective responses to acute exercise performed at a self-selected intensity are relatively unknown (Focht & Hausenblas, 2003); more effort should be directed at understanding the self-selection of physical activity intensity (Ekkekakis et al., 2005b).

Researchers have been interested in individual characteristics that are associated with self-selected exercise intensity. In one of the first studies to examine self-selected exercise intensity, Dishman et al. (1994) compared physiological data, including RPE and percent VO₂peak in active and inactive men at their self-select intensity for 20 min on the cycle ergometer. The highly active group selected higher power outputs than the inactive group did, but RPE was identical for both groups despite differences in relative intensity. The mean self-selected intensity on a cycle ergometer for both groups was approximately 60% VO₂max at the end of a 20 min bout.
Another early work by Spelman et al. (1993) tested treadmill walking at self-selected intensity among 29 adult female habitual walkers. Their mean walking intensity was 51.5% VO$_{2\text{max}}$. Murtagh, Boreham, and Murphy (2002) found that 82 female participants’ mean walking intensity was 59% VO$_{2\text{max}}$ and 67.3% HR$_{\text{max}}$, but when instructed to walk briskly, the mean intensity was increased to 78.5% HR$_{\text{max}}$. In active college students, mean self-selected intensity on a treadmill was even higher, namely, 71% VO$_{2\text{max}}$ (Parfitt et al., 2000). Focht and Hausenblas (2003) examined self-selected bouts of acute exercise with 30 female college students with high social physique anxiety. They found that the mean self-selected intensity on a cycle ergometer was 63.5% HR$_{\text{max}}$. All of these studies demonstrated that the mean self-selected intensity was within a moderate intensity range that met ACSM’s recommendation for improvement of cardiorespiratory fitness. However, these values were varied across studies.

Lind, Joens-Matre, and Ekkekakis (2005) hypothesized that participants would select an intensity that was proximal to the level of transition from aerobic to anaerobic metabolism. The participants of the study were 23 middle-aged previously sedentary women who performed a 20-min bout of treadmill exercise at their self-selected intensity. The results showed the mean intensity ranged from 67% to 83% HR$_{\text{max}}$. The results indicated that the participants tended to choose intensities at the point of transition from aerobic to anaerobic metabolism. Moreover, affective valence remained positive and stable. It was concluded that self-selected intensity is considered physiologically effective and beneficial, resulting in positive affective responses (Lind et al., 2005).
Other researchers have attempted to compare effects of self-selected intensity exercise to imposed intensity exercise on affective responses. Parfitt et al. (2006) examined affective valance response to 20 min of treadmill exercise at above-, below-LT intensity conditions and at a self-selected intensity condition among 12 sedentary men. The majority reported an increase in affective valence in the self-selected condition during exercise, whereas affective valence was more negative in the above-LT condition. The average intensity of self-selected intensity was 54.1% $\text{VO}_2\text{max}$, which would meet the current guidelines. Moreover, the mean lactate blood level in the self-selected condition was between that of the below-lactate and above-lactate conditions. In a follow-up study, Rose and Parfitt (2007) added an at-LT intensity condition, in addition to below-, above-LT, and self-selected intensity conditions among 19 sedentary women with mean age of 39.37 years old. As with the previous study, the results of affective responses were the least positive during above-LT condition and most positive at self-selected and below-LT conditions. Furthermore, affective responses at the self-selected condition were significantly more positive compared with the at-LT condition. The mean self-selected intensity was equivalent to 67.04% $\text{VO}_2\text{max}$ and lactate levels were not different between self-selected and at-LT intensity conditions.

Lind, Ekkekakis, and Vazou (2008) examined 10% higher treadmill speed than self-selected intensity, which was 98.1% VT on average in 25 middle-aged sedentary women. The result suggested even a minor increase in exercise intensity can bring about a significant decrease in pleasure during a 20-min exercise bout.
The results suggest that self-selected intensity exercise would be one way to generate more positive affective responses. On the other hand, considerable inter-individual variability in affective responses to self-selected intensity exercise has also been reported. Lind et al. (2005) showed a considerable amount of inter-individual variability at the self-selected exercise, particularly in the physiological markers of intensity. For example, exercise intensity at 20 min ranged from 61% VT to 134% VT. Likewise, percentage of heart rate at VT ranged from 72% to 140%, and VO₂ at VT ranged from 62% to 140%. Rose and Parfitt (2007) showed inter-individual variability in affective responses at self-selected intensities, where 47.4% of participants increased in affective valence, 26.3% decreased, and 21.1% had no change.

Individual factors, such as overweight or obesity may also influence psychological responses to self-selected intensity exercise. Ekkekakis and Lind (2006) investigated affective response to self-selected and imposed intensity (10% faster speed than the self-selected speed) of acute exercise among both overweight and normal weight women. Overweight women reported higher exertion ratings during exercise at both exercise conditions. At the self-selected speed, the two groups did not differ in pleasure-displeasure ratings; however, at imposed speeds, overweight women showed a significant decline in pleasure over time. Moreover, overweight women exercised at a higher percentage of their aerobic capacity than normal weight women throughout at both intensity conditions. Findings from this study revealed that exercise even at the same relative speed (i.e., 10% faster than self-selected) may be a harder experience for overweight women than normal weight women.
Another noticeable observation from research that employed self-selected intensity exercise is that participants were allowed to change or modify their intensity over the course of the exercise bout. In fact, the participants gradually increased their intensity (Dishman et al., 1994; Lind et al., 2005; Lind et al., 2008; Parfitt et al., 2000; Parfitt et al., 2006).

Collectively, these studies show that self-selected intensity may be a good way for exercise prescriptions to have affective benefits that may foster exercise adherence. However, inter-individual differences in self-selected intensity exercise, as well as imposed intensity exercise remains an issue. Ekkekakis (2009a) warned that some individuals may choose intensities that are too low to be effective or too high to be safe; therefore, effective methods are needed to help individuals enhance their ability to self-monitor and self-regulate intensity while exercising.

**Mechanisms**

As discussed above, cognitive and physiological factors have significant roles in determining affective responses to exercise. Several mechanisms underlying improvements in affective responses to exercise have been proposed.

**Self-efficacy.**

One cognitive factor that has received considerable attention in respect to affective responses is self-efficacy. A group of studies has demonstrated that acute exercise increases post exercise self-efficacy (e.g., Butki, Rudolph, & Jacobsen, 2001;
McAuley & Courneya, 1992; Raedeke et al, 2007; Rudolph & McAuley, 1995; Tate et al., 1995), and there is speculation that self-efficacy enhancement may be a mechanism for improved affect with exercise. Self-efficacy theory was developed as part of Social Cognitive Theory (Bandura, 1986). Self-efficacy is defined as the belief that one has in personal capabilities to perform a specific behavior that will result in an expected outcome. Bandura (1997) asserted that self-efficacy is governed by perceptions of control; it can be viewed as a situation-specific form of control (McAuley & Blissmer, 2000). Within self-efficacy theory, mastery experience is one of the primary sources of information that are used to form self-efficacy beliefs. Mastery experience occurs when individuals meet goals by gaining necessary skills. A sense of mastery can be acquired as people exercise, and they become more confident in performing the same exercise. Increased confidence will have a positive influence on affective responses.

Social cognitive theory (Bandura, 1986) also suggests that self-efficacy cognitions may predict physiological arousal, stress reactions, and affective status. Individuals with a high sense of efficacy tend to approach more challenging tasks and persist longer in the face of aversive or stressful stimuli; accordingly high efficacious individuals will more likely be successful in adopting and sustaining the behavior.

Several studies showed that higher self-efficacy beliefs were associated with more positive psychological responses to acute exercise. For example, McAuley and Courneya (1992) demonstrated that highly efficacious middle-aged low active adults had more positive affect during sub-max cycle ergometer exercise than did adults with lower self-efficacy. Bozoian et al. (1994) reported similar findings in unfit college women. Highly
efficacious participants maintained a sense of energy during exercise; moreover, they reported both increased levels of revitalization and positive engagement following cycling, whereas revitalization decreased in low efficacious participants during exercise. Jerome et al. (2002) examined whether manipulated self-efficacy has an influence on affective responses. Female college students who were low to moderately active were assigned to either high or low efficacy conditions that were manipulated by providing false feedback for the graded exercise test (GXT). After the initial manipulation, participants in the high efficacy (HE) condition had significant higher positive well-being and energy and less fatigue and psychological distress than their low efficacy (LE) counterparts. Then, both groups completed a 20 min acute bout of exercise on the treadmill at a moderate to vigorous intensity. In the second bout of activity, participants in the HE condition consistently reported positive well-being and less psychological distress throughout the exercise. Although both groups increased their efficacy levels after 20 min of treadmill exercise, participants in the HE condition reported a greater increase in efficacy than did those individuals in the LE condition.

Some studies investigated the relationship between pre exercise self-efficacy, in-task affective responses, and post exercise self-efficacy. However these findings were inconsistent. McAuley and Courneya (1992) suggested that self-efficacy and affect relationship may get stronger as exercise becomes more challenging. Treasure and Newberry (1998) found a stronger self-efficacy-affect relationship at high intensity cycling (70-75% age-predicted HRR) than at moderate intensity (45-50% HRR) among inactive college students. Their results were in line with McAuley and Courneya (1992),
however self-efficacy was not measured until 5 min into the exercise bout instead of before exercise. Both studies found that affect during an exercise bout significantly predicted post exercise self-efficacy.

On the contrary, Tate et al. (1995) failed to replicate the results with active male college students. Their results showed that pre exercise self-efficacy was related to affective responses during 30-min cycling exercise at 55% $\text{VO}_{2\text{max}}$, but not at 70% $\text{VO}_{2\text{max}}$. In addition, Tate et al. (1995) showed that affect during exercise did not significantly predict post exercise self-efficacy responses for both exercise conditions. In a study of older adults, McAuley, Blissmer, Katula, and Duncan (2000) reported that a greater increase in self-efficacy was associated with positive affect and less psychological distress in light and high intensity exercise groups, but changes in efficacy were unrelated to changes in affect in the moderate intensity exercise group. Finally, in a study by Focht et al. (2007), inactive older and younger adults completed a 20-min bout of cycling at 65% of $\text{VO}_{2\text{max}}$. There were no significant correlations between baseline self-efficacy and affective responses during exercise. However, they observed a trend that less efficacious individuals reported greater levels of physical exhaustion during exercise. The inconsistency in these findings may not be due to only exercise intensity, but also participants’ age, their level of physical activity, or different measurement methods.

In a recent study, Welch et al. (2010) employed new methodologies to examine the self-efficacy and affect relationship. One was using ventilatory threshold (VT) to define exercise intensity. The other was to measure self-efficacy during exercise rather than before exercise. As self-efficacy theory suggests, individuals need to go through
performance experience in order to assess accurately an efficacy expectation. When self-efficacy is measured during exercise, it is a reasonable predictor of affective valence during an exercise session. Twenty-four low active women completed two 30 min bouts on a cycle ergometer at 90% of the VT (moderate intensity). In one condition, participants were told the exercise duration, and in the other condition, exercise duration was unknown. The results revealed that during exercise self-efficacy was a stronger predictor of during exercise affect than pre exercise self-efficacy. Furthermore, this relationship was strongest at the end of exercise when exercise duration was unknown. Authors speculated that the perceptions of personal control (Bandura, 1997) may have modified the relationship between self-efficacy and affect during exercise.

Recently, self-selected intensity exercise has received considerable attention as a way to generate positive affective responses to exercise. Choosing exercise intensity may enhance perceptions of control, and in turn, higher perceptions of control would be associated with improvements in affective responses during and post exercise (Lind et al., 2008, Rose and Parfitt, 2007, 2010). Few studies have examined the self-efficacy and affect relationship at self-selected intensity exercise. In one of few and most recent studies, Rose and Parfitt (2010) examined cognitive factors by using “think aloud” procedures, that is, every 5 min participants provided affective responses and explained thought process that led them to report the corresponding affective response. Both low active and high active women completed two 30 min bouts of treadmill exercise at self-selected intensity and imposed intensity around VT. Thoughts about perception of ability (e.g., ability to sustain intensity, ability to cope with the exercise challenge) were
reported more frequently by low active participants than high active participants. As for perception of control, low active participants reported that being in control positively influenced affective response during the self-selected intensity. Interestingly, participants also reported positive affective responses during imposed intensity. The authors concluded that the extent to which perceptions of autonomy and control influence affective responses to exercise should be investigated in future research.

Collectively, these findings indicate that cognitive factors, such as self-efficacy can influence the affective responses of different populations. However, the relationship between self-efficacy and affective responses in the exercise domain seems to be very complex and warrants further investigation.

**Hypothalamic pituitary adrenal (HPA) axis.**

The hypothalamic pituitary adrenal (HPA) axis is one of the physiological pathways involved in the response to stress, and HPA hormones and neurohormones are markers of the stress response. When a stressor is introduced, the HPA axis is activated. During stress, corticotrophin- releasing hormone (CRH) is secreted from the paraventricular nucleus of the hypothalamus. Following secretion of CRH, the posterior pituitary is stimulated and secretes vasopressin; the anterior pituitary is also stimulated and secretes adrenocorticotropic hormone (ACTH), prolactin, and ß-endorphin. Adrenocorticotropic hormone activates the adrenal cortex to secrete cortisol, which plays an important role in the stress response. The primal role of cortisol in response to stress is to foster physiological responses to limit the extent of potential damage. In
addition, cortisol regulates metabolism of fat, protein and carbohydrate, stimulates gluconeogenesis, and mobilizes fatty acids for energy requirements during stress. Moreover, high levels of cortisol suppress the immune response. When the level of cortisol is elevated, the cortisol receptors on the hypothalamus and anterior pituitary provide negative feedback to control the secretion of CRH and ACTH, and thus regulate the further secretion of cortisol.

It has been shown that cortisol exhibits a diurnal rhythm with highest concentrations in the morning and lowest in the evening in healthy adults. Specifically, cortisol concentrations increase by between 50 and 160% in the first 30 min immediately post-awaking (Clow, Thorn, Evans, & Hucklebridge, 2004). On the other hand, considerable inter- and intra- individual differences in the diurnal cycle of salivary free cortisol have been reported in many studies (e.g., Hruschka, Kohrt, & Worthman, 2005; Stone, Schwartz, & Smyth, 2001).

Several studies have shown effects of psychological stress on the diurnal cortisol rhythm. For example, working women with more than 10 hours overtime a week had about twice as high morning cortisol levels as women with less than 10 hours overtime a week (Lundberg & Hellström, 2002). In a study of 316 male employees, Van Eck, Berkhof, Nicolson, and Sulon (1996) found that stressful daily events, specifically the events that were still ongoing at the time of assessment were associated with increased cortisol levels. Similarly, Smyth et al. (1998) reported both the experience of a current stressor and anticipating a stressor were associated with increased salivary cortisol levels among 35 men and 85 women. In another study with college students, cortisol levels
were higher during the high examination stress session than during the low examination stress session in both male and female students (Weeks et al., 2006). In this study, male students had higher cortisol levels than did female students. In contrast, another study found that some of the participants exhibited a lower morning concentration level under high stress (Dahlgren, Kecklund, Theorell, & Åkerstedt, 2009). Authors speculated that these people had a higher level of exhaustion and this might be reflected in a flattered cortisol rhythm (low morning values) under high levels of stress. A flattened diurnal cycle possibly indicates a dysregulation of the HPA axis (Stone et al., 2001).

Studies of the association between perceived stress and cortisol levels have produced conflicting results. For example, in a study with 389 white-collar workers aged 25-67 years, including 257 women, perceived job-related stress was associated with high concentration of cortisol (Hansen, Blangsted, Hansen, Søgaard, & Sjøgaard, 2010). On the contrary, no association between perceived stress and cortisol levels was found in 41 healthy late middle-aged adults aged 55-69 years (Simpson et al., 2008); perceived stress did not elevate increase cortisol reactivity to daily events in 316 men (Van Eck et al., 1996).

Previous research that investigated the association between cortisol secretion and affective responses has not been conclusive. The general understanding from previous studies is that the secretion of cortisol is primarily influenced by negative affect (e.g., Buchanan, al’Absi, & Lovallo, 1999). However, some studies, for instance, a study by Simpson et al. (2008) did not find this association. Furthermore, the evidence for positive affect being associated with lower cortisol levels has been scant. The aforementioned
study by Smyth et al. (1998) supported the association between positive affect and lower cortisol levels, whereas others (e.g., Van Eck et al., 1996) did not.

Although evidence from current research has shown inter- and intra-individual differences in cortisol responses to acute psychological stress, it has been well documented that chronic stress causes a dysfunction of the HPA axis activity and the negative feedback results in a chronic elevation of cortisol. Numerous studies have demonstrated that high levels of cortisol are associated with negative psychological states, such as trait anxiety, depression and mood disorders (Gold et al. 1986; O'Connor, Morgan, Raglin, Barksdale, & Kalin, 1989; Van Eck, et al., 1996).

Physical exercise can be connected to eustress, as well as to distress, depending on the features of the effort and on the coping and performance resources of the subjects (Derevenco & Derevenco, 1998). Acute exercise is one of the physical stressors that may stimulate and activate the HPA axis, and then induce cardiovascular and metabolic responses to meet the physical and mental demands of the stress of exercise. A number of studies documented that cortisol levels are related to exercise intensity and duration (Davis et al. 1981; Scavo et al. 1991). Research on effects of cortisol responses to acute exercise has been examined extensively by using mostly trained male athletes. It has been well documented that cortisol concentration increases after a bout of incremental exercise to exhaustion or a maximal exercise test (e.g., Rojas Vega et al., 2006).

The results from studies that used non-athletes have supported this general trend of cortisol responses to a bout of maximal exercise (elevated cortisol levels post
exercise). Davis and colleagues (1981) investigated the serum cortisol responses to incremental bicycle exercise to exhaustion among both trained and untrained males. The results showed that serum cortisol levels were significantly increased at 20 min post exercise. Specifically, the magnitude of increase in cortisol levels was significantly greater in untrained men (138%) than trained men (59%). However, these researchers did not sample blood immediately at the termination of exercise. It was unknown when the peak value of cortisol concentrations occurred. Similarly, another study compared runners and non-runners in serum cortisol responses to a maximal cycle ergometer test. Mathur, Torlola, and Dada (1986) demonstrated that cortisol levels increased by 36% in runners and by 161.3% in non-runners immediately after exercise. Interestingly, cortisol levels dropped to 18.6% at 1 hour recovery in runners, but it remained elevated (173.9%) in non-runners. In a more recent study, Acevedo et al. (2007) examined serum cortisol levels during and after incremental treadmill exercise until 100% VO$_{2\text{max}}$. The results demonstrated that serum cortisol levels were significantly elevated at 90 and 100% VO$_{2\text{max}}$, which was the last 7 min of exercise, and throughout recovery (about 1 hour post exercise).

Likewise, studies that examined cortisol responses to a maximal exercise test in untrained women demonstrated an increased cortisol level post exercise. Odor, Grissom, Randall, Berger, & Leppo (1994) found that cortisol values increased at 2, 6, 10, and 14 minutes after maximal treadmill exercise in female students. The peak cortisol values were attained at 6 min post exercise and remained elevated throughout the sampling period (14 min post exercise). In the same study, cortisol responses to short duration high
intensity exercise were also examined. In this exercise condition, the peak cortisol values were observed at 10 min post exercise. Another study with 53 healthy untrained women reported that the participants had a highly significant salivary cortisol response after a maximal cycle ergometer exercise test (Kirschbaum, Platte, Pirke, & Hellhammer, 1996). Interestingly, the peak cortisol concentrations were observed at 30 min following exercise in this study.

Effects of menstrual cycles and oral contraceptive use on cortisol responses to exercise were of interest in studies with women. Kirschbaum and colleagues (1996) revealed that participants who used oral contraceptives (OC) had an attenuated cortisol response at 30 min post exercise (the peak level) compared to nonusers. In this study, menstrual cycle had no effect on cortisol responses to a maximal cycle ergometer test. In contrast to the study by Kirschbaum and colleagues, changes in cortisol levels after a 90 min cycling session at 65% VO$_{2\text{max}}$ were not different between OC users and non-users (Timmons, Hamadeh, Devries, & Tarnopolsky, 2005). Likewise, this study found that cortisol changes with exercise were not different between the follicular and the luteal phases.

The next question is what intensity of acute exercise could elicit cortisol responses besides a maximal exercise test. In 20 active men, Bonen (1976) found that excretion rates of urinary free cortisol were significantly elevated after running on the treadmill at 7.5 mph for 10 min or 30 min., with the greatest changes observed in the 30 min running condition. On the contrary, walking at 3 mph for 10 and 30 min did not change cortisol levels. Moreover, the cortisol excretion rated during the 30-60 min and
the 60-90 min periods following 30 min running were still significantly increased. Davies and Few (1973) examined plasma cortisol responses to 1 hour of treadmill exercise at lower intensity (< 50% VO\textsubscript{2max}) and higher intensity (65-90% VO\textsubscript{2max}) in 10 men (one participant was trained). The results of this study suggested that approximately 60% of individual VO\textsubscript{2max} had to be exceeded to elicit cortisol responses to exercise. Some other studies that investigated effects of different intensities of exercise on cortisol responses had similar results to those of Davies and Few (1973). Luger et al. (1987) demonstrated that treadmill exercise at 70 and 90% of VO\textsubscript{2max} proportionally elevated plasma cortisol levels among 3 groups of inactive, moderately trained, and highly trained participants. There were no cortisol responses to exercise at 50% VO\textsubscript{2max} in any of the three groups. There were no group differences in cortisol responses at any given relative exercise intensity. In a more recent study, Hill et al. (2008) had moderately active men cycle for 30 min at intensities of 40, 60, and 80% VO\textsubscript{2max} to determine the threshold of exercise intensity to provoke an increase in cortisol. The authors showed that exercise at 60 and 80% VO\textsubscript{2max} significantly increased cortisol levels post exercise, whereas there was no change in cortisol levels in the 40% VO\textsubscript{2max} exercise condition. In a study by Lac, Pantelidis, and Robert (1997), both active men and women performed a 30 min submaximal test on a bicycle ergometer, with their heart rate held constant at 170 bpm (greater than 70% VO\textsubscript{2max}). Salivary cortisol levels rose by 50% at the first 5 min of exercise and reached the maximum level. Then, the levels of cortisol were stable for the rest of exercise, but cortisol concentration increased again (127%) at the termination of
the test. The elevated cortisol levels did not return to basal values at 90 min post exercise, but did so 6 hours post exercise.

In a study with trained women, Blownlee and Hackney (2007) examined the cortisol responses to prolonged endurance exercise. Participants ran on the treadmill at their ventilatory threshold until reaching volitional fatigue. The duration of this exercise was between 53 and 97 min. Serum cortisol concentration was significantly elevated at the end of the exercise session. Furthermore, the elevated cortisol values were maintained up to 30 min post exercise, then, gradually decreased until 90 min post exercise.

In contrast, some studies had conflicting results in cortisol responses to moderate intensity exercise. Lovallo, Farag, Thomas, & Wilson, (2006) reported that salivary cortisol was not increased in healthy 96 men and women after 30 min on a cycle ergometer at a moderate workload. Likewise, both serum and salivary cortisol did not increase significantly in 27 young men after 9 min of graded submaximal cycle exercise up to 85% of maximal heart rate (Ben-Aryeh et al., 1989). In more recent study, Jacks, Sowash, Anning, McGloughlin, & Andres (2002) demonstrated that cortisol responses to exercise were related to not only exercise intensity, but also to exercise duration. Ten active men performed 1 hour of cycle ergometry exercise at 44.5, 62.3, and 76% of VO$_2$peak. Saliva samples were collected during and 20 min following exercise. During the 76% VO$_2$peak exercise session, salivary cortisol was significantly higher 59 min into the exercise session and 20 min post exercise. However, significant cortisol responses were not observed in the 62.3% VO$_2$peak and 44.5% VO$_2$peak exercise conditions, which implied no support for exercise intensity at 60% VO$_2$max as a threshold to elicit cortisol responses
(Davies & Few, 1973). In addition, the results indicated that exercise shorter than 40 min did not elicit cortisol responses at any intensity. Li and Cheng (2007) demonstrated that exercise intensity lower than 60% VO$_{2\text{max}}$, but for a longer duration could elicit cortisol responses. In their study with 10 recreationally active men, plasma cortisol concentrations were significantly elevated immediately after 2-hour of prolonged cycling at 55% VO$_{2\text{peak}}$ (Li & Cheng, 2007). Cortisol levels remained elevated for 6 hours post exercise.

As shown above, there is consistent evidence that high intensity exercise can elicit cortisol responses irrespective of gender and training status, and that levels of cortisol remain elevated post-exercise and gradually decrease to the basal level.

Despite consistent results for cortisol responses to high intensity exercise conditions, the cortisol responses to moderate intensity exercise have not been consistent. Also, low intensity exercise did not change cortisol responses in most of the studies, but it should be noted that some studies observed that cortisol concentrations decreased in some conditions. Lower levels of cortisol were found during and after 1 hour of treadmill exercise below 50% VO$_{2\text{max}}$ in 10 healthy men (Davies & Few, 1973), 65 min of a mixture of endurance and strength exercises in 25 early postmenopausal women (Kemmler et al., 2003), and 30 min of aerobic exercise at 40% VO$_{2\text{max}}$ in moderately trained men (Hill et al., 2008).

There are a few studies that investigated the role of cortisol in affective responses to acute exercise. Rudolph and McAuley (1998) examined cortisol and affective responses to 30 min treadmill running at 60% VO$_{2\text{max}}$ in both active and inactive
individuals. Their results suggested that higher levels of positive affect during and after exercise were associated with decreased cortisol responses after exercise. Further, negative affect was significantly increased in inactive individuals during exercise compared to active individuals. Affect and cortisol levels 30 min post-exercise were inversely related, which was in line with other studies (Rudolph & McAuley, 1995). The authors suggested that these results provide partial support for the hypothesis that cortisol levels are related to exercise-induce affective states. In another study with highly trained male runners, affect was unchanged from 60 to 75% VO_{2max} with a significant increase in negative affect from 75 to 90% VO_{2max}, then a plateau from 90 to 100% VO_{2max}; similar changes in cortisol were observed (Acevedo et al., 2007). These changes in affect and cortisol provide some support for the proposed curvilinear relationship between stress system activity and a sense of well-being (Chrousos & Gold, 1992).

Arent, Landers, Matt, and Etnier (2005) examined the dose-response relationship between exercise induced-affective change and cortisol responses. They employed different intensities of resistance exercise, that is, 40, 70, and 100% of 10-repetition maximum (RM) in young active aerobic exercisers. The results revealed that moderate intensity (70% RM) produced the greatest improvements in affect while high intensity (100% RM) produced the largest decrements. Interestingly, low intensity (40% RM) was generally ineffective in producing beneficial changes in affect. With respect to cortisol responses to resistance exercise, the results showed that cortisol secretion was only increased in the high intensity condition. In addition, the study found that cortisol is a significant predictor of negative affective changes (Arent et al., 2005).
Within the social cognitive framework, self-efficacy is hypothesized to have a role in biological stress reactions and psychobiological functioning (Bandura, 1977) (Bandura, 1986). Bandura and Wood (1989) stated that self-efficacy is related to controllability; perceived controllability during stress is a critical factor in activation of the HPA axis. For example, animals exposed to inescapable and uncontrollable foot shock exhibited deficits in later escape or avoidance of leaning (“learned helplessness”) (e.g., Seligman & Maier, 1967) compared to animals who received physically identical, but controllable shocks. Dess, Linwick, Patterson, and Overmier (1983) reported that uncontrollable shock produced significantly greater cortisol elevations than controllable shock in dogs.

Bandura (1986, 1989) discussed that self-efficacy and environmental controllability are products of reciprocal causation; when people believe the environment is controllable on matters of import to them, they are motivated to exercise fully their personal efficacy, which enhances the likelihood of success.

There has been limited research to investigate the relationship between self-efficacy and cortisol responses to acute exercise. In a relatively early study, researchers showed that high levels of salivary cortisol were related to low self-efficacy (Wiedenfeld et al., 1990). In a more recent study, Rudolph and McAuley (1995) discovered similar results. Active undergraduate students demonstrated lower cortisol levels during a 30-min treadmill running at 60% VO$_{2\text{max}}$ and faster dissipation of cortisol following exercise compared to their inactive counterparts. Those physically active individuals possessed higher exercise related efficacy pre-and post-exercise compared to less active individuals.
In addition, this study presented more interesting findings. Pre-efficacy cognitions significantly predicted salivary cortisol levels during exercise, and enhanced post-exercise efficacy was inversely related to post-exercise salivary cortisol (Rudolph & McAuley, 1995). A study by Butki et al. (2001) with physically active males who participated in 20-min of treadmill running at 85% maximal heart rate supported Rudolph and McAuley’s results, in which acute exercise produced increases in post-exercise efficacy and post-exercise cortisol levels were inversely related to self-efficacy scores.

Collectively, these studies suggest that mastery experiences through exercising and subsequent gains in self-efficacy might result in increases in stress resistance as indicated by levels of cortisol.

**Summary**

Stress causes an imbalance of the physiological systems and elicits physiological and behavioral responses. The consequences of chronic stress can be positive or negative. The harmful consequences of chronic stress have influence on our health and threaten our quality of life.

Accumulating evidence suggests that exercise is beneficial for stress and psychological well-being. Research has shown that acute bouts of exercise are associated with post exercise improvements in a variety of psychological responses. In addition, improvements in psychological states remain within 20 min post exercise and can last hours.
Affective valence (i.e., pleasure or displeasure) to acute exercise has received considerable attention and has been examined in many studies. However, efforts to optimize the exercise intensity and duration to generate positive affect have not been successful in previous studies. For example, higher intensity exercise was often associated with negative affect in inactive individuals.

There are some critical methodological issues illustrated in previous studies that point to ways to strengthen study designs. First, affective responses should be measured during exercise in addition to pre and post exercise. Second, exercise intensity should be defined by using metabolic landmarks, such as ventilatory threshold or lactate threshold. Third, the total workload of exercise should be held constant, meaning control calorie expenditure of exercise bouts. Recent research that used LT or VT to define exercise intensity and measured affect during and post exercise demonstrated that affect declined during exercise at intensity exceeding LT or VT, whereas affect was more positive below the VT or LT.

Furthermore, positive affective response to acute bout of exercise was associated with future physical activity (Williams et al., 2008). Examining the effects of acute exercise on future intentions can provide insight into exercise prescriptions that will foster better adherence.

Self-selected exercise has been encouraged as one way to have affective benefits that may foster exercise adherence to regular exercise. Although there is limited research examining the psychological benefits of self-selected intensity, self-selected intensity exercise has been shown to generate more positive affective responses than imposed
intensity exercise. However, inter-individual differences in self-selected intensity exercise, as well as imposed intensity exercise remain an issue. For example, Rose and Parfitt (2007) reported that 47.4% of participants increased in affective valence, 26.3% decreased, and 21.1% had no change during a self-selected intensity exercise session.

A number of cognitive and biological mechanisms underlying improvements in affective responses to acute exercise have been proposed. Self-efficacy has been proposed as one of cognitive mechanisms, and self-efficacy during exercise may be a good predictor of affective responses during exercise. More efficacious individuals also report greater levels of positive affect, but the results are mixed depending on exercise intensity. Self-efficacy is related to perception of control (Bandura, 1986), therefore, degree of perceived control may influence affective responses to acute exercise, which points to the need to examine absolute, as well as self-selected and imposed intensities.

The hypothalamic pituitary adrenal (HPA) axis is one of physiological pathways involved in the response to stress. Maximal effort and high intensity exercise activate the HPA axis and elevate cortisol concentrations. On the other hand, the effects of moderate intensity exercise on HPA axis response are mixed; cortisol concentrations are not always elevated during moderate or lower intensity exercise. A few studies that examined the relationship between cortisol and affective responses to acute exercise demonstrated an inverse relationship between cortisol levels and affective responses to exercise.

Finally, studies have reported an inverse relationship between self-efficacy and cortisol responses to acute exercise. These studies suggest that mastery experiences through exercising can result in increases in stress resistance. Indeed, perceived control
gained through exercise, especially at self-selected intensities, may contribute to modifications in the stress response.
Chapter 3: Method

The primary purpose of this study was to examine psychological responses to self-selected and imposed-intensity acute exercise in inactive women with high levels of stress. Encouraging self-selected or self-paced exercise (USDHHS, 2000; ASCM, 2006) has been proposed as one way to enhance the likelihood of positive psychological responses and future adherence. However, there is limited and mixed evidence examining the psychological benefits of self-selected acute exercise. The secondary purpose of the study was to examine potential psychobiological mechanisms, especially HPA axis responses and self-efficacy that are associated with changes in psychological states. Several mechanisms responsible for improvements in affective states with acute exercise (e.g., improve mood or pleasure) have been proposed, yet none of proposed mechanisms, including psychological and psychobiological explanations are conclusive.

This chapter outlines the method for this study, including subject recruitment and characteristics, required sample size, research design, measures, procedures, and data analysis.

Subjects

All participants were volunteers recruited from the Ohio State University campus. They were recruited via e-mail, flyers posted around the campus, word of mouth, and
academic classes. In order to recruit from academic classes, the investigator visited some yoga classes upon the instructors’ approval to describe the study and recruit volunteers because students with higher levels of stress might be more likely to enroll in a yoga class as a stress management strategy.

The eligibility criteria were as follows: (a) Female; (b) Pre-menopausal; (c) Non-smoker; (d) English speaker; (e) BMI ≤ 34.9 (not obese); (f) Aged between 18 and 40; (g) Experiencing high levels of stress; (h) Physically inactive at least 3 months; (i) Not engaged in weight training; (j) Not diagnosed with depression or anxiety disorders; (k) Not taking antidepressants or receiving psychotherapy; (l) Not pregnant, nursing, or planning for pregnancy within 6 months; (m) Apparently healthy, free of any self-reported medical prohibition to exercise; and (n) No physical prohibitions to exercise (e.g., orthopedic problems). More details about how some of these criteria were operationalized will be explained next.

To be eligible to participate in this study, participants had to report experiencing high levels of stress, as determined by their score on The Perceived Stress Scale (PSS-10) (Cohen & Williamson, 1988). The Perceived Stress Scale is designed to measure trait stress and the degree to which an individual perceives life situations as stressful. The scale consists of 10 items that are answered on a 5-point Likert scale on a continuum ranging from never (0) to very often (4). For example, one of the items is “In the last month, how often have you been upset because of something that happened unexpectedly?” (See Appendix J) A total score is calculated by adding the points for each item; a possible range of points is from 0 to 40. Higher scores indicate greater perceived
stress. In this study, scores ≥ 25 were considered as high stress. This criterion was selected based on a study of undergraduate students by Robertil, Harrington, and Storch (2006), in which a score of 25 would be more than one standard deviation above the mean score. This scale has been widely used as a psychological instrument in a range of settings. Test-retest reliability calculated at 2 days and 6 weeks were 0.85 and 0.55, respectively (Cohen, Kamarck, & Mermelstein, 1983).

Participants had to be inactive at least 3 months to participate in this study. Inactive was defined as engaging in no more than two 20 min exercise sessions of moderate or greater intensity during a typical week. Exercise intensity, duration, and frequency were determined by responses to The Leisure Time Exercise Questionnaire (LTEQ) (Godin & Shephard, 1985). The LTEQ is a self-report questionnaire assessing the number of mild, moderate, and strenuous exercise sessions that participants perform during an average week. The LTEQ has adequate reliability and validity (Jacobs, Jr., Ainsworth, Hartman, & Leon, 1993). Participants’ weekly energy expenditure from exercise had to be less than 500 kcal per week. This was also estimated from the responses to the LTEQ using reports of typical weekly exercise intensity and duration. Reported exercise was converted into metabolic equivalents (METs) by multiplying the number of sessions by different values based on the intensity, that is, by 3 for mild, 5 for moderate, and 9 for strenuous exercise. A minute of energy expenditure was calculated by using the following formula: [METs x 3.5 x body weight in kg] / 200 = kcal/min. The result of this calculation was multiplied by the duration (in minutes) of exercise per week at that intensity and summed to calculate the weekly energy expenditure from exercise.
To be eligible, participants had a BMI ≤ 34.9. Women with BMI > 35 were excluded because obesity could serve as a confounding variable in assessing cortisol responses. Other select demographic and behavioral information, such as pregnancy screening, smoking status, and medication (i.e., birth control pills) were obtained with a standard demographic questionnaire at the outset of this study.

To determine the sample size necessary for feasible results, a priori power analysis needed to be conducted. The ability to reject the null hypothesis is dependent on alpha level, sample size, and effect size. In this study, a priori alpha level was set at $p < .05$, which is the conventional significance within behavioral research. Likewise, power was set a priori to .80, as recommended by Keppel (1991). To determine a priori the magnitude of the expected effect size, key variables such as affect and cortisol responses in previous studies were reviewed. Cohen’s $d$ (Cohen, 1988) was calculated to determine the effect size. The equation is expressed as mean difference divided by the pooled variance between two means.

$$
Cohen's \ d = \frac{M_1 - M_2}{\sigma_{pooled}}
$$

Where: $M = \text{Mean}$, and $\sigma_{pooled} = \sqrt{\frac{\sigma_1^2 + \sigma_2^2}{2}}$

Cohen (1988) suggested criteria for evaluating the size of an effect, such that 0.1 is a small effect, 0.5 is a medium effect and 0.8 is a large effect. Studies were selected that used the same variables and interventions similar to this proposed study. The effect sizes from these studies are presented in Table 3.1.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Study</th>
<th>Comparison</th>
<th>Mean Diff.</th>
<th>Pooled SD</th>
<th>Effect Size in SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affect (positive engagement/EFI)</td>
<td>Focht &amp; Hausenblas (2006) Women in Social physical anxiety ( n = 30 ) 20 min cycling (self &amp; imposed intensity)</td>
<td>Pre- 5 min post</td>
<td>1.2</td>
<td>2.85</td>
<td>0.42</td>
</tr>
<tr>
<td>Affect (pleasure/SAM)</td>
<td>Rozorea (2007) Depressed, sedentary women, moderate intensity ( n = 19 )</td>
<td>Pre- 15 min post</td>
<td>0.34</td>
<td>1.29</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Rozorea (2007) Depressed, sedentary women, high intensity ( n = 19 )</td>
<td>Pre- 30 min post</td>
<td>1.43</td>
<td>1.17</td>
<td>1.22</td>
</tr>
<tr>
<td></td>
<td>Ekkekakis et al. (2000) Men &amp; women, 10 min walking ( n = 52 )</td>
<td>Pre- post</td>
<td></td>
<td></td>
<td>1.12</td>
</tr>
<tr>
<td>Cortisol</td>
<td>Rudolph &amp; McAuley (1998) Inactive men, moderate intensity ( n = 13 )</td>
<td>Pre- 25 min</td>
<td>0.15</td>
<td>0.263</td>
<td>0.57</td>
</tr>
<tr>
<td></td>
<td>Rudolph &amp; McAuley (1998) Inactive men, moderate intensity ( n = 13 )</td>
<td>25 min- 30 min post</td>
<td>0.08</td>
<td>0.263</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Table 3.1 Studies used for effect size estimation

Based on the literature presented above, a moderate effect size for differences in psychological states among exercise conditions was expected. Therefore, we selected an effect size of 0.25. G*Power 3.0.8 software was used to determine the required sample size for an alpha level of .05, a power of .80, and a moderate effect of 0.25. In addition, G*Power requires the correlation between outcome variables over time to estimate power for within-subjects design. The data from a study by Rozorea (2007) showed that the
smallest correlation for affective variables over time during the moderate intensity exercise condition was .774 and the smallest correlation during the high intensity exercise condition was .306. The average correlation for data from the high intensity condition was .62. Therefore, we used .62 for the correlation estimate. Using the stipulations described above, G*POWER software indicated that the number of subjects needed for this study was 15. We expected some participants might not be able to complete all exercise sessions, therefore, we planned to recruit up to 20 participants.

**Research Design**

This investigation employed a 2 factor within-subjects experimental design with 3 conditions (self-selected intensity, 10% above, and 10% below relative self-selected intensity) x 6 times (pre-test, the midpoint of the exercise session, 5 min before the end of exercise, 10 and 30 min post exercise). After participating in a graded treadmill test to estimate aerobic capacity, participants performed all three exercise intensity conditions (self-selected, 10% above and 10% below relative self-selected intensity). In the first session, they chose their exercising (walking) intensity. The investigators assigned the other two imposed intensities to them randomly in the second and third sessions. The duration of each exercise session was computed so participants expended 150 kcal in each session. Assessments of the dependent variables were obtained at the following time points: (1) Pre-test, (2) Midpoint of the exercise session, (3) 5 min before the end of exercise, (4) End of exercise session, (5) 10 min post exercise, and (6) 30 min post exercise. All necessary information about this study was submitted to The Ohio State
University Institutional Review Board, Office of Responsible Research Practices, to obtain permission to conduct this study.

**Measures**

**Peak oxygen consumption (VO\textsubscript{2peak}).**

An assessment of peak oxygen consumption (VO\textsubscript{2peak}) was conducted to determine each participant’s aerobic capacity and calculate the workload for the imposed intensity conditions. The VO\textsubscript{2peak} test was performed using a motorized treadmill. A standard Bruce treadmill protocol was used for each test. The participant wore a heart rate monitor and a mouthpiece that was connected to Cardio O\textsubscript{2} Metabolic Cart to estimate VO\textsubscript{2peak}. The participant began the test by walking on the treadmill at a speed of 1.7 mph with 10% grade for three minutes. Thereafter, the speed was increased to 2.5 mph, 3.4 mph, 4.2 mph, 5.0 mph, and 5.5 mph every 3 min and the incline was increased by 2% every 3 min.

The VO\textsubscript{2peak} test was terminated by the participant at the point of volitional fatigue and was signaled to the investigator by placing both hands on the support rails of the treadmill. A five-minute recovery period was started at 0% grade and a 1.5 mph belt speed during which recovery heart rate and blood pressure were taken.

All tests were completed at the Ohio State University in the W. Michael Sherman Exercise Physiology Laboratory (A39) in the Physical Activity & Educational Services (PAES) Building.
**Ventilatory threshold.**

The ventilatory threshold (VT) was assessed based on the data from the VO$_{2}\text{peak}$ test, as it is considered an indirect index of the transition from aerobic to anaerobic metabolism. The ventilatory threshold was determined by the V-slope method, which involves plotting CO$_2$ production over O$_2$ utilization and identifying a breakpoint in the slope of the relationship between these two variables. Ventilatory threshold indicates an intensity above which individuals can begin to experience exercise as noticeably more effortful. The percentage of aerobic capacity at which VT occurred for each subject was compared to her percentage of VO$_{2}\text{peak}$ in each exercise condition.

**Exercise intensity.**

All participants exercised at three different exercise intensity conditions on a treadmill. The first condition was self-selected intensity exercise. Each participant was permitted to determine her preferred treadmill speed during 5 min of walking on the treadmill before the actual self-selected exercise session. The exercise mode was limited to walking; therefore the speed did not exceed more than 4.0 mph. Participants were also permitted to choose to increase the treadmill incline. Once participants had selected their speed and incline, they would perform the walking exercise with this constant intensity for a designated duration to expend 150 kcal. They were not allowed to change speed and incline during this exercise session. The second and third exercise conditions were imposed intensity sessions prescribed at 10% above and 10% below the relative intensity performed during the self-selected condition. As described previously, all participants
performed a VO$_{2peak}$ test at the beginning of the study. VO$_{2peak}$ was used to estimate the relative VO$_2$ of self-selected and imposed intensity conditions. Grade, or both speed and grade, if necessary, for the imposed intensity conditions were determined. The total volume of work (calorie expenditure) was equated in all exercise conditions to 150 kcal using modifications in duration so that the energy expenditure was not a confounder.

To determine target VO$_2$, the following equation was used.

Walking: \[ \text{VO}_2 = 0.1 \times \text{Speed} + 1.8 \times \text{Speed} \times \text{Grade} + 3.5 \text{ml/kg/min} \]

(Speed in meter/min; Grade is the percent grade expressed as a fraction)

For metabolic calculations, the following equations were used.

\[ \text{MET} = \frac{\text{VO}_2 \text{ ml/kg/min}}{3.5 \text{ml/kg/min}} \]

\[ \text{VO}_2 \text{l/min} = \frac{\text{VO}_2 \text{ ml/kg/min}}{1000} \times \text{weight kg} \]

\[ \text{Caloric expenditure in kcal/min} = 5 \times \text{VO}_2 \text{l/min} \]

For example, participant A is 53 kg and her VO$_{2peak}$ is 35 ml/kg/min. Her self-selected speed is 3.7 mph and the grade is 2%. The exercise duration would be calculated as follows.

\[ \text{VO}_2 = 0.1 \times (3.7 \text{ mph} \times 26.8 \text{ m/min}) + 1.8 \times (3.7 \text{ mph} \times 26.8 \text{ m/min}) \times (0.02) + 3.5 \text{ml/kg/min} = 16.99 \text{ml/kg/min} \]

\[ \% \text{ of VO}_{2\text{peak}} = \frac{16.99 \text{ml/kg/min}}{35 \text{ml/kg/min}} = 0.485 \]

\[ = 48.5\% \text{ of VO}_{2\text{peak}}. \]
\[ \text{VO}_2 (\text{l/min}) = 16.99 \text{ ml/kg/min} \times \frac{53 \text{ kg}}{1000} = 0.9 \text{ l/min} \]

\[ \text{Caloric expenditure} = 5 \text{ kcal/l} \times 0.9 \text{ l/min} = 4.5 \text{ kcal/min} \]

\[ \text{Exercise duration} = \frac{150 \text{ kcal}}{4.5 \text{ kcal/min}} = 33.3 \text{ min} \]

In order to determine the imposed intensity (10% above) for a similar duration, the following calculation would be made with the same speed and a 4% grade.

10% above intensity condition: 58.5% of \( \text{VO}_2 \text{peak} \).

\[ \text{VO}_2 (\text{ml/kg/min}) = 0.585 \times 35 \text{ ml/kg/min} = 20.5 \text{ ml/kg/min} \]

\[ 20.5 \text{ ml/kg/min} = 0.1 (3.7 \text{ mph} \times 26.8 \text{ m/min}) + 1.8 (3.7 \text{ mph} \times 26.8 \text{ m/min}) \times (0.04) + 3.5 \text{ ml/kg/min} \]

\[ \text{VO}_2 (\text{l/min}) = 20.5 \text{ ml/min} \times \frac{53 \text{ kg}}{1000} = 1.086 \text{ l/min} \]

\[ \text{Caloric expenditure} = 5 \text{ kcal/l} \times 1.086 \text{ l/min} = 5.43 \text{ kcal/min} \]

\[ \text{Exercise duration} = \frac{150 \text{ kcal}}{5.43 \text{ kcal/min}} = 27.6 \text{ min} \]

Likewise, we can determine exercise intensity and calculate duration for the other imposed intensity condition. The following is the summary of exercise intensity and duration for each condition.

- Self-selected intensity (48.5% of \( \text{VO}_2 \text{peak} \)): 33 min (3.7 mph and 2% grade)
- 10% above intensity (58.5% of \( \text{VO}_2 \text{peak} \)): 27 min (3.7 mph and 4% grade)
- 10% below intensity (38.5% of \( \text{VO}_2 \text{peak} \)): 41 min (3.7 mph and 0% grade)
Ratings of Perceived Exertion (RPE).

The Ratings of Perceived Exertion (RPE) scale (Borg & Dahlstorm, 1962) was used to assess perceptions of overall effort sense during exercise. The Borg RPE scale has been used extensively as an index of perceived exertion in previous studies. The Borg RPE consists of a 15-point scale that ranges from 6 (very, very light) to 20 (very, very hard). Participants were asked to choose the number that described their exertion level during each exercise session. During the VO₂epak test, RPE was measured every 3 min while increasing the treadmill grade and speed. For the remaining three exercise sessions, after the participant had reached the indicated treadmill speed and grade, RPE was measured at the end of every 5 min.

Self-Assessment Manikin (SAM).

The Self-Assessment Manikin (SAM) is a non-verbal communication tool to measure global dimensions of affect. This scale contains three independent and bipolar dimensions: pleasure-displeasure, perceived arousal, and dominance-submissiveness. Research (e.g., Bladley & Lang, 1994) has shown that these three dimensional scales, identified as pleasure, arousal, and dominance (PAD), can capture affective responses. Mehrabian and Russell (1977) stated that these elements are autonomous, as differing values along any of these three dimensions can occur concurrently without affecting one another. The scale consists of three dimensions (pleasure, arousal, and dominance) and each dimension includes five or nine graphic characters arrayed along a continuous 9-point scale. This scale is easy to administer and useful especially during exercise sessions.
because the participants simply choose by pointing below a figure or between figures that match their emotional responses. We used a nine graphic version instead of a five graphic version in this study because it was easier to distinguish between graphics, especially during walking exercise.

The correlations between scores obtained using SAM and other instruments measuring similar constructs in a study by Mehrabian and Russell (1977) were high for both pleasure (.94) and arousal (.94) and smaller but still substantial for dominance (.66) (Lang, 1985). The arousal scale of the SAM exhibited correlations ranging from .45 to .70 with the Felt Arousal Scale (FAS) of the Telic State Measure. The SAM has been used extensively in psychophysiological research within a circumplex framework and formal evidence of its validity is satisfactory (Gauvin & Rejeski, 1993). The SAM has been used in the exercise domain, for example, to examine the affective responses associated with short bouts of walking (Gauvin & Rejeski, 2001).

**Exercise-Induced Feeling Inventory (EFI).**

To measure categorical affective responses, we used the Exercise-Induced Feeling Inventory (Rodgers & Sullivan, 2001). This is a 12-item multidimensional scale to assess the degree that participants’ experience four specific feeling states, including revitalization, physical exhaustion, positive engagement, and tranquility. Participants responded to each inventory item on 5-point scale ranging from 0 *(do not feel)*, to 5 *(feel very strongly)*. The EFI has been used in several studies on acute exercise-affect and demonstrates adequate psychometric properties. In addition, the EFI measures more
positive affect rather than negative affect, which was in line with the purpose of our study.

**Self-Efficacy.**

Self-efficacy is one of the central constructs of social cognitive theory developed in the mid 1980’s (Bandura, 1986). The definition of self-efficacy is the belief in one’s ability to successfully satisfy specific situational demands. It has been applied to many exercise behavior studies.

Task self-efficacy refers to an individual’s confidence in the ability to perform the elemental aspects of task (Clow et al., 2004). Task self-efficacy was assessed to determine how confident participants were in their ability to walk on a treadmill at moderate to moderately hard effort for the designated duration of each exercise condition. Participants responded to each item on a 100-point percentage scale with 10% increments that range from 0% (*not at all confident*) to 100% (*completely confident*). In-task self-efficacy was assessed the first 30 seconds of exercise, the midpoint of exercise, and 10 min post exercise.

**Cortisol.**

Cortisol, a stress hormone, was measured in response to each acute bout of exercise. Cortisol is the end product of and indicator of the function of the hypothalamic pituitary adrenocortical (HPA) axis. Salivary cortisol was sampled to measure the activation of the HPA axis. The assessment of salivary cortisol has proven a reliable
indicator of the free cortisol in plasma and is widely accepted and frequently used (Edwards, Clow, Evans, & Hucklebridge, 2001; Kirschbaum & Hellhammer, 1994). Participants were instructed to refrain from eating at least one hour prior to the exercise session. Alcohol and caffeine consumption were restricted for 3 hours prior to the exercise session. Cortisol has a circadian cycle and the resting cortisol levels differ according to the time of collection. In healthy adults, salivary cortisol concentrations increase by between 50 and 160% in the first 30 min immediately post awakening and then decline in the afternoon (Clow et al., 2004). In order to minimize the potential influence of circadian variations on cortisol responses, the time of day testing occurred was standardized for each participant. Further, all testing occurred between 10 am and 8 pm.

Saliva samples were collected for the baseline measurement prior to any exercise testing condition. For each exercise condition, saliva samples were collected immediately before, the midpoint during the exercise session, 5 min before the end of the exercise session, at the end of exercise session, and at 10 and 30 min post exercise. These samples were collected using Salivette sampling device. The device is composed of a small polyester swab on which the subject gently chews for about 60 seconds. Swabs were transferred into small plastic tubes and centrifuged. The saliva samples were then stored at -80°C until analysis. All collected saliva samples were analyzed in the biochemistry lab in Health and Exercise Science by using commercially available kits (Alpco Diagnostics cortisol – direct salivary enzyme immunoassay). Saliva samples were prepared for analysis per assay kit instructions. Two replicates of each collected saliva
sample were tested per cortisol assay plate. A standard curve provided with the kit was included with each assay plate for cortisol quantitation, and positive and negative controls also were included with each plate.

**Future Intentions of Exercise.**

Exercise intention was assessed to determine whether exercise intensity and affect are related to motivational correlates of future exercise participation. Behavioral intention is one of the constructs of the Theory of Reasoned Action and Theory of Planned Behavior and directly affects behavior. Participants were asked at 10 and 30 min after each exercise session to rate how likely it was that they would participate in the same exercise intensity and duration in the future on a scale from 0% to 100%. This would allow for an assessment of the extent to which intensity and affect are related to motivational correlates of exercise behavior (Bray, Millen, Eidsness, & Leuzinger, 2005; Fox, Rejeski, & Gauvin, 2000; Focht, 2009).

**Procedures**

**Initial screening.**

Before potential participants came to the lab for baseline measurements, they had participated in an initial screening by telephone or e-mail with the investigator to make sure of their general eligibility to participate in this study. They were asked their age, height and weight for BMI criteria, and their exercise status with the LTEQ to estimate level of physical activity. The participants were asked to rate their stress level from 1 to
10, with 1 indicating no stress at all and 10 indicating the most stress they had ever experienced. A score of 7 or greater was considered to indicate a high level of stress. For the last question, the participants were asked if they had a current diagnosis of depression or anxiety disorder. If participants met these general criteria, they would be asked to schedule their first visit to the lab.

After initial screening for eligibility, all participants participated in four sessions in this study. These four sessions included:

- **Visit 1**: Screening and baseline measurements
- **Visit 2**: Self-selected exercise condition
- **Visit 3 or 4**: Imposed intensity: 10% above relative self-selected exercise intensity
- **Visit 3 or 4**: Imposed intensity: 10% below relative self-selected exercise intensity

All exercise sessions were designed to have an equal workload expending 150 kcal. To minimize the potential influence of diurnal effects, all testing was scheduled at the same time of day for each participant. All testing occurred between 10 am and 8 pm. Participants were instructed to refrain from eating 1 hour prior to exercise sessions and avoid alcohol and caffeine for the 3 hours before exercise sessions. Each exercise session was separated by a minimum of 48 hours and maximum of 7 days. The average time between each session was 2 to 4 days. Two participants failed to come back to the 4th appointment within 7 days due to illness and time conflict. Both of them came back in 14 days. All data were collected between June and early December in 2009. A detailed description of each session is provided below.
Visit 1 (Participants’ screening and baseline measurements).

Each potential participant met with the investigator at the lab (A40, PAES Building) for screening. The goals, objectives, and procedures of the study were explained and discussed. Volunteers had the opportunity to ask questions. If a volunteer agreed to participate, she completed an informed consent form. After signing the consent form, participants completed a health information form including demographic information, menstrual cycle pattern, pregnancy status, current medication use, smoking status, etc. (Please see Appendix G). They also completed the Physical Activity Readiness Questionnaire (PAR-Q), which measures whether the participant had any contradictions to participation in regular physical activity. Participants then completed the Perceived Stress Scale (PSS-10), which assesses the level of stress, and the Godin Leisure-Time Exercise Questionnaire (LTEQ), which assesses level of physical activity for screening. Next, height and weight were measured to determine BMI. Participants were asked to take off their shoes for the measurement. Height was measured using a stadiometer to the nearest quarter inch and weight was measured on a medical weight scale to the nearest half-pound. The units of the participants’ height and weight were converted to meters and kilograms, respectively. The BMI was calculated by dividing body weight in kilograms by height in meters squared (kg/m$^2$). In addition, the waist and hip ratio (WHR) was measured to determine the type of obesity present. A standard tape measurer was placed at the narrowest part of the torso to determine waist circumference and at the maximal circumference of the hip to determine hip circumference. The waist hip ratio was calculated by dividing the waist circumference by the hip circumference.
Overall, participants who scored ≥ 25 on the PSS, reported ≤ 2 session of moderate or higher intensity leisure time exercise sessions (energy expenditure from exercise < 500 kcal per week) on the LTEQ, had a BMI ≤ 34.9, and were not diagnosed with or in treatment for depression or anxiety disorder were eligible to participate in the study.

After the participation criteria were confirmed, the investigator asked each participant to sit in a chair for 5 min before taking resting blood pressure. In the mean time, each participant completed the remaining baseline assessments, including questions about when, what time and what food they had eaten before their visit to the lab. A saliva sample was collected to measure baseline cortisol level. Cortisol samples were obtained by requesting participants to chew a small polyester swab for about 60 seconds. The swabs were transferred into small plastic tubes, stored in a suitable storage box in a refrigerator and subsequently centrifuged. Then, saliva samples were stored at -80°C until analysis. After cortisol sampling and the participant sat for 5 min, resting blood pressure was measured.

Next, each participant performed a graded exercise test on a treadmill. The procedures for estimating VO₂peak were explained to the participant. Before the test, the investigator guided the participants in 1 min of active stretching to reduce risk of injury. The participant was instructed to wear a heart rate monitor and a mouth piece that was connected to a Cardio O₂ Metabolic Cart to measure oxygen consumption. The Bruce protocol was used to estimate peak oxygen consumption (VO₂peak). The participant started to walk on the treadmill at a speed of 1.7 mph with 10% grade for 3 min.
Thereafter, the speed was increased to 2.5 mph, 3.4 mph, 4.2 mph, 5.0 mph, and 5.5 mph every 3 min, while the grade was increased by 2% every 3 min. During the VO₂peak test, RPE was measured at the beginning of every 3 min while increasing the treadmill grade and speed.

The VO₂peak test could be terminated when there was a plateau in oxygen uptake compared to the previous stage, a respiratory exchange ratio (RER) ≥ 1.1, and/or heart rate within 10 b/min of the age-predicted maximum (220-age). The test could also be stopped by the participant at the point of volitional fatigue. Each participant was instructed to signal the investigator to stop the test by placing both hands on the support rails of the treadmill. Other general indications for stopping an exercise test included: leg cramps, light-headedness, confusion, pallor, nausea, cold skin, and failure of heart rate to increase with increased exercise intensity. A 5 min recovery period was started at 0% grade with a 1.5 mph speed during which recovery heart rate and blood pressure were taken. If criteria for VO₂max were not met, test results would be recorded as VO₂peak.

Lastly, the investigator and the participants scheduled the 2nd visit.

**Visit 2 (Self-selected intensity condition).**

Upon arriving at the lab for the second session, each participant was instructed to sit in a chair for 5 min before resting blood pressure was measured. During this rest time, the investigator gave a brief overview of the procedure for the second appointment. Participants were asked what time and what food they had eaten before their exercise session, and then were asked how many days had passed since the beginning of their last
menstrual cycle. Next, the pre-test salivary sample was obtained. This sample would be analyzed later for levels of cortisol. After 5 min of sitting, resting blood pressure was then measured. Afterwards, participants completed the pre-test affective assessments of the Self-Assessment Manikin (SAM) and the Exercise-Induced Feeling Inventory (EFI). During visit 2, participants performed the self-selected intensity exercise condition. Before the exercise session, the investigator guided the participant in 1 min of active stretching to reduce risk of injury. Then, participants were instructed to: “select a comfortable walking speed and grade that you prefer. The intensity should be high enough so that you would get a good work-out but not so high that exercising daily or every day would be objectionable. It should be an intensity that feels appropriate for you.” The instruction was modified from the study by Dishman et al. (1994). Participants were allowed to change the speed and grade for 5 min, but the speed could not exceed 4.0 mph so that they would remain walking throughout the exercise. After determining the most preferable intensity, the investigator immediately computed the duration of exercise necessary to expend 150 kcal without stopping the participant’s exercise. The participant remained at her preferred intensity throughout the exercise session.

The RPE was recorded every 5 min during the exercise. In-task self efficacy was measured at 3 time points, the first 30 seconds of exercise, the midpoint of exercise, and 10 min post exercise. The SAM and the EFI were assessed at 6 time points, prior to, at the midpoint, in the last 5 min before the end of the exercise, at the end of the exercise, at 10 min post, and at 30 min post exercise. Salivary cortisol was sampled after the participants complete the SAM and the EFI at each of the measurement time points.
On the completion of the exercise session, the treadmill was stopped. After the measurements, the participant walked to cool-down, if necessary. Then, participants were asked to sit down on a chair and rest quietly for 30 min. Several travel magazines were provided to standardize how participants spent the post exercise time period. At 10 min post exercise, self-efficacy, the SAM, the EFI, and cortisol were assessed. At 30 min post exercise, the SAM, the EFI, and cortisol were assessed. In addition, future intentions for exercise were measured at 10 and 30 min post exercise.

At the end of this session, the investigator scheduled an appointment with the participants for the 3rd visit to be within the next week.

**Visit 3 & Visit 4 (Imposed exercise intensity conditions).**

The imposed exercise intensity and duration were determined in reference to the self-selected intensity by equating the same energy expenditure (150 kcal) in advance. For example, if participant A’s self-selected intensity was equivalent to 50% of VO$_{2\text{peak}}$, one of her imposed intensities was equivalent to 60% of VO$_{2\text{peak}}$, and the other imposed intensity was equivalent to 40% of VO$_{2\text{peak}}$.

The order of the treatment was randomized and participants were not aware of which condition they were to perform each day. In fact, the investigator prescribed the exercise intensity, either 10% above or 10% below the relative intensity at the self-selected exercise at the 3rd and 4th visit. On arriving for the 3rd and 4th appointments, the participants were asked to sit in a chair for 5 min before resting blood pressure measurement. During this rest time, they were asked what time and what food they had
eaten before the exercise session, and then were asked how many days had passed since the beginning of their last menstrual cycle. Next, the pre-test salivary sample was obtained. Resting blood pressure was then measured. Then, the participants completed the pre-test SAM and the EFI.

Before the exercise session, the investigator guided the participants in 1 min of active stretching to reduce the risk of injury. Then, participants began walking on the treadmill, and the speed and/or grade were changed to either 10% above or 10 below intensity of exercise for the planned duration.

All parameters were measured at the same designated measurement points as for the self-selected intensity condition during and after the exercise session.

At the end of the last session, the investigator congratulated the participant for successfully completing the exercise sessions. A personalized exercise prescription was provided to each participant.

In Table 3.2, the timeline of the measurements is presented.

<table>
<thead>
<tr>
<th></th>
<th>Pre test</th>
<th>Midpoint</th>
<th>5 min B</th>
<th>End</th>
<th>10 min P</th>
<th>30 min P</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAM</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>EFI</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>SE</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RPE</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CORT</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 3.2 Timeline of the measurements

*Note.* Every 5 min during the exercise session. <sup>a</sup> SE pre test was assessed at the first 30 seconds of the exercise session.
Data Analysis

Preliminary analyses were conducted to provide baseline characteristics of the participants’ age, BMI, resting blood pressure, waist-hip ratio, VO_{2peak}, ventilatory threshold (VT), salivary cortisol, the PSS and the GODIN scores. Descriptive statistics (means and standard deviation) for exercise intensity and duration, affective responses, self-efficacy, salivary cortisol, and future intentions were computed.

The first research question is whether exercising at self-selected intensity results in more positive affective responses than exercising at imposed intensity (higher or lower) in inactive women, when equating for total energy expenditure. To answer this question, separate repeated measures ANOVA’s were performed on each subscales of the SAM and the FEI. There were 3 exercise intensity conditions (self-selected, 10% above and 10% below the relative intensity at the self-selected intensity) and 6 time points (pre-test, the midpoint of exercise session, the last 5 min of exercise session, the end of exercise session, 10 min post exercise, and 30 min post exercise). Repeated measures ANOVA was used to determine the significance of main effects for time and intensity. Greenhouse-Geisser epsilon corrections were used if the assumption of Sphericity was violated. Post-hoc analysis was performed to determine the location of significant mean differences. Simple comparison was performed to compare self-selected intensity exercise to imposed intensity exercise in terms of affective responses.

The second research question is to examine if the HPA axis (operationalized as levels of cortisol) is a contributing mechanism to changes in affective responses during and after an acute bout of exercise. The hierarchical linear modeling (HLM) on cortisol
was used to deal with missing data. The self-selected intensity exercise was used as the referent and we tested the interactions between exercise conditions. For follow up, t-tests were used to examine whether cortisol levels were different from pre test to the other measurement time points at each exercise intensity condition. For further analyses, bivariate correlations were computed to examine the relationship between cortisol levels and each affective response, such as pleasure, arousal, dominance, positive engagement, revitalization, tranquility, and physical exhaustion within each of the exercise conditions.

The third research question is whether in-task self-efficacy is related to affect and cortisol level. A 3 (exercise condition) x 3 (time) ANOVA with repeated measures on self-efficacy was performed. Greenhouse-Geisser epsilon corrections were applied to the violation of Sphericity assumption. Bivariate correlations between cortisol levels and self-efficacy were conducted within each of the exercise conditions. A series of simple regression analyses was conducted to investigate whether self-efficacy during exercise would predict positive affective responses during exercise sessions.

For the analysis of future exercise intentions, we conducted correlation analyses to examine the association between future exercise intentions and affective responses and self-efficacy under each exercise conditions. Further, we used a series of multiple regression analyses to determine the final model, with affective variables as predictors and intentions at 10 and 30 min post exercise as dependent variables.

Statistic analyses were completed using the Statistical Package for the Social Sciences (PASW, version 18.0) software. The significance level was set $\alpha = .05$. The power was set at .80 and expected effect size was at 0.25 of Cohen’s $d$. 
Chapter 4: Results

This chapter presents the results of the statistical analysis of physiological and psychological responses to treadmill walking exercise at 3 different intensities. The outline of this chapter includes research questions and hypotheses, characteristics of participants, and the results of affective responses (research question 1) and cortisol responses to exercise (research question 2), self-efficacy (research question 3), and future intentions of exercise (additional analysis).

Research Questions and Hypotheses

The first research question was whether exercising at self-selected intensity results in more positive affective responses than exercising at imposed intensity (higher or lower) in inactive women experiencing high levels of stress, when equating for total energy expenditure.

Hypotheses tested:

1. Affective responses will become more positive pre to post exercise, irrespective of exercise intensity.
2. Global and categorical assessments of affective valence (pleasure), assessed with the Self-Assessment Manikin (SAM) and the Exercise Feeling Inventory (EFI) will be higher at the self-selected intensity exercise than at the imposed exercise.
intensity conditions during exercise and 10 and 30 min post exercise.

3. Dominance, a variable of the SAM will be higher during exercise at the self-selected intensity exercise than during the imposed exercise intensity conditions.

4. Arousal, a variable of the SAM will be highest during exercise at 10% above the self-selected intensity exercise.

The second research question addressed the role of the HPA axis (operationalized as levels of salivary cortisol) as a contributing mechanism to changes in affective responses during and after acute bouts of exercise.

Hypotheses tested:

5. Cortisol levels at imposed intensities (10% above and 10% below the relative intensity at the self-selected exercise) will be associated with less positive affective response during exercise.

6. Positive affect and cortisol responses will be inversely related 10 and 30 min post exercise.

The third question was whether in-task self-efficacy is related to affect and cortisol level.

Hypotheses tested:

7. At the self-selected intensity, exercise self-efficacy will be significantly higher than during exercise of imposed intensities.

8. Self-efficacy during exercise will be inversely related to cortisol levels post exercise.
9. Higher self-efficacy will be strongly related to more favorable affective responses during the self-selected intensity exercise and 10% below the relative self-selected intensity exercise compared to 10% above the relative self-selected intensity exercise.

**Characteristics of Participants**

A total of 52 women contacted the investigator to inquire about this study in response to advertisements and word of mouth. Fourteen volunteers did not meet the inclusion criteria due to high levels of physical activity, a diagnosis of depression, or reports of stress below the criterion level. Of those 38 who were eligible, 24 women agreed to participate in this study. There were four experimental sessions; 19 participants completed the all sessions, whereas 5 participants dropped out after the first session. Reasons reported for dropping out included illness \((n = 3)\), muscle discomfort, \((n = 1)\) and time conflicts \((n = 1)\).

Figure 4.1 presents the flow chart of recruitment, participants, and drop-out.
The participants were aged between 18 and 36 ($M = 23.58, SD = 5.30$), and had a Body Mass Index (BMI) of 18.1 to 32.6 ($M = 22.83, SD = 4.12$). Of the 19 participants, 11 (57.9%) were non-Hispanic White, 5 (26.3%) were Asian, 2 (10.5%) were non-Hispanic Black, and 1 (5.3%) was White and Hispanic.
The mean score of the Perceived Stress Scale (PSS-10) was 27.32 \( (SD = 2.52) \), and ranged from 25 to 35. We conducted the reliability test for the PSS and found Chronbach’s alpha for this questionnaire was .60. The mean score of Godin leisure-time exercise questionnaire (GODIN) was 5.11 \( (SD = 6.79) \), and ranged from 0 to 21. All of our participants scored less than 14 units from strenuous exercise and moderate exercise, which indicates they were insufficiently active and receive less substantial or low health benefits from their level of physical activity (Godin, 2011). The mean peak oxygen consumption \( (VO_{2peak}) \) was 33.4 ml/kg/min \( (SD = 5.14) \), and ranged from 22.5 to 44.8.

To estimate baseline cortisol, each saliva sample was assayed in duplicate and the cortisol concentration was determined by averaging the two values. Coefficient of variability (CV) was defined as the ratio of the standard deviation to mean and was used to judge the validity of the cortisol data. The baseline cortisol data for 7 participants were excluded because these values had more than 15% CV, which was recommended by the manufacturer as criterion for inclusion. For the remaining of 12 participants, baseline cortisol was between 9.79 and 55.70 ng/ml \( (M = 19.04, SD = 10.53) \). The average waist-hip-ratio (WHR) was 0.75 \( (SD = 0.050) \), and ranged from 0.68 to 0.86. One participant’s WHR was 0.86, which is classified as high risk and associated with more health risks. The mean value of systolic blood pressure was 100.6 mmHg \( (SD = 8.9) \), and ranged from 82 to 122. The mean value of diastolic blood pressure was 66.5 mmHg \( (SD = 5.2) \), and ranged from 58 to 76.

The baseline characteristics of participants are summarized in Table 4.1.
Table 4.1 Baseline characteristics $N = 19$

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>$M$</th>
<th>$SD$</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>23.58</td>
<td>5.30</td>
<td>18 – 36</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>22.83</td>
<td>4.12</td>
<td>18.10 - 32.60</td>
</tr>
<tr>
<td>PSS</td>
<td>27.32</td>
<td>2.52</td>
<td>25 – 35</td>
</tr>
<tr>
<td>GODIN</td>
<td>5.11</td>
<td>6.79</td>
<td>0 - 21</td>
</tr>
<tr>
<td>VO$_{2\text{peak}}$(ml/kg/min)</td>
<td>33.37</td>
<td>5.14</td>
<td>22.50 - 44.80</td>
</tr>
<tr>
<td>Cortisol (ng/ml)</td>
<td>19.04</td>
<td>12.4</td>
<td>9.79 - 55.7</td>
</tr>
<tr>
<td>WHR</td>
<td>0.75</td>
<td>0.05</td>
<td>0.68 – 0.86</td>
</tr>
<tr>
<td>Systolic BP (mmHg)</td>
<td>100.6</td>
<td>8.9</td>
<td>82 - 122</td>
</tr>
<tr>
<td>Diastolic BP (mmHg)</td>
<td>66.5</td>
<td>5.2</td>
<td>58 - 76</td>
</tr>
</tbody>
</table>

Note. BMI = Body Mass Index; PSS = Perceived Stress Scale; GODIN = Godin leisure-time exercise questionnaires. Cortisol $n = 12$.

In addition, we collected information on oral contraceptives (OC) use and menstrual phase. Although previous studies that examined the influence of OC use and menstrual phase on cortisol responses to exercise had conflicting results (Kirschbaum et al., 1996; Kirschbaum et al., 1999; Timmons et al., 2005), it was advisable to collect this information (Hansen, Garde, & Person, 2008). Ten participants (53%) were OC users in this study. Participants’ menstrual cycles varied across 3 exercise conditions; however two participants had experienced irregular menstrual cycles during the last 6 months.

**Treadmill walking exercise sessions.**

Each participant walked on the treadmill at 3 different intensities, including self-selected intensity, 10% above and 10% below the relative self-selected intensity. Exercise intensities were determined based on the VO$_{2\text{peak}}$ test. The mean intensity during the self-selected exercise was 57.7% VO$_{2\text{peak}}$ ($SD = 10.8$), the range was 34.7% to 82.3%.
Accordingly, the mean intensity of the 10% above intensity exercise condition was 67.7% \( \text{VO}_2\text{peak} \) (44.7 - 92.3) and the 10% below intensity exercise condition was 47.7% \( \text{VO}_2\text{peak} \) (24.7-72.3).

Figure 4.2 shows the descriptive statistic for the exercise intensity at all exercise conditions.

Figure 4.2 Exercise intensity at self-selected, 10% above and 10% below intensity conditions \( n = 19 \)
Ventilatory threshold (VT) was used as another way to evaluate exercise intensity. Ventilatory threshold was estimated from the VO$_{2peak}$ test data for all but one participant, for whom VT could not be estimated because of a measurement error. Ventilatory threshold was expressed as a percentage of VO$_{2peak}$. The mean percentage of VO$_{2peak}$ when VT occurred was 73% VO$_{2peak}$ ($SD = 4.9$), and ranged from 63.2 to 82.2.

The estimation of exercise intensities by using VT are summarized in Table 4.2.

<table>
<thead>
<tr>
<th></th>
<th>$M$</th>
<th>$SD$</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-selected</td>
<td>79.0</td>
<td>13.8</td>
<td>54.3 - 115.7</td>
</tr>
<tr>
<td>10% above intensity</td>
<td>92.7</td>
<td>13.7</td>
<td>69.9 - 129.8</td>
</tr>
<tr>
<td>10% below intensity</td>
<td>65.2</td>
<td>14.0</td>
<td>38.6 - 101.7</td>
</tr>
</tbody>
</table>

Table 4.2 Mean intensity expressed as the percentage of VT at each exercise condition $n = 18$

The results presented in Table 4.2 indicated that most participants exercised at a lower intensity than their VT during the exercise conditions. When we looked at each individual, we found one participant exercised at 115.7 % VT at the self-selected intensity exercise, 129.8% VT at the 10% above intensity exercise and 101.7% VT at the 10% below intensity exercise. However, all three values were more than 2 standard deviations from the group mean; we concluded that she was an extreme case. The rest of the participants exercised at a lower intensity than their VT during the self-selected and the 10% below intensity exercise sessions. At 10% above intensity, we found three other participants who exercised slightly above their VT, which were 102.6, 106, and 106.4% VT.
These data are also presented graphically in Figure 4.3.

Figure 4.3 Exercise intensity expressed as the percentage of VT at self-selected, 10% above, and 10% below intensity conditions $n = 18$

*Note.* $^015 = \text{outlier} \ (\geq 2 \ SDs)$

The mean exercise duration to expend 150 kcal was 27.6 min (range 17.5 - 40.8) at the self-selected intensity, 23.4 min (range 15.0 - 31.7) at the 10% above intensity, and 33.9 min (range 21.0 - 57.4) at the 10% below intensity. We examined whether exercise duration influenced affective responses and self-efficacy. We performed correlation.
analysis and did not find any significant relationships between exercise duration at each intensity condition and post exercise affective and self-efficacy responses.

Figure 4.4 presents the exercise duration at each exercise intensity condition.

Figure 4.4 Exercise duration at self-selected, 10% above and 10% below intensity conditions n = 19

*Note.* $^02$ and $^017$ = outliers ($\geq 2$ $SD$s); $^2$ = outlier ($\approx 3$ $SD$s).
Affective Responses

We performed a 3 (Exercise intensities: self-selected, 10% above, and 10% below relative self-selected intensity) x 6 (Time: pre-test, the midpoint of exercise, 5 min before the end of exercise, the end of exercise, 10 and 30 min post exercise) repeated measures ANOVA on affective responses. Descriptive analyses for affective responses are summarized in Table 4.3.
Table 4.3 Means ($M$) and standard deviations ($SD$) of the affective responses before, during, and post exercise at self-selected, 10% above, and 10% below intensity conditions.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Self-selected</th>
<th>10% above</th>
<th>10% below</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M \pm SD$</td>
<td>$M \pm SD$</td>
<td>$M \pm SD$</td>
</tr>
<tr>
<td>Pleasure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>6.16 ± 1.43</td>
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<td>5.74 ± 1.63</td>
</tr>
<tr>
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</tr>
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<td>5 min before</td>
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<td>6.32 ± 1.20</td>
<td>6.79 ± 1.03</td>
</tr>
<tr>
<td>End</td>
<td>7.37 ± 1.01</td>
<td>6.68 ± 1.49</td>
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<tr>
<td>10 min post</td>
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<tr>
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<td>5.68 ± 1.49</td>
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<tr>
<td>Midpoint</td>
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<td>6.42 ± 1.07</td>
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<td>End</td>
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<tr>
<td>10 min post</td>
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<td>6.89 ± 1.45</td>
<td>6.79 ± 1.65</td>
</tr>
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<td>6.74 ± 2.31</td>
</tr>
<tr>
<td>End</td>
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<td>7.84 ± 2.85</td>
</tr>
<tr>
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<td>7.74 ± 2.18</td>
</tr>
<tr>
<td>End</td>
<td>9.26 ± 1.94</td>
<td>8.11 ± 2.66</td>
<td>8.53 ± 2.48</td>
</tr>
<tr>
<td>10 min post</td>
<td>8.68 ± 2.36</td>
<td>8.21 ± 2.64</td>
<td>8.26 ± 2.21</td>
</tr>
<tr>
<td>30 min post</td>
<td>8.16 ± 2.32</td>
<td>7.79 ± 2.68</td>
<td>8.05 ± 2.12</td>
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Continued
Table 4.3 continued

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<td>$M \pm SD$</td>
<td>$M \pm SD$</td>
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<tr>
<td>Tranquility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>6.68 ± 2.29</td>
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<td>5.79 ± 2.68</td>
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<td>5.68 ± 2.16</td>
</tr>
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<td>4.89 ± 2.66</td>
<td>5.58 ± 2.29</td>
</tr>
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<td>End</td>
<td>6.74 ± 3.09</td>
<td>5.89 ± 3.45</td>
<td>6.53 ± 2.46</td>
</tr>
<tr>
<td>10 min post</td>
<td>8.74 ± 2.18</td>
<td>8.16 ± 3.29</td>
<td>7.95 ± 2.27</td>
</tr>
<tr>
<td>30 min post</td>
<td>8.58 ± 2.27</td>
<td>8.47 ± 2.86</td>
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<td>5.58 ± 3.72</td>
<td>5.63 ± 3.06</td>
<td>5.79 ± 4.28</td>
</tr>
<tr>
<td>Midpoint</td>
<td>4.63 ± 2.54</td>
<td>4.84 ± 2.91</td>
<td>4.37 ± 3.10</td>
</tr>
<tr>
<td>5 min before</td>
<td>4.53 ± 2.91</td>
<td>4.95 ± 3.06</td>
<td>4.63 ± 2.83</td>
</tr>
<tr>
<td>End</td>
<td>4.11 ± 2.89</td>
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<td>4.11 ± 2.98</td>
</tr>
<tr>
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<td>3.32 ± 2.29</td>
<td>4.16 ± 3.08</td>
<td>3.58 ± 2.99</td>
</tr>
<tr>
<td>30 min post</td>
<td>3.16 ± 2.65</td>
<td>3.42 ± 2.99</td>
<td>3.63 ± 3.30</td>
</tr>
</tbody>
</table>

**Note.** Midpoint = the midpoint of exercise session; 5 min before = 5 min before the end of exercise.

In addition, descriptive data for each affect variable is graphically presented in Figures from 4.5 to 4.11. Assessment time points included in these figures are pre exercise, the end of exercise, and 30 min post exercise.
Figure 4.5 Pleasure at pre test, the end of exercise, and 30 min post exercise at self-selected, 10% above, and 10% below intensity

*Note.* ʰ₀₈, ʰ₀₃₅, ʰ₀₄₈, ʰ₀₁₃₄ and ʰ₀₁₆₉ = outliers (≥ 2 SDs).

Figure 4.6 Arousal at pre test, the end of exercise, and 30 min post exercise at self-selected, 10% above, and 10% below intensity

*Note.* ʰ₀₁₄, ʰ₀₉₆, ʰ₀₁₃₈ and ʰ₀₁₄₇ = outliers (≥ 2 SDs); *ʰ₉₃ = outlier (∼ 3 SDs).
Figure 4.7 Dominance at pre test, the end of exercise, and 30 min post exercise at self-selected, 10% above, and 10% below intensity

Note. \( ^{0}38 = \) outlier (\( \geq 2 \) SDs).

Figure 4.8 Revitalization at pre exercise, the end of exercise, and 30 min post exercise at self-selected, 10% above, and 10% below intensity

Note. \( ^{0}146 = \) outlier (\( \geq 2 \) SDs).
Figure 4.9 Positive engagement at pre test, the end of exercise, and 30 min post exercise at self-selected, 10% above, and 10% below intensity

*Note.* $^0_{1}$ and $^0_{48} = $ outliers ($\geq 2$ $SD$s).

Figure 4.10 Tranquility at pre test, the end of exercise, and 30 min post exercise at self-selected, 10% above, and 10% below intensity

*Note.* $^0_{1}$, $^0_{98}$, $^0_{143}$ and $^0_{165} = $ outliers ($\geq 2$ $SD$s).

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The results of each affective variable are presented next.

**Pleasure.**

Analysis of pleasure, a variable of the SAM showed a significant main effect for time, $F(2.174, 39.136) = 16.748, p < .001, \eta^2 = .482$. The main effect for exercise condition $F(2,36) = 2.848, p = .071$, and exercise condition and time interaction, $F(5.621, 101.176) = 1.109, p = .362$, were not significant. Post hoc analyses revealed that pleasure increased significantly from pre to all post exercise assessments (the end of exercise, 10 and 30 min post exercise). In addition, pleasure increased from assessments during exercise (the midpoint of exercise and 5 min before the end of exercise) to all post exercise assessments (the end of exercise, 10 and 30 min post exercise).
Revitalization.

Analysis of the revitalization subscale of the EFI showed a significant main effect for time, $F(2.291, 41.240) = 24.908, p < .001, \eta^2 = .580$. The main effect for exercise condition $F(1.4,25.191) = 1.792, p = .193$, and exercise condition and time interaction, $F(4.536, 81.652) = 1.560, p = .186$, were not significant. Post hoc analyses revealed that revitalization increased significantly from pre to both during exercise (the midpoint of exercise and 5 min before the end of exercise) and post exercise (the end of exercise, 10 and 30 min post exercise), and from assessments during exercise (both midpoint exercise and 5 min before exercise end) to end of exercise.

Positive engagement.

Analysis of the positive engagement subscale of the EFI showed a significant main effect for time, $F(1.883, 33.895) = 13.829, p < .001, \eta^2 = .434$ and the main effect for exercise condition, $F(2, 36) = 5.046, p < .05, \eta^2 = .219$. Exercise condition and time interaction, $F(5.200, 93.598) = .881, p = .500$, was not significant. Post hoc analyses revealed that positive engagement increased significantly from pre to assessments both during exercise (the midpoint of exercise and 5 min before the end of exercise) and post exercise (the end of exercise, 10 and 30 min post exercise). Post hoc analysis for exercise condition demonstrated that positive engagement was significantly higher at the self-selected intensity than at the 10% above intensity regardless of time.
Tranquility.

Analysis of the tranquility subscale of the EFI showed a significant main effect for time, $F(2.124, 38.240) = 12.914, p < .001, \eta^2 = .418$. The main effect for exercise condition, $F(2, 36) = 2.177, p = .128$, and exercise condition and time interaction, $F(4.804, 86.464) = 1.121, p = .348$, were not significant. Post hoc analyses revealed that tranquility increased significantly from assessments during exercise (the midpoint and 5 min before the end of exercise) to post exercise (the end of exercise, 10 and 30 min post exercise), and also from the end of exercise to both 10 and 30 min post exercise. A marginally significant increase was detected from pre exercise to 30 min post exercise ($p = .05$).

Physical exhaustion.

Analysis of the physical exhaustion subscale of the EFI showed a significant main effect for time, $F(1.772, 31.890) = 6.421, p < .01, \eta^2 = .263$. The main effect for exercise condition, $F(2, 36) = .595, p = .557$, and exercise condition and time interaction, $F(4.413, 79.435) = .830, p = .520$, were not significant. Post hoc analyses revealed that physical exhaustion decreased significantly from assessment 5 min before the end of exercise to both 10 and 30 min post exercise.

As shown above, the main effect for time found in all variables and the following post hoc analysis indicated that affective states became more positive from pre to post exercise irrespective of exercise intensity condition.
Next, we performed simple comparisons to find whether affective valence was higher at the self-selected intensity exercise than at the imposed exercise intensities conditions during exercise and 10 and 30 min post exercise (hypothesis 2). We examined three variables, including pleasure, revitalization, and positive engagement to test this hypothesis. Analysis of pleasure demonstrated that the pleasure score was significantly higher at self-selected intensity at 10 min post exercise than at 10 % above at 10 min post exercise, $F(1,18) = 5.056, p < .05, \eta^2 = .219$. No significant differences from the imposed intensity conditions were detected during exercise, $F(1,18) = .005, p = .945$, and 30 min post exercise, $F(1,18) = 1.378, p = .256$.

The revitalization score at the self-selected intensity was significantly higher during exercise than at both 10% above intensity, $F(1,18) = 6.167, p < .05, \eta^2 = .255$ and 10% below intensity, $F(1,18) = 13.680, p < .05, \eta^2 = .432$ during exercise. No significant differences were found at 10 and 30 min post exercise.

Similarly, positive engagement was significantly higher at the self-selected intensity during exercise than at both 10% above intensity, $F(1,18) = 14.372, p < .01, \eta^2 = .444$ and 10% below intensity, $F(1,18) = 10.843, p < .01, \eta^2 = .376$ during exercise. No significant differences were found at 10 and 30 min post exercise.

These results of the simple comparisons demonstrated that affective valence (pleasure) was higher at self-selected intensity than at imposed intensities at 10 min post exercise, but not 30 min post exercise. Furthermore, both positive engagement and revitalization were higher at self-selected intensity than at two imposed intensities during exercise, but not at post exercise.
Dominance.

Analysis of dominance, a variable of SAM showed a significant main effect for time, $F(1.813, 32.638) = 15.142, p < .001, \eta^2 = .457$. The main effect for exercise condition $F(2, 36) = .257, p = .775$, and exercise condition and time interaction, $F(5.183, 93.297) = .487, p = .791$, were not significant. Post hoc analyses revealed that dominance increased significantly from pre to during exercise (the midpoint of exercise and 5 min before the end of exercise) and post exercise (the end of exercise, 10 and 30 min post exercise), from midpoint of exercise to both 5 min before the end of exercise and the end of exercise, and from 5 min before the end of exercise to the end of exercise. The simple comparison was performed to examine whether dominance was higher during exercise at the self-selected intensity exercise than during the imposed intensity conditions (hypothesis 3). The results of simple comparisons demonstrated that there were no significant differences in dominance during exercise between self-selected intensity exercise and the imposed intensity exercise conditions, $F(1,18) = .244, p = .627$.

Arousal.

Analysis of arousal, a variable of SAM showed a significant main effect for time, $F(2.128, 38.299) = 10.346, p < .001, \eta^2 = .365$. However, the main effect for exercise condition $F(1.501, 27.026) = .139, p = .871$, and exercise condition and time interaction, $F(5.018, 90.328) = .803, p = .551$, were not significant. Post hoc analyses revealed that arousal increased significantly from pre to during exercise (the midpoint of exercise and 5 min before the end of exercise) and the end of exercise. The simple comparison was
performed to examine whether arousal was higher during exercise at 10% above the relative self-selected intensity exercise (hypothesis 4). The results showed that there were no significant differences in arousal scores between the 10% above intensity exercise and the self-selected intensity exercise conditions, $F(1,18) = .587, p = .454$ and between the 10% above intensity exercise and the 10% below intensity exercise conditions, $F(1, 18) = .290, p = .597$.

Cortisol responses

Salivary cortisol analysis.

We assayed saliva samples using the Enzyme-linked immunosorbent assay (ELISA) kit to determine concentrations of cortisol. A 50 $\mu$l sample was used for duplicate analysis. We found large inter- and intra-assay CV in some saliva samples. Therefore, we tested different inclusion criteria for CV values for the analysis. We included samples with CV < 25% as the criterion. Two additional datasets were created with CV < 20% and CV < 15% as criteria for potential later comparison.

Missing data.

Some of the cortisol concentration data could not be included based on the three inclusion CV criteria. Of the 342 saliva samples that were possible, 22.2% were missing with CV < 25%, 31% were missing with CV < 20%, and 41.8% were missing with CV < 15%.
Preparation of cortisol data.

Cortisol values were logarithmically transformed because raw cortisol values were positively skewed. This resulted in a normal distribution, and all subsequent analyses were performed based on logarithmic transformed data.

Descriptive analyses for Cortisol responses.

Descriptive analyses for cortisol responses are summarized in Table 4.4.

<table>
<thead>
<tr>
<th>Cortisol (log data)</th>
<th>Self-selected $M \pm SD$</th>
<th>10% above $M \pm SD$</th>
<th>10% below $M \pm SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>3.11 ± .545</td>
<td>3.15 ± .525</td>
<td>2.91 ± .429</td>
</tr>
<tr>
<td>Midpoint</td>
<td>3.12 ± .400</td>
<td>3.11 ± .598</td>
<td>3.12 ± .369</td>
</tr>
<tr>
<td>5 min before</td>
<td>3.04 ± .493</td>
<td>3.10 ± .432</td>
<td>2.87 ± .443</td>
</tr>
<tr>
<td>End</td>
<td>3.15 ± .398</td>
<td>3.06 ± .481</td>
<td>2.83 ± .408</td>
</tr>
<tr>
<td>10 min post</td>
<td>2.90 ± .364</td>
<td>3.30 ± 5.34</td>
<td>2.89 ± .345</td>
</tr>
<tr>
<td>30 min post</td>
<td>3.12 ± .452</td>
<td>3.21 ± .353</td>
<td>2.82 ± .326</td>
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</table>

Table 4.4 Means ($M$) and standard deviations ($SD$) of cortisol responses before, during, and post exercise at self-selected, 10% above, and 10% below intensity conditions.

*Note.* Midpoint = the midpoint of exercise session; 5 min before = 5 min before the end of exercise.

Also, descriptive data for cortisol responses variable is graphically presented in Figure 4.12. Assessment time points included in this figure are pre exercise, the end of exercise, and 30 min post exercise.
Figure 4.12 Cortisol responses at pre test, the end of exercise, and 30 min post exercise at self-selected, 10% above, and 10% below conditions.

*Note.* $^{O}161 = \text{outlier } (\geq 2 \text{ SDs}).$

We attempted to use a 3 (exercise intensities) x 6 (time points) repeated measures ANOVA on cortisol responses. However, general linear model (GLM) approaches had limitations to the analysis of repeated-measures data with missing values. Therefore, we used the Hierarchical Linear Modeling (HLM). The HLM approach to repeated-measures analysis is an improvement over GLM methods; for example, it has the ability to include cases with missing data, it accommodates situations in which the time of data collection
might vary across participants, and it allows within- and between-subjects variability (O’Connell & McCoach, 2004).

The level 1 model includes time as a predictor. At the level 2, exercise intensities were predictors of the intercepts (initial status) and slopes (change over time) from level 1. At the level 2 model, the dummy codes were created to represent two conditions (COND1: self-selected intensity vs. 10% above intensity, COND 2: self-selected intensity vs. 10% below intensity), with the self-selected intensity exercise as the referent. Using the CV < 25% dataset, the HLM results yielded no significant interaction in both comparisons, $t = -1.083, p = .280$ and $t = .446, p = .656$, respectively. We tested slopes as linear, quadratic, and cubic rate of change, however none of them was significant. Likewise, we ran the same analysis with CV < 20% and CV < 15% datasets, and no significant interaction were observed, either. The HLM results also indicted that there were significant individual differences ($\tau_{oo} = .136914, p = .005$) in initial status of cortisol concentrations.

The results of the HLM analysis with the CV < 25% dataset are summarized in Table 4.5.
Estimate | $P$
---|---
Intercept | 3.0970 | .000
Cond_1 | .0562 | .573
Cond_2 | -.1867 | .076
$\tau_{00}$ | .1369 | .005
Linear | .0485 | .733
Cond_1 | -.2115 | .280
Cond_2 | .0887 | .656
$\tau_{11}$ | .001386 | |
Quadratic | -.0429 | .548
Cond_1 | .1189 | .227
Cond_2 | -.0354 | .720
$\tau_{22}$ | .002459 | |
Cubic | .0063 | .492
Cond_1 | -.0141 | .276
Cond_2 | .0034 | .790
$\tau_{33}$ | 0 | |
$\sigma^2$ | .07587 | .000

Table 4.5 Hierarchical linear model results for cortisol responses to exercise: Exercise intensity conditions as level 2 predictors of the intercept (initial status) and slopes (change overtime) from level 1 (linear, quadratic, & cubic)

*Note.* Cond_1 = self-selected intensity vs. 10% above intensity; Cond_2 = self-selected intensity vs. 10% below intensity.

Similarly, we used the 10% below intensity exercise as the referent and created the dummy codes to test two more conditions (10% below intensity vs. 10% above intensity and 10% below intensity vs. self-selected intensity). The results with the < 25% CV dataset showed that initial status of cortisol concentrations for the 10% above intensity exercise was significantly higher than for the 10% below intensity exercise, $F(1, 262.740) = 6.039, p = .015$. No interactions were found in both comparisons, $t = -1.544, p = .124$ and $t = -.446, p = .656$, respectively. These results suggested that cortisol responses to exercise at different intensities had the same pattern of change.
In addition, we used paired t-tests to examine whether cortisol levels were different from pre test to the other measurement time points at each exercise intensity condition; likewise we did not find any significant differences in cortisol levels at any time point and at any exercise condition. Then, we performed another paired samples t-tests to compare cortisol levels from baseline to during (the midpoint of exercise and 5 min before the end of exercise) and post exercise assessments (the end of exercise, 10 and 30 min post exercise) at each exercise condition. We found significant cortisol elevations in 10 and 30 min after 10% above intensity exercise compared to baseline value.

Table 4.6 presents the results of paired t-tests.

<table>
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<tr>
<th>Cortisol</th>
<th>$M$</th>
<th>$SD$</th>
<th>$T$</th>
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</thead>
<tbody>
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<td>Baseline-ACO5</td>
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<td>.47576</td>
<td>-2.976</td>
<td>.018</td>
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<td>Baseline-ACO6</td>
<td>-.57446</td>
<td>.31731</td>
<td>-5.121</td>
<td>.001</td>
</tr>
</tbody>
</table>

Table 4.6 Changes in cortisol levels from baseline to post exercise

*Note.* ACO5 = cortisol level at 10 min post 10% above intensity exercise; ACO6 = cortisol level at 30 min post 10% above intensity exercise.

We also found significant cortisol elevations in 30 min after 10% above intensity exercise compared to baseline value in the CV < 15% dataset, $t = -4.825, p = .005$ and in the CV < 20% dataset, $t = -5.121, p = .001$.

Furthermore, we conducted a series of one-way ANOVA to examine changes in cortisol levels from baseline to during and post exercise assessments among exercise intensity conditions. These results showed significant changes in cortisol from baseline to
10 min post exercise, $F(2,25) = 3.724, p = .038$ and 30 min post exercise, $F(2,25) = 5.100, p = .014$. Post hoc analyses indicated that the magnitude of changes in cortisol from baseline to 10 min post exercise were significantly larger in the 10% above intensity condition than the self-selected intensity condition ($p = .038$). Also, changes in cortisol from baseline to 30 min post exercise were significantly larger in the 10% above intensity condition than the 10% below intensity condition ($p = .014$).

In the CV < 20% dataset, we found significant changes in cortisol levels from baseline to 30 min post exercise, $F(2,22) = 5.552, p = .011$. Post hoc analyses indicated that changes in cortisol from baseline to 30 min post exercise were significantly larger in the 10% above intensity condition than the 10% below intensity condition ($p = .011$). However, we did not find any significant result in the CV < 15% dataset, $F(2, 17) = 2.743, p = .093$.

**Correlation analysis.**

A series of bivariate correlation analyses was performed to answer hypothesis 5 and 6. First analysis was to investigate whether cortisol levels at imposed intensities were associated with less positive affective responses during exercise, that is, in the midpoint and 5 min before the end of the exercise session (hypothesis 5). Pearson correlation revealed that cortisol levels at imposed intensities were not associated with less positive affective responses during exercise. Contrary to our hypothesis, the results revealed a positive relationship between cortisol levels and some affective responses at 10% below intensity measured at 5 min before the end of exercise. Using the CV < 25% dataset, the
positive relationship between cortisol levels and arousal ($r = .618, p = .004$), positive engagement ($r = .559, p = .014$), and revitalization ($r = .508, p = .044$) were found. Using the CV < 20% dataset, cortisol levels and pleasure ($r = .585, p = .028$), arousal ($r = .561, p = .016$), and positive engagement ($r = .669, p = .009$) were significantly related. Using the CV < 15% dataset, the relationship between cortisol levels and arousal ($r = .646, p = .044$), and positive engagement ($r = .660, p = .038$) were significant.

The second correlation analysis was to examine whether cortisol levels and affective responses were inversely related at 10 and 30 min post exercise (hypothesis 6). There were no significant inverse relationships between cortisol levels and affective responses. We found a negative association between cortisol levels and arousal at 30 min post exercise at 10% above intensity in the CV < 15% dataset ($r = -.769, p = .015$). Furthermore, we found a positive relationship between cortisol levels and positive engagement at 10% below intensity measured at 30 min post exercise in the CV < 25% ($r = .533, p = .028$) and the CV < 20% ($r = .585, p = .017$) datasets.

**Self-efficacy**

We performed a 3 (Exercise intensities: self-selected, 10% above, and 10% below relative self-selected intensity) x 3 (Time: the first 30 seconds of exercise session, the midpoint of exercise session, and 10 min post exercise) repeated measures ANOVA on self-efficacy scores. Descriptive analysis of self-efficacy is summarized in Table 4.7.
<table>
<thead>
<tr>
<th></th>
<th>Self-selected</th>
<th>10% above</th>
<th>10% below</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M \pm SD$</td>
<td>$M \pm SD$</td>
<td>$M \pm SD$</td>
</tr>
<tr>
<td>First 30 sec</td>
<td>85.26 ± 18.37</td>
<td>81.05 ± 21.58</td>
<td>90.00 ± 22.85</td>
</tr>
<tr>
<td>Midpoint</td>
<td>91.05 ± 12.43</td>
<td>86.84 ± 16.00</td>
<td>93.16 ± 17.01</td>
</tr>
<tr>
<td>10 min post</td>
<td>98.95 ± 3.150</td>
<td>95.26 ± 9.640</td>
<td>97.89 ± 5.350</td>
</tr>
</tbody>
</table>

Table 4.7 Means ($M$) and standard deviations ($SD$) of self-efficacy the first 30 seconds of exercise, midpoint of exercise, and 10 min post exercise for self-selected, 10% above, and 10% below intensity conditions.

Note. First 30 sec = the first 30 seconds of exercise, Midpoint = the midpoint of exercise.

In addition, descriptive statistic for self-efficacy is presented graphically in Figure 4.13.
Figure 4.13 Self-efficacy at the first 30’s of exercise, the midpoint of exercise, and 10 min post exercise at self-selected, 10% above, and 10% below intensity conditions.


Analysis of self-efficacy showed a significant main effect for time, $F(1.048, 18.865) = 9.833, p < .001$, $\eta^2 = .353$. However, the main effect for exercise condition $F(1.488, 26.781) = 3.429, p = .060$, and exercise condition and time interaction, $F(2.083, 37.500) = 1.608, p = .213$, were not significant. Post hoc analysis revealed that self-efficacy increased significantly from the first 30 seconds of exercise to the midpoint of
exercise and 10 min post exercise. Likewise, self-efficacy increased from the midpoint of exercise to 10 min post exercise.

Next, we performed simple comparisons to examine whether self-efficacy at self-selected intensity was significantly higher than during exercise of imposed intensities (hypothesis 7). The results demonstrated that there were no significant differences in self-efficacy between self-selected intensity and both 10% above and 10% below intensity, $F(1, 18) = 2.320, p = .145$ and $F(1, 18) = .721, p = .407$, respectively.

**Correlation analysis.**

We performed bivariate correlation analyses to examine the association between self-efficacy and cortisol (hypothesis 8).

Self-efficacy during exercise (the midpoint of exercise) and cortisol levels at 10 and 30 min post exercise were examined at each exercise intensity condition. There were no significant inverse associations found at any exercise intensity condition; self-efficacy experienced during exercise was not related to cortisol levels post exercise.

**Simple linear regression analysis.**

A series of simple regression analyses was conducted to investigate whether higher self-efficacy during exercise would predict more positive affective responses during the self-selected and the 10% below intensity exercise than the 10% above intensity exercise (hypothesis 9). The dependent variables were affective responses
measured at the midpoint of exercise and 5 min before the end of exercise; the predictor was self-efficacy at the midpoint of exercise.

At the self-selected intensity, self-efficacy measured at the midpoint of exercise significantly predicted more positive responses of Pleasure, $b = .041$, $\beta = .518$, $F(1, 17) = 6.220$, $p = .023$, $R^2 = .268$, Dominance, $b = .057$, $\beta = .564$, $F(1, 17) = 7.944$, $p = .012$, $R^2 = .318$, Positive engagement, $b = .123$, $\beta = .662$, $F(1, 17) = 13.250$, $p = .002$, $R^2 = .438$, and Revitalization, $b = .120$, $\beta = .568$, $F(1, 17) = 8.105$, $p = .011$, $R^2 = .323$ at the midpoint of exercise.

At the 10% below intensity, self-efficacy measured at the midpoint of exercise significantly predicted lower physical exhaustion, $b = -.100$, $\beta = -.551$, $F(1, 17) = 7.405$, $p = .015$, $R^2 = .303$ during the midpoint of exercise. No significant results were found at 10% above intensity.

Next, we tested self-efficacy at the midpoint exercise as a predictor with affective responses 5 min before the end of exercise as dependent variables. We found self-efficacy was a significant predictor of only dominance and positive engagement at the self-selected intensity exercise, with $b = .062$, $\beta = .576$, $F(1, 17) = 8.438$, $p = .010$, $R^2 = .332$ and $b = .088$, $\beta = .574$, $F(1, 17) = 8.356$, $p = .010$, $R^2 = .330$, respectively.

At the 10% below intensity exercise condition, self-efficacy was a significant predictor of lower physical exhaustion, $b = -.086$, $\beta = -.516$, $F(1, 17) = 6.179$, $p = .024$, $R^2 = .267$ at 5 min before exercise ended. No significant results emerged at the 10% above intensity condition 5 min before exercise ended, as well.
These results show that participants who reported higher self-efficacy during exercise also reported more favorable affective states at the self-selected intensity and at 10% below intensity. Although the mean self-efficacy score was higher during 10% below preferred intensity exercise ($M = 93.16$) than during self-selected intensity exercise ($M = 91.05$), this difference was not statistically significant. The 10% above intensity exercise had the lowest self-efficacy and self-efficacy at this intensity did not predict any affective states.

**Future Intentions of Exercise**

Future intentions of exercise were assessed at 10 and 30 min post exercise at each exercise intensity condition to determine whether affect and self-efficacy were predictors of motivational correlates of future exercise participation.

First, we conducted descriptive analysis on future intentions and summarized the results in Table 4.8.

<table>
<thead>
<tr>
<th>Intentions</th>
<th>Self-selected $M \pm SD$</th>
<th>10% above $M \pm SD$</th>
<th>10% below $M \pm SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 min post</td>
<td>91.32 ± 13.324</td>
<td>87.11 ± 16.357</td>
<td>90.00 ± 17.873</td>
</tr>
<tr>
<td>30 min post</td>
<td>93.95 ± 8.753</td>
<td>87.63 ± 16.275</td>
<td>88.68 ± 21.975</td>
</tr>
</tbody>
</table>

Table 4.8 Means ($M$) and standard deviations ($SD$) of intentions of exercise 10 and 30 min post exercise at self-selected, 10% above, and 10% below intensity conditions.

In addition, descriptive analysis for future intentions is graphically presented in Figure 4.14.
Next, we conducted a series of correlation analyses to examine the association between intentions and affective responses, and between intentions and self-efficacy under each exercise condition.

We found Tranquility and Physical exhaustion were not predictors at any measurement time point for any exercise intensity condition.
At self-selected intensity, we found that four affective variables, including Pleasure (5 min before the exercise end), Arousal (pre exercise, 5 min before the end of exercise, the end of exercise, & 10 min post exercise), Dominance (5 min before the end of exercise & 10 min post exercise), and Revitalization (5 min before the end of exercise) were significantly associated with intentions at both 10 and 30 min post exercise.

At 10% above intensity, we found that two variables, Revitalization pre exercise and Self-efficacy at 10 min post were significantly related to intentions at both 10 and 30 min post exercise.

At the 10% below intensity, Arousal (5 min before the end of exercise), Positive engagement (5 min before the end of exercise, the end of exercise & 10 min post exercise), and Revitalization (10 min post exercise) were significantly associated with intentions at 10 min post exercise. Also, Arousal (the midpoint of exercise & 5 min before the end of exercise), Positive engagement (5 min before the end of exercise, the end of exercise, 10 and 30 min post exercise), and Revitalization (the end of exercise, 10 and 30 min post exercise) were significantly associated with intentions at 30 min post exercise.

We ran a series of multiple regressions in each exercise intensity condition by adding all significant variables into the model. Dependent variables were intentions at both 10 and 30 min post exercise. Then, we reviewed a value of tolerance in each predictor included in the model and detected multicollinearity in some affective variables. It was expected because we added some of the same variables that were assessed at
different time points. Therefore, we selected the strongest predictor of each variable to trim the model and ran multiple regressions again.

Table 4.9 presents the summary of the regression model that predicts intentions at 10 min post exercise at the self-selected intensity exercise condition.

<table>
<thead>
<tr>
<th>Predictors</th>
<th>B</th>
<th>SD</th>
<th>Beta</th>
<th>T</th>
<th>P</th>
<th>R²</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>65.339</td>
<td>16.219</td>
<td></td>
<td>4.029</td>
<td>.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pleasure</td>
<td>2.533</td>
<td>2.486</td>
<td>.191</td>
<td>1.019</td>
<td>.325</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arousal Time 3</td>
<td>-5.063</td>
<td>1.541</td>
<td>-.497</td>
<td>-3.285</td>
<td>.005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arousal Time 1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominance Time 3</td>
<td>2.751</td>
<td>2.146</td>
<td>.273</td>
<td>1.282</td>
<td>.221</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revitalization Time 2</td>
<td>1.705</td>
<td>1.115</td>
<td>.331</td>
<td>1.529</td>
<td>.149</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.002</td>
<td>.691</td>
<td>7.828</td>
</tr>
</tbody>
</table>

Table 4.9 Multiple regression analysis predicting future intentions of exercise at 10 min post exercise at self-selected intensity from affective states

*Note.* Pleasure Time 3 = pleasure at 5 min before the exercise end; Arousal Time 1 = arousal pre exercise; Dominance Time 3 = dominance at 5 min before the end of exercise; Revitalization Time 2 = revitalization at the midpoint of exercise.

Pleasure at 5 min before the end of exercise, arousal pre exercise, dominance at 5 min before the end of exercise, and revitalization at the midpoint of exercise emerged as predictors of intentions at 10 min post exercise. This model explains 69.1% of the total variability in intentions at 10 min post exercise.

Table 4.10 presents the summary of the regression model that predicts intentions at 30 min post exercise at the self-selected intensity exercise condition.
Table 4.10 Multiple regression analysis predicting future intentions of exercise at 30 min post exercise at self-selected intensity from affective states

<table>
<thead>
<tr>
<th>Predictors</th>
<th>B</th>
<th>SD</th>
<th>Beta</th>
<th>T</th>
<th>P</th>
<th>R²</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>77.254</td>
<td>11.675</td>
<td></td>
<td>6.617</td>
<td>.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pleasure Time 3</td>
<td>2.301</td>
<td>1.789</td>
<td>.267</td>
<td>1.286</td>
<td>.219</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arousal Time 1</td>
<td>-3.350</td>
<td>1.110</td>
<td>-.508</td>
<td>-3.02</td>
<td>.009</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominance Time 3</td>
<td>1.752</td>
<td>1.545</td>
<td>.269</td>
<td>1.134</td>
<td>.276</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revitalization Time 2</td>
<td>.577</td>
<td>.803</td>
<td>.173</td>
<td>.719</td>
<td>.484</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td></td>
<td></td>
<td></td>
<td>.006</td>
<td>.618</td>
<td>5.656</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.10 Multiple regression analysis predicting future intentions of exercise at 30 min post exercise at self-selected intensity from affective states

*Note*. Pleasure Time 3 = pleasure at 5 min before the end of exercise; Arousal Time 1 = arousal pre exercise; Dominance Time 3 = dominance at 5 min before the end of exercise; Revitalization Time 2 = revitalization at the midpoint of exercise.

The same predictors (Pleasure at 5 min before the end of exercise, arousal pre exercise, dominance at 5 min before the end of exercise, and revitalization at the midpoint of exercise) were included to this model. The total variability of 61.8% was smaller than that of the variability of intentions at 10 min post exercise (69.1%).

Table 4.11 presents the summary of the regression model that predicts intentions at 10 min post exercise at the 10% above intensity exercise condition.
Table 4.11 Multiple regression analysis predicting future intentions of exercise at 10 min post exercise at 10% above intensity from affective states and self-efficacy

Note. Revitalization Time 1 = revitalization pre exercise; Self-efficacy Time 5 = self-efficacy at 10 min post exercise.

Revitalization pre exercise and self-efficacy at 10 min post exercise were included as predictors to this model. Likewise, these predictors were also included in the model to predict intentions at 30 min post exercise (Table 4.12). The total variability was higher for intentions at 30 min post exercise (63.1%) than for intentions at 10 min post exercise (57.4%). These models indicate that the combination of less revitalization before exercise and higher self-efficacy at 10 min after exercise predicts intentions.

Table 4.12 Multiple regression analysis predicting future intentions of exercise at 30 min post exercise at 10% above intensity from affective states and self-efficacy

Note. Revitalization Time 1 = revitalization pre exercise; Self-efficacy Time 5 = self-efficacy at 10 min post exercise.
Finally, Table 4.13 presents the summary of the regression model that predicts intentions at 10 min post exercise at the 10% below intensity exercise condition.

<table>
<thead>
<tr>
<th>Predictors</th>
<th>B</th>
<th>SD</th>
<th>Beta</th>
<th>t</th>
<th>p</th>
<th>R²</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>38.135</td>
<td>17.88</td>
<td>.2133</td>
<td>2.133</td>
<td>.049</td>
<td>.021</td>
<td>.383</td>
</tr>
<tr>
<td>Positive eng.</td>
<td>3.497</td>
<td>1.82</td>
<td>.427</td>
<td>1.922</td>
<td>.073</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arousal</td>
<td>4.099</td>
<td>3.131</td>
<td>.291</td>
<td>1.309</td>
<td>.209</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.021</td>
<td>.383</td>
</tr>
</tbody>
</table>

Table 4.13 Multiple regression analysis predicting future intentions of exercise at 10 min post exercise at 10% below intensity from affective states.

*Note.* Positive eng. Time 3 = positive engagement at 5 min before the end of exercise; Arousal Time 3 = arousal at 5 min before the end of exercise.

Initially, positive engagement at 5 min before the end of exercise, arousal at 5 min before the end of exercise, and revitalization at 10 min post exercise were included into the model. However, the model was not significant, therefore, the least strong predictor, which was revitalization at 10 min post exercise was removed from the model. The final model included positive engagement at 5 min before the end of exercise and arousal at 5 min before the end of exercise.

Table 4.14 presents the summary of the regression model that predicts intentions at 30 min post exercise at the 10% below intensity exercise condition.
Table 4.14 Multiple regression analysis predicting future intentions of exercise at 30 min post exercise at 10% below intensity from affective states

<table>
<thead>
<tr>
<th>Predictors</th>
<th>B</th>
<th>SD</th>
<th>Beta</th>
<th>t</th>
<th>P</th>
<th>R²</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>39.269</td>
<td>16.697</td>
<td></td>
<td>2.352</td>
<td>.032</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive eng. Time 3</td>
<td>4.658</td>
<td>2.34</td>
<td>.463</td>
<td>1.991</td>
<td>.064</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revitalization Time 4</td>
<td>1.705</td>
<td>1.79</td>
<td>.221</td>
<td>.953</td>
<td>.355</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td></td>
<td></td>
<td></td>
<td>.025</td>
<td>.369</td>
<td>4.685</td>
<td></td>
</tr>
</tbody>
</table>

Note. Positive eng. Time 3 = positive engagement at 5 min before the end of exercise; Revitalization Time 4 = revitalization at the end of exercise.

Similar to intentions at 10 min post exercise, initially three variables, which are positive engagement at 5 min before the end of exercise, revitalization at the end of exercise, and arousal at the midpoint of exercise were included in the model. However, the model was not significant. We removed arousal at the midpoint of exercise from the model because it was the weakest predictor. The final model includes positive engagement at 5 min before the end of exercise and revitalization at the end of exercise. These predictors of intentions at 30 min post exercise were different from the predictors of intentions at 10 min post exercise for the 10% below intensity condition.
Chapter 5: Discussion

Stress is a risk factor linked to illness, including mental disorders such as depression and anxiety. Research has shown that women experience higher levels of stress than men (e.g., Pierceall & Keim, 2007). Notably, depression is 50% greater for women than for men; women also have a higher burden from anxiety disorders (Lopez et al., 2006).

Regular exercise is beneficial for managing stress and stress-related emotions. However, physical inactivity and low adherence to regular exercise are public health concerns, especially for women, and have spurred research to determine psychosocial and environmental factors that promote physical activity behavior. It has been hypothesized that the quality of acute bouts of exercise may influence an individual’s psychological responses to exercise. Accordingly, positive psychological states may be associated with future exercise behavior. Accumulating evidence suggests that acute bouts of exercise are associated with improvements in affective responses following exercise. Specifically, low to moderate intensity exercise is consistently related to positive affect, while high intensity exercise is often associated with negative affect during exercise, mostly among inactive individuals. Therefore, investigations of what intensity should be prescribed to generate positive affect are very important. Promoting self-selected intensity exercise has received considerable attention as a potential way to facilitate more favorable
psychological responses during and post exercise. However, research examining the psychological benefits of self-selected acute exercise is limited. In addition, mechanisms underlying generation of positive and negative affect during and after acute exercise have not been fully examined.

The primary purpose of this study was to examine psychological responses to self-selected and imposed intensity acute exercise in inactive women with high levels of stress. As we expected, treadmill walking exercise at self-selected, 10% above and 10% below intensity brought about positive affective responses. The total workload of 150 kcal was held constant for each exercise intensity condition, and was adequate for eliciting positive affective responses in low active women with high levels of stress. The main effect for time was significant for all outcome variables; pleasure, dominance, positive engagement, revitalization, and tranquility improved significantly over time regardless of exercise intensity condition, while physical exhaustion decreased significantly. These results are consistent with previous studies, which reported improvements in affective states after exercise. Furthermore, post hoc analyses revealed that improvements in affective responses were observed during exercise as well as post exercise, indicating that the participants had favorable experiences throughout the bouts of exercise. Inter-individual variability was small as evaluated by standard deviation of each variable. These results support the 1st hypothesis, that acute bouts of exercise improve affect, irrespective of exercise intensity.

The 2nd hypothesis proposed that self-selected intensity exercise would generate more positive affect than imposed intensity exercise. We found a significant main effect
for exercise intensity condition for positive engagement. Positive engagement was significantly higher at self-selected intensity than 10% above intensity. There were no hypothesized differences among intensity conditions for the other outcome variables. The literature shows some differences in affective responses as a function of intensity, and the lack of effects in this study may be related to mostly moderate intensities in our three conditions. The mean intensity of the self-selected exercise was 57.7% VO$_2$peak, which is within the range of intensity defined as moderate (40% to 64% VO$_2$R, or 3.0 to 5.9 METS) by ACSM (2008). The 10% above intensity exercise condition mean intensity was 67.7% VO$_2$peak. Other researchers have recommended examining intensity in respect to ventilatory threshold (VT) for a more accurate measure of physiological strain (Ekkekakis et al., 2004). However, most of our participants exercised at a lower intensity than their VT during all exercise intensity conditions, including the 10% above self-selected condition.

Further, we examined whether self-selected intensity exercise elicited higher affective valence (pleasure) during and following exercise than imposed intensity exercise. Pleasure scores were consistently higher for the self-selected intensity exercise compared to the 10% above intensity exercise in the all measurement time points. However, statistical significance was found only at 10 min post exercise.

We also investigated other affective states, including positive engagement and revitalization. Positive engagement was statistically higher during exercise at self-selected intensity than at both imposed exercise intensity conditions. When we looked at a particular time point during exercise, significant differences were found between self-
selected intensity and both imposed intensity conditions at the midpoint of exercise as well as between self-selected intensity and 10% below intensity at 5 min before the end of exercise. In fact, positive engagement was consistently highest post exercise at the self-selected intensity, but this was not statistically significant. Likewise, revitalization was also consistently highest at self-selected intensity during and post exercise. We found significant differences between self-selected and both imposed intensities at the midpoint of exercise and 5 min before the end of exercise. No statistical differences were found post exercise.

Our findings provide some evidences that the self-selected intensity exercise generated more favorable affective responses than the imposed intensities exercise during and post exercise. This is in line with other studies that reported that positive affect was generated in self-selected intensity conditions (Parfitt et al., 2006; Rose & Parfitt, 2007). These studies imposed higher intensity exercise that exceeded lactate threshold (LT) to compare with the self-selected intensity exercise. Their results showed a significant difference between the self-selected conditions and the above LT condition, in which the self-selected condition had more positive affective responses, whereas the above LT condition had negative affective responses.

Two possible explanations exist for why we found significant differences in affect at only a few time points. First, the 10% above intensity exercise in our study might not have been a high intensity (i.e., it was lower than the participant’s VT) for our participants and elicited more positive affect rather than less positive affect. Parfitt et al. (2006) and Rose and Parfitt (2007) reported that affect was positive and stable at both
self-selected and below lactate intensity conditions, supporting acute bouts of exercise under VT or LT intensity can result in improved affective states.

Another explanation is that, unlike most other studies on self-selected intensity, we did not allow the participants to change exercise intensity during the exercise bout. Once the participants chose their exercise intensity, they remained at that same intensity throughout the session. A constant intensity was necessary for our protocol because the intensity the participants selected was used to determine exercise duration necessary to expend 150 kcal in each intensity condition. Cognitive appraisal, such as the perception of control during an exercise bout has been shown to influence positive affect in low active women (Rose & Parfitt, 2010). Not being allowed to change exercise intensity throughout the exercise bout even when the condition was labeled self-selected might have influenced their perception of control during the exercise. Another possible explanation is that energy expenditure contributes to affective responses, and to our knowledge, ours is the first study to equate calorie expenditures (150 kcal) when examining psychological differences between self-selected intensity exercise and imposed intensities exercise. Equal energy expenditure might have been a factor contributing to similar changes in the generation of most affective responses in all exercise intensity conditions.

Our results provide partial support for the 2nd hypothesis that self-selected intensity exercise generates more positive affect than imposed intensity exercise. However, there is a need for additional research to investigate whether self-selected
intensity exercise is more beneficial for improving psychological states than imposed or prescribed exercise intensities.

The 3rd hypothesis proposed that dominance would be higher during self-selected intensity than during imposed exercise intensity. We found no significant differences among all exercise intensity conditions. Although dominance was highest during exercise at self-selected intensity, differences did not reach statistical significance. Dominance was statistically improved overtime in all exercise intensity conditions. The results suggest that participants felt they were controlling the situation during exercise; moreover the sense of dominance increased during the exercise session. Therefore, these results did not support the 3rd hypothesis.

The 4th hypothesis proposed that arousal would be highest at 10% above intensity. We found no significant differences among intensity conditions. Even more, the descriptive statistics showed that arousal was highest at self-selected intensity at the midpoint of exercise, 5 min before exercise ended, and at the end of exercise. This lack of significant difference may be due to the fact that all exercise intensity conditions did not exceed VT. Another possibility is an influence on responses because of our protocol of exercise sessions. In order to determine exercise intensity for imposed conditions, the self-selected intensity exercise had to be performed first. The participants completed the VO_{2peak} test in the 1st visit and the self-selected intensity bout in the 2nd visit, which might have contributed to a sense of mastery for treadmill walking exercise. Concurrently, the physical sensation from the exercise stimulus may not have been perceived as new and strong in the second or third session as in the first exercise session.
The secondary purpose of this study was to examine potential psychobiological mechanisms for affective responses to acute exercise, specifically Hypothalamus-Pituitary-Adrenal (HPA) axis response (salivary cortisol) and self-efficacy associated with changes in psychological states.

First, the results of the cortisol analysis should be interpreted cautiously due to missing values. Great inter-individual variability was found in our data, as found in many other studies (e.g., Stone et al., 2001). Given that fact, we did not find significant differences in salivary cortisol responses to exercise at self-selected, 10% above, and 10% below intensities. Furthermore, there were no significant changes in cortisol levels from pre test to during and post exercise assessments at any exercise intensities. However, we found significant increases in cortisol levels from baseline to post exercise assessments in the 10% above intensity condition. In addition, changes in cortisol levels from baseline to 30 min post exercise were significantly larger in the 10% above condition than the 10% below intensity condition. These findings may add some explanations of the HPA axis activity in response to exercise, especially when exercise intensity is prescribed higher than self-selected.

Several other studies reported no significant elevation of cortisol concentration after exercise at low to moderate intensities. These studies used a different mode and intensity of exercise, such as submaximal cycle exercise up to 85% HR\textsubscript{max} (Ben-Aryeh et al., 1989), 30 min of walking exercise (Bonen, 1976), 40 min of cycling at 75% HR\textsubscript{max} (Consitt, Copeland, & Tremblay, 2001), 1 h cycle ergometer bout at 62.3% VO\textsubscript{2max} (Jacks et al., 2002), and 20 min of treadmill exercise at 50% VO\textsubscript{2max} (Luger, 1987). On the other
hand, studies that examined exercise at intensities of 70% VO$_{2\text{max}}$ and higher have consistently showed elevation of cortisol concentrations (e.g., Lac et al., 1997).

Exercise duration has been shown to be a contributing factor for elevation of cortisol concentrations. Recent research has shown that a longer duration of exercise also elevates cortisol levels even when exercise intensity is not high. Brownlee and Hackney (2007) showed a significant increase in cortisol levels after 75 min of treadmill exercise at the intensity around VT until the point of volitional fatigue. Similarly, a 2 h cycling trial at 55% VO$_{2\text{peak}}$ elicited cortisol increases (Li & Cheng, 2007). However, neither of these studies reported cortisol responses during exercise, so the point of the onset of increase in cortisol levels is unknown. Jacks and colleagues (2002) examined cortisol responses to 1 h cycle ergometer and showed that exercise less than 40 min in duration did not elicit significant differences at 76% VO$_{2\text{max}}$ or at either 44.5 or 62.3% VO$_{2\text{peak}}$. In our study, even the longest mean exercise duration was approximately 34 min at the 10% below intensity condition.

Davies and Few (1973) proposed that 30 min of exercise at 60% VO$_{2\text{max}}$ is a critical level for eliciting cortisol responses, and there are studies that supported this contention (Hill et al., 2008; Rudolph and McAuley, 1998). However, findings from other studies (e.g., Jacks et al., 2002) indicate that 30 min of exercise at 60% VO$_{2\text{max}}$ is not enough to elicit cortisol responses.

In our study, even at the 10% above intensity exercise, the mean intensity was 67.7% VO$_{2\text{peak}}$ and the exercise duration was 23.4 min. Having reviewed previous research, we concluded that the HPA axis might not have activated or activated at too low
a level to stimulate cortisol secretion during exercise in our study. The role of increased cortisol levels is to prepare the body to meet physical challenges and to maintain homeostasis. Acute bouts of exercise at intensities lower than VT might not have been physical challenges, and thus it was not necessary to support steady-state adaptations to exercise stress. A study that used mental effort instead of exercise stimulation (Peters et al., 1998) reported that cortisol levels were significantly elevated during uncontrollable conditions. The participants in our study showed that higher levels of dominance and self-efficacy during exercise at all exercise intensities, thus they kept higher perceptions of control and might have suppressed the activation of the HPA axis.

We hypothesized that higher cortisol levels would be associated with less positive affective responses during the imposed exercise (5th hypothesis). We did not find any meaningful associations between any affective variable and cortisol levels during exercise. Affective states shift from positive to negative at the point of the metabolic shift from aerobic to anaerobic (Ekkekakis et al., 2004). In our study, most participants exercised at a lower intensity than their VT during the two imposed intensity exercise sessions, and did not have a decline in affect. Unexpectedly, we found a positive relationship between pleasure, arousal, positive engagement, and revitalization and cortisol levels during exercise at 10% below intensity. We cannot draw any speculations or conclusions from these findings, although the lower intensity might have been perceived as a positive stress with a corresponding activation of the HPA axis.

Some studies have reported more prominent increases in cortisol levels during recovery from exercise, (e.g., Kirschbaum et al., 1996), and it was common to not
observe significant increases in cortisol concentrations during exercise. We hypothesized that there would be an inverse relationship between cortisol levels and affective responses after exercise (6th hypothesis). Specifically, we were interested in the association between positive affect and lower cortisol concentrations. Rudolph and McAuley (1998) reported an association between increased positive affect and lower levels of cortisol after 30 min of exercise at 60% VO$_{2max}$. In our study, we did not find any meaningful relationships at any exercise intensity conditions. This may be due to the amount of missing values in our data and the lack of substantial HPA axis activation. However, to our knowledge, few exercise studies have examined a relationship between positive affect and lower levels of cortisol. It may be too early to draw any conclusions. Further investigation of this relationship is necessary.

Rudolph and McAuley (1998) reported that negative affect during exercise was associated with higher levels of cortisol after exercise. Looking at the descriptive statistics, cortisol levels were slightly higher post exercise compared to the levels during exercise, which led us to examine the relationship between affect during exercise and cortisol levels after exercise in the 10% above intensity exercise condition. Interestingly, we found an inverse relationship between pleasure at the midpoint of exercise and cortisol levels at 10 min post exercise. This result suggests that the less they reported pleasure during the exercise bout, the higher the physiological stress even 30 minutes after exercise. Scores for physical exhaustion during and at the end of exercise were positively associated with cortisol levels at 30 min post exercise, which would be
expected. These finding may add some support for the role of the HPA axis in affective responses to exercise at different intensities.

We investigated the relationship between self-efficacy and psychological and physiological responses to exercise and found no statistically significant effects. Findings indicate the participants maintained their perceptions of efficacy during and after exercise at the self-selected and the imposed intensities exercise. Increases in self-efficacy during exercise were similar to the patterns found for dominance, that is, self-efficacy improved overtime in all exercise intensity conditions. The 7th hypothesis was not supported.

Our 8th hypothesis that self-efficacy during exercise and cortisol levels at post exercise would be inversely related was not supported. There is little evidence to compare our finding with. Pre exercise self-efficacy has been used in previous studies to compare with other variables. For example, Rudolph and McAuley (1995) reported pre exercise efficacy did not predict significant variance in post exercise cortisol. We measured self-efficacy two times during exercise; the first time was during the first 30 seconds of exercise and the second one was at the midpoint of exercise. We did not find any existing research that measured self-efficacy during exercise and compared it to the cortisol levels at post exercise. We cannot draw any conclusions on the relationship between self-efficacy and cortisol levels at this point.

Further, we examined self-efficacy as a contributing mechanism associated with changes in affective responses to exercise. As hypothesized, self-efficacy during exercise significantly predicted affective states during exercise at self-selected intensity (the 9th hypothesis). We also found that self-efficacy was a predictor of lower physical
exhaustion at 10% below intensity. Our results support the notion that efficacy expectation antedates affect (Bandura, 1997). Welch et al. (2010) tested low active women and reported that self-efficacy during 30 min of cycle ergometer at 90% VT predicted affective responses during exercise. Noteworthy, the 10% above exercise condition (23 min duration of exercise at 92.7% VT) in our study was relatively similar to the exercise condition in Welch’s (2010) study. Contrary to their results, we did not find any significant relationship between self-efficacy and affect during exercise at 10% above intensity.

Furthermore, Welch et al. (2010) reported that the relationship between self-efficacy and affect was stronger toward the end of exercise bout. In our study, variances accounted for by self-efficacy were similar (around 30%) in both measurement time points, that is the midpoint of exercise and 5 min before the end of exercise. Interestingly, in our study, self-efficacy predicted more variables, such as pleasure, dominance, positive engagement and revitalization at the midpoint of exercise in the self-selected intensity condition. Only dominance and positive engagement were predicted by self-efficacy at 5 min before the end of exercise. The relationship between self-efficacy and affect was more prominent at the midpoint of exercise in our study. Our findings suggest that self-efficacy is a strong predictor of affective states, specifically at self-selected intensity. Self-efficacy during exercise may be one of factors that influence positive affective responses to exercise.

Finally, intentions to future exercise participation were assessed post exercise. We were specifically interested in the association between affective responses and self-
efficacy during and post exercise and intentions. Kwan and Bryan (2010) proposed that a positive affective response to exercise strengthens the relationship between intentions and behavior. First, our results demonstrated that tranquility and physical exhaustion were not associated with intentions at any exercise intensity condition. Other studies that used different exercise modes, durations, and intensities reported a significant relationship between tranquility and physical exhaustion and intentions. A study by Raedeke et al. (2007) reported that intention had a positive association with tranquility and a negative association with physical exhaustion after group-fitness exercise. Focht (2009) showed that physical exhaustion was inversely related to intention during 10 min walk in an outdoor setting.

We found positive and negative relationships between pleasure, arousal, dominance, revitalization, and positive engagement and intentions. Interestingly, we found that the variables that predicted intentions were different as a function of exercise intensity. At self-selected intensity, several affective variables, including pleasure at 5 min before the exercise end, arousal pre exercise, dominance at 5 min before the exercise end, and revitalization at the midpoint of exercise were included in the final model to predict both intentions at 10 and 30 min post exercise. The model indicates that more positive responses in pleasure, dominance and revitalization during exercise and negative response in arousal pre exercise explain more than 60% of the variability of intentions. Arousal during self-selected exercise was highest among 3 intensity conditions, although the differences did not reach significance. This may indicate that the participants experienced a larger magnitude of change in arousal during the beginning of exercise,
that is, between before and during exercise at self-selected intensity. Physical sensation from exercise at self-selected intensity may contribute to future exercise participation.

At 10% below intensity, fewer affective variables were included in the final model for both intentions at 10 and 30 min post exercise. Positive engagement at 5 min before the end of exercise is a common predictor of intentions at both 10 and 30 min post exercise. In addition, arousal at 5 min before the exercise end was included to predict intentions at 10 min post exercise, whereas revitalization at the end of exercise was included to predict intentions at 30 min post exercise. Raedeke et al. (2007) also reported stronger relationships between intentions and revitalization and positive engagement.

At 10% above intensity, self-efficacy at 10 min post exercise appeared to be a strong predictor of intentions at both 10 and 30 min post exercise. Similar findings were reported in Raedeke et al. (2009) after group exercise in women with high social physique anxiety. Likewise, Rhodes and Courneya (2003) used a structural model analysis and demonstrated that self-efficacy was an optimal predictor of intention. The perception of control may be important when people exercise at higher intensity than at their preferred intensity. Another interesting finding is that negative revitalization pre-exercise was also included in the final model for the prediction of both intentions at 10 and 30 min post exercise. This may indicate that the participants felt less revitalization before exercise may receive benefits from a higher intensity exercise that may contribute to future intentions.

Our findings support the notion that positive affective responses and self-efficacy are important predictors for intentions for future exercise. Specifically, more affective
variables were found to be strong predictors of intentions at the self-selected intensity condition. It may indicate that self-selected intensity exercise has a positive influence on future intentions.

There were limitations in this study. First, the results of this study may not generalize beyond younger, generally healthy women with high levels of stress. The participants might be more motivated to participate in a study involving exercise and might have expected positive effects of exercise on psychological states.

Missing data for cortisol values precluded our ability to provide meaningful information on cortisol responses to exercise.

Third, the order of the exercise sessions might have affected outcome variables. The first session was the self-selected intensity exercise. Then, we randomized the order of two imposed intensity exercise sessions. The experience with treadmill walking in the previous sessions before the imposed intensity conditions might have influenced their sense of mastery and other psychological variables.

Fourth, all exercise intensity conditions were lower than most of participants’ VT. Accordingly, exercise intensities may not have been challenging enough to have a significant effect on psychological and physiological responses to exercise.

In summary, acute bouts of exercise at around and lower intensity than VT may generate positive affective responses during and after exercise in young low active women with high levels of stress. The total workload of 150 kcal from exercise is effective for generating positive affect. Self-selected intensity may be effective for eliciting more favorable experiences during and following acute bouts of exercise, and
promote future intentions for exercise more than exercise intensities that are imposed by someone else.

We cannot draw conclusion from our results as to whether the HPA axis activity is a plausible mechanism for changes in affective responses to exercise. With respect to self-efficacy, the results of the present study provide partial support for the hypothesis that self-efficacy during exercise may be a potential mechanism underlying the generation of positive affective responses at self-selected intensity. There is need to reexamine the mechanisms of psychological responses to acute bouts of exercise at different intensities, specifically more physiological mechanisms, including the HPA axis.
References


Appendix A

Flyer
Volunteers Needed!

Stress and Exercise Study

Exercise is a good way to manage stress!

If you are:
- Female
- Aged between 18 and 45
- Not pregnant or nursing
- Not obese
- Non smoker
- Inactive*

You may be eligible to participate in a study on stress and exercise!

What participation involves:
Visit our lab 4 times (each visit will be at the same time of day)
Walk on a treadmill
Complete questionnaires & biomedical measures

Benefits for you:
- You will know your fitness level
- You will be given comfortable and manageable walking exercise prescription for psychological benefits and general health at the completion of the study

*(If you exercise, you exercise ≤ 2 times/ a week, for ≤ 20 min each time.)

If you are interested in participating in this study

Please contact:

Kyoko Wardwell at 937-243-5256, or wardwell.5@osu.edu
Dr. Janet Buckworth buckworth.1@osu.edu

Health & Exercise Science, School of PAES
The Ohio State University
Appendix B

Recruitment Script (Academic Class)
Hello everyone. My name is Kyoko Wardwell. I am a Ph.D. student in the Health and Exercise Science Program. I would like to recruit volunteers to participate in my study. The purpose of this study is to examine psychological and physiological responses to single sessions of walking exercise in women. For this study, I would like to recruit healthy women aged between 18 and 45 years old who are under more than usual levels of stress and are not exercising regularly. For example, to be in the study, you would be exercising less than 3 times a week and each activity session would last less than 30 minutes. In addition, we need our volunteers to be non-smokers, not pregnant or nursing, and not obese.

Exercise is often cited as effective stress management technique, and that’s why we want volunteers who are more stressed. If you participate in this study, you will walk on a treadmill in three different conditions, in addition to a session to estimate your aerobic capacity, for a total of four visits. Before, during, and after you walk, we will take a sample of your saliva to measure cortisol, which is a marker of stress, and give you questionnaires to measure psychological states. Each visit will take between 90 minutes and 120 minutes. If you participate in this study, you will know your capacity to do aerobic activities and we will give you a personalized exercise program designed for both mental and general physical health.

Your participation is completely voluntary. You can refuse to answer questions and withdraw your participation without penalty. Your personal information will be kept secure and confidential.

If you are interested or you know someone who may be interested in this study, please feel free to contact me for more information. My contact information is on the flyer I am handing out. I really appreciate it. Thank you for your time today.
Appendix C

E-mail Recruitment Script
Recruitment script (Email)  IRB Protocol Number: 2009H0085

We would like to invite you to participate in a study on the psychological and physiological responses of women to single sessions of walking. This study is being conducted by Kyoko Wardwell, PhD student, Health and Exercise Science for her dissertation research and Dr. Janet Buckworth, associate professor, Health and Exercise Science.

Exercise is often reported to be an effective stress management technique, and that’s why we want volunteers who are more stressed. For this study, we are recruiting healthy women between 18 and 45 years of age who are under more than usual levels of stress and are not exercising regularly. For example, to be in the study, you would be exercising less than 3 times a week and each activity session would last less than 20 minutes. In addition, we need our volunteers to be non smokers, not pregnant or nursing, not obese, and not diagnosed with depression and anxiety.

If you participate in this study, you will walk on a treadmill three different times. You will also complete exercise on a treadmill to estimate your aerobic capacity. There will be a total of four visits, each lasting between 90 minutes and 120 minutes. After you complete the study, we will give you a personalized exercise program designed for both mental and general physical health and information about your capacity to do aerobic activities.

Your participation is completely voluntary. You can refuse to answer questions and withdraw from the study at any time without penalty. Your personal information will be kept secure and confidential.

If you are interested or you know someone who may be interested in this study, please feel free to contact us for more information.

Thank you.

Kyoko Wardwell, MA Co-Investigator
Email: wardwell.5@osu.edu
Phone: 937-243-5256

Janet Buckworth, PhD, FACSM Principal Investigator
Email: j buckworth@ehe.osu.edu
Phone: 614-292-0757
Appendix D

E-mail Screening
E-mail Screening

IRB Protocol Number: 2009H0085

E-Mail 1:
Hello, this is Kyoko Wardwell. Thank you for your interest in this study. [Answer questions, if asked.] We are conducting research on the psychological and physiological responses of women to single sessions of walking. I would like to ask you a couple of questions to determine your general eligibility to participate in this study. We want to save you a trip to the lab if you don’t meet some of the criteria.

1. How old are you?
2. What is your height and weight?
3. Do you exercise regularly?
4. How many times do you exercise at moderate or higher intensity a week?
5. How long does each exercise session last?
6. Do you have a current diagnosis of depression or anxiety?
7. Please rate your stress level from 1 to 10 during the last month (or last 30 days). For example, 1 indicates no stress at all and 10 indicates the most stress you have ever experienced.

Thank you.

E-Mail 2a- 1: When general eligibility is satisfied.
Hello, thank you for providing your answers. You meet the general eligibility to participate in this study. I would like to schedule a time for you to come in for the complete screening session. Please let me know your schedule. Thank you.

E-Mail 2a- 2:
[Schedule time and day. Provide directions to lab.]
Thank you so much for contacting me. I will send you an email reminder of our first meeting a few days before you are scheduled to come in.

E-Mail 2b: When general eligibility is not satisfied.
Hello, thank you for providing your answers. Unfortunately, you are not eligible to participate.

[If under 18 or over 45 of age.]
You have to be between 18 and 45 to be in this study. Thank you for your interest.

[If BMI is ≥ 35.]
You don’t meet the study criteria for BMI, which is based on your height and weight. Thank you for your interest.
Appendix E

Telephone Screening
1. Hello, this is Kyoko Wardwell. I’m calling because you expressed interest in the study we are conducting on the psychological and physiological responses of women to single sessions of walking. Thank you for your interest in this study. I would like to ask you a couple of questions to determine your general eligibility to participate in this study. We want to save you a trip to the lab if you don’t meet some of the criteria. Do you have time to talk for a few minutes now?  
   [If no, arrange another time to call. If yes, continue.]
2. Before I start, do you have any questions?  
   [Answer questions, if asked.]
3. Let me ask you the first question. How old are you?  
   [If between 18 and 45 years of age, continue to #4. If under 18 or over 45:]  
   I’m sorry, but you have to be between 18 and 45 to be in this study. Thank you for your interest.
4. What is your height and weight?  
   [Check BMI using chart. If BMI is < 35, continue to #5. If BMI is ≥ 35:]  
   I’m sorry, but you don’t meet the study criteria for BMI, which is based on your height and weight. Thank you for your interest.
5. Do you exercise regularly?  
   [If no, skip to #7. If yes, continue.]
6. How many times do you exercise at moderate or higher intensity a week?  
   [If < 3 times per week, continue to #7. If ≥ 3 times:]  
   I’m sorry, but you have to be physically inactive to be in this study. Thank you for your interest.
7. How long does each exercise session last?  
   [If < 20 minutes, continue to #8. If ≥ 20 minutes:]  
   I’m sorry, but you have to be physically inactive to be in this study. Thank you for your interest.
8. Do you have a current diagnosis of depression or anxiety?  
   [If no, continue to #9. If yes:]  
   I’m sorry, but you don’t meet the eligibility criteria to be in this study. Thank you for your interest! This is the last question. I would like to know your stress level. Please rate your stress level from 1 to 10 during the last month (or last 30 days). For example, 1 indicates no stress at all and 10 indicates the most stress you have ever experienced.
   [If ≥ 7, continue to #10. If < 7:]  
   I’m sorry, but you don’t meet the eligibility criteria to be in this study. Thank you for your interest.
9. You meet the general eligibility to participate in this study. Can we schedule a time for you to come in for the complete screening session? [Schedule time and day. Provide directions to lab.]
10. Do you have any other questions?
Appendix F

Data Form for Telephone Screening
Data Form for Telephone Screening

IRB Protocol Number: 2009H0085

Name: ____________________________________________

Phone #: __________________________________________

Email: ____________________________________________

Age: _________ (Between 18 and 45 years old)

Height: _________    Weight: _________

BMI = weight (kg)/ height (meters)^2 = _________ (BMI ≤ 34.9)

Exercise status: _________ (yes or no)

Frequency: _________ (< 3 times a week)

Duration: _________ (< 20 minutes each session)

Stress level: _________ (> 7 out of 10)

Screening Session Date and Time: ____________________________

Date of Reminder Email: ____________________________
Appendix G

Health Information Form
Health Information Form

Today’s Date: ________________

1. Name: __________________________________________
   Last    First    Middle initial

2. Age: __________

3. Address: _________________________________________
   Phone: ___________________    E-mail: _____________________

4. How would you describe yourself?
   White – not Hispanic ☐    Black – not Hispanic ☐    Hispanic ☐
   Asian or Pacific Islander ☐    American Indian or Alaskan Native ☐
   Other ☐

5. Height: _______________    Weight: _______________
   (* height & weight will be measured by the investigator)

6. Do you work?    YES ☐    NO ☐
   If YES, part-time ☐    full-time ☐    Other ☐

7. Are you a student? If YES, what academic class?
   Freshman ☐    Sophomore ☐    Junior ☐    Senior ☐
   5th year and more ☐    Graduate ☐    Other ☐

8. Have you used the following tobacco products? Please CHECK all that apply.
   ☐ Cigarette    Age started ______    Age quit ______    No. per day ______
   ☐ Cigars/Pipes    Age started ______    Age quit ______    No. per day ______
   ☐ Snuff/dip/chew    Age started ______    Age quit ______    No. per day ______

9. Are you currently taking any prescribed medications? (Vitamins are NOT included.)
   YES ☐    NO ☐
   If YES, please list the medication(s) you are currently taking:
   ___________________________    How long have you been taking this medication? ______
   ___________________________    How long have you been taking this medication? ______
10. Are you currently receiving any treatment for your depressive symptoms or anxiety?
   YES □  NO □

11. Are you currently under medical care for reasons? YES □  NO □
    If YES, please explain:
    ________________________________________________________________
    ________________________________________________________________

12. Age when menstrual periods began: __________

13. Are your periods regular? YES □  NO □
    How often? _______

14. How long have your periods been regular?
    □ < 6 months □ > 6 months □ Never

15. When your last period started? __________

16. Are you currently pregnant? YES □  NO □

17. Are you currently nursing? YES □  NO □

18. Do you plan to be pregnant during the next 6 months? YES □  NO □

19. Are you using birth control? YES □  NO □
    If YES, which brand? _______________________

20. Have you ever exercised on a treadmill? YES □  NO □

Thank you!
Appendix H

Physical Activity Readiness Questionnaire (PAR-Q)
PAR-Q & YOU
(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly—check YES or NO.

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?</td>
<td></td>
</tr>
<tr>
<td>2. Do you feel pain in your chest when you do physical activity?</td>
<td></td>
</tr>
<tr>
<td>3. In the past month, have you had chest pain when you were not doing physical activity?</td>
<td></td>
</tr>
<tr>
<td>4. Do you lose your balance because of dizziness or do you ever lose consciousness?</td>
<td></td>
</tr>
<tr>
<td>5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?</td>
<td></td>
</tr>
<tr>
<td>6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?</td>
<td></td>
</tr>
<tr>
<td>7. Do you know of any other reason why you should not do physical activity?</td>
<td></td>
</tr>
</tbody>
</table>

If you answered YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want—so long as you start slowly and build up gradually. Or you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

If you answered NO to all questions, you can be reasonably sure that you can:

- start becoming much more physically active—begin slow and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal—this is an excellent way to determine your basic fitness so that you can plan the best way for you to live activity. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

Please note:
- If your health changes so that you then answer YES to any of the above questions, will your fitness or health professional.
- Ask whether you should change your physical activity plan.

Internet use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME:
SIGNATURE:
SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority):
DATE:
WITNESS:

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.
PAR-Q & YOU

Get Active Your Way, Every Day—For Life!

Physical activity improves health.
Every little bit counts, but more is even better...everyone can do it!

Get active your way—build physical activity into your daily life...
- at home
- at school
- at work
- at play
- on the way
...that's active living!

Benefits of regular activity:
- Increases your energy level
- Improves your mood
- Reduces stress

Health risks of inactivity:
- Increased risk of heart disease
- Increased risk of diabetes

You Can Do It—Getting started is easier than you think

Physical activity doesn’t have to be very hard. Build physical activities into your daily routine.

- Start with what you can—get off the too easy, use the stairs instead of the elevator. Reduce the amount of time you spend in front of the computer or TV. Cut down on the time you spend driving around. Instead, use walking or cycling as a means of transportation. Focus on physical activity with your kids. Choose to walk, walk, walk. Be active and move more.

For more information, please contact the:

Canadian Society for Exercise Physiology
202-155 Somerset Street West
Ottawa, ON K2P 02
Tel. 1-877-631-3755 • FAX (613) 234-7055
Online: www.csae.ca

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The following companion forms are available for doctors’ use by contacting the Canadian Society for Exercise Physiology (address below):

- The Physical Activity Readiness Medical Examination (PARmed-X) — to be used by doctors with patients who answer YES to one or more questions on the PAR-Q.
- The Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for Pregnancy) — to be used by doctors with pregnant patients who wish to become more active.

References:

The original PAR-Q was developed by the British Columbia Ministry of Health. It has been revised by an Expert Advisory Committee of the Canadian Society for Exercise Physiology chaired by Dr. N. Gushue (2002).

Disponible en français sous le titre “Questionnaire sur l’aptitude à l’activité physique - QAP (revet 2002).”
Appendix I

Godin Leisure-Time Exercise Questionnaire
Godin Leisure-Time Exercise Questionnaire

Considering a 7-day period (a week), how many times on the average do you do the following kinds of exercise for more than 15 minutes during your free time. Write on each line the appropriate number.

a) STRENUOUS EXERCISE (HEART BEAT RAPIDLY) _______________
   (For example, running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, roller skating or blading, vigorous swimming, vigorous long-distance biking)

b) MODERATE EXERCISE (NOT EXHAUSTING) _______________
   (For example, fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, downhill skiing, popular and folk dancing)

c) MILD EXERCISE (MINIMAL EFFORT) _______________
   (For example, yoga, archery, fishing from river bend, bowling, horseshoes, golf, snowmobiling, easy walking)

Considering a 7-day period (a week), during your leisure-time, how often do you engage in any regular activity long enough to work up a sweat (heartbeats rapidly)?

           OFTEN          SOMETIMES          NEVER/RARELY
           __________    ___________    ___________
Appendix J

Perceived Stress Scale
Perceived Stress Scale

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, please indicate how often you felt or thought a certain way by circling the corresponding number.

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>never</td>
<td>almost never</td>
<td>sometimes</td>
<td>fairly often</td>
<td>very often</td>
</tr>
</tbody>
</table>

1. In the last month, how often have you been upset because of something that happened unexpectedly? 0 1 2 3 4

2. In the last month, how often have you felt that you were unable to control the important things in your life? 0 1 2 3 4

3. In the last month, how often have you felt nervous and "stressed"? 0 1 2 3 4

4. In the last month, how often have you felt confident about your ability to handle your personal problems? 0 1 2 3 4

5. In the last month, how often have you felt that things were going your way? 0 1 2 3 4

6. In the last month, how often have you found that you could not cope with all the things that you had to do? 0 1 2 3 4

7. In the last month, how often have you been able to control irritations in your life? 0 1 2 3 4

8. In the last month, how often have you felt that you were on top of things? 0 1 2 3 4

9. In the last month, how often have you been angered because of things that were outside of your control? 0 1 2 3 4

10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them? 0 1 2 3 4
Appendix K

Baseline Measurements Sheet
Baseline Measurements

ID: ________________

Date & Time: ________________

Height: __________

Height (meter): __________ (1 inch = 2.54 cm, 100 cm = 1 meter)

Weight: __________

Weight (kg): __________ (1 Lb = 0.45 kg)

BMI: __________ kg/(meters)²

Waist: __________  Hip: __________

Waist/Hip ratio: __________

Resting BP: ______________

Menstrual cycle: _______ day

Food: ________________________________________________
Appendix L

VO₂peak Test Sheet
Exercise Testing (Peak Oxygen Consumption) Sheet
(Bruce Protocol)

ID: ________________  Height: __________  Weight: __________

Resting BP: __________  Waist/ Hip: __________  Ratio: __________

Date: __________  Time: __________

<table>
<thead>
<tr>
<th>Stage</th>
<th>Duration</th>
<th>Speed (mph)</th>
<th>Elevation (%)</th>
<th>Mets</th>
<th>Heart Rate</th>
<th>Blood pressure</th>
<th>RPE</th>
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<tbody>
<tr>
<td>1</td>
<td>3 (0-3)</td>
<td>1.7</td>
<td>10</td>
<td>4.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3 (3-6)</td>
<td>2.5</td>
<td>12</td>
<td>7.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3 (6-9)</td>
<td>3.4</td>
<td>14</td>
<td>10.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3 (9-12)</td>
<td>4.2</td>
<td>16</td>
<td>13.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3 (12-15)</td>
<td>5.0</td>
<td>18</td>
<td>17.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3 (15-18)</td>
<td>5.5</td>
<td>20</td>
<td>24.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3 (18-21)</td>
<td>6.0</td>
<td>22</td>
<td>28.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recovery</td>
<td>2</td>
<td>1.7</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Recovery</td>
<td>2</td>
<td>1.7</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recovery</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Seated</td>
</tr>
</tbody>
</table>

Total Exercise Time: __________
Maximum Heart Rate: __________
Appendix M

Ratings of Perceived Exertion
6 No exertion at all
7 Extremely light
8
9 Very light
10
11 Light
12
13 Somewhat hard
14
15
16 Hard (heavy)
17
18 Very hard
19
20 Extremely hard
21 Maximal exertion
Appendix N

Self-Assessment Manikin (SAM)
Appendix O

Exercise-Induced Feeling Inventory (EFI)
Exercise-Induced Feeling Inventory (EFI)

ID: ____________________
Date & Appointment time: ____________________
Assessment Time Point: ____________

Instructions: Using the scale in the box below, please circle the number that best describes how you feel right now, at the present moment.

<table>
<thead>
<tr>
<th>0 = Do No Feel</th>
<th>1 = Feel Slightly</th>
<th>2 = Feel Moderately</th>
<th>3 = Feel Strongly</th>
<th>4 = Feel Very Strongly</th>
</tr>
</thead>
</table>

1. Refreshed 0 1 2 3 4
2. Calm 0 1 2 3 4
3. Fatigued 0 1 2 3 4
4. Enthusiastic 0 1 2 3 4
5. Relaxed 0 1 2 3 4
6. Energetic 0 1 2 3 4
7. Happy 0 1 2 3 4
8. Tired 0 1 2 3 4
9. Revived 0 1 2 3 4
10. Peaceful 0 1 2 3 4
11. Worn-out 0 1 2 3 4
12. Upbeat 0 1 2 3 4
Appendix P

Self-Efficacy Scale
Self-Efficacy Scale

Using the scale listed below, please indicate how confident you are to complete the amount of treadmill walking without stopping. For example, in question #1, if you have confidence in completion of the walking exercise at a certain pace without stopping, you would choose 100%. On the other hand, if you have not confidence at all in completion of the walking exercise at a certain pace without stopping, you would choose 0%.

Please remember to answer honestly and accurately. There is no right or wrong answers.

<table>
<thead>
<tr>
<th></th>
<th>Not At All Confident</th>
<th>Moderately Confident</th>
<th>Completely Confident</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 sec-Exercise</td>
<td>0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle-Exercise</td>
<td>0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-min Post</td>
<td>0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix Q

Data Collection Sheet
ID: ________________

Date & Time: ________________

Number of visit / Exercise condition: ________________ / ________________

Menstrual cycle: ______ day

Food: ____________________________________________________________________

Resting BP: ________________

Treadmill speed: ____________  Grade: ____________

Exercise duration: ________________

   Middle time: ______  5min before time: ______

RPE scores

<table>
<thead>
<tr>
<th></th>
<th>5min</th>
<th>10min</th>
<th>15min</th>
<th>20min</th>
<th>25min</th>
<th>30min</th>
<th>35min</th>
<th>40min</th>
<th>45min</th>
<th>50min</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPE</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
</tr>
</tbody>
</table>

Future Intentions to exercise:

Please rate how likely you will intend to participate in the same exercise intensity & duration in the future on a scale from 0% to 100%.

10 min post: ______ %

30 min post: ______ %
Appendix R

Application for Initial Review of Human Subjects Research
INITIAL REVIEW OF HUMAN SUBJECTS RESEARCH
The Ohio State University Institutional Review Boards
Office of Responsible Research Practices (ORRP)
300 Research Foundation Building, 1960 Kenny Road, Columbus, OH 43210
Phone: (614) 688-8457  Fax: (614) 688-0366  www.orrp.osu.edu

<table>
<thead>
<tr>
<th>OSU PROTOCOL NUMBER</th>
<th>DATE RECEIVED</th>
<th>DATE VERIFIED COMPLETE</th>
</tr>
</thead>
</table>

1. PROJECT TITLE
Effects of self-selected and imposed intensity of acute exercises on the HPA-axis response and psychological well-being in inactive women with high levels of stress

2. INSTITUTIONAL REVIEW BOARD
Select the Board to review this research:
☐ Behavioral and Social Sciences
☒ Biomedical Sciences
☐ Cancer
Final Board assignment is determined by ORRP.

3. PRINCIPAL INVESTIGATOR (or Advisor) - see Qualifications for service as a PI
Name (Last, First, Md.): Buchworth, Janet
University Academic Title: Associate Professor
Degree(s): Ph.D.
Department Name (TIU): PAES
College (TIU): Education and Human Ecology
Department # (TIU): 1270
Campus Mailing Address: PAES Building A44
303 West 17th Avenue
Columbus, OH 43202
E-mail: buctworth1@osu.edu
Fax: (614) 688-3432
Phone: (614) 292-0757
Osu ID Number: 9607524

4. CO-INVESTIGATOR(S)
Are there any OSU Co-Investigators on this protocol?
☒ Yes → Complete Appendix A1
☐ No
Signatures of Co-Investigator(s) are required on Appendix A1.

5. KEY PERSONNEL
Are there any OSU key personnel on this protocol?
☒ Yes → Complete Appendix A1
☐ No
Key personnel are defined as individuals who participate in the design, conduct, or reporting of human subjects research. At a minimum, include individuals who recruit or consent participants or who collect study data.

6. EXTERNAL CO-INVESTIGATOR(S) & KEY PERSONNEL
Are any external (non-OSU) Investigators or key personnel engaged in the OSU research?
☐ Yes
☒ No → Go to Question #7
“Engaged” individuals are those who intervene or interact with participants in the context of the research or who will obtain individually identifiable private information for research, funded, supervised, or coordinated by OSU. See http://www.hhs.gov/ohrp/humansubjects/assurance/engag.htm or contact ORRP for more information.
If Yes → Who will provide approval for these external personnel?
☐ OSU IRB → Complete Appendix A2
☐ Non-OSU IRB → Provide a copy of the approval(s)
7. ADDITIONAL CONTACT(S) N/A

If further information about this application is needed, specify the contact person(s) if other than the PI (e.g., study or regulatory coordinator, research assistant, etc.).

Name (Last, First, MD): Wartwell, Kyoko, K. Phone: (614) 244-5250
E-mail: wartwell.5@osu.edu Fax: (614) 642-2523

Name (Last, First, MD): Phone: E-mail: Fax:

All OSU individuals listed on this protocol will have access to information about IRB actions and the completion status of each individual's administrative and training requirements (CTII, COI disclosure). Note: Personal financial information provided in COI disclosures is not included.

8. EDUCATION

Have all OSU investigators and key personnel completed the required web-based course (CTII) in the protection of human research subjects? Yes No

Educational requirements (initial and continuing) must be satisfied prior to submitting the application for IRB review. See http://orrrp.osu.edu/irb/training/ctii.cfm or contact ORRP for more information.

9. CONFLICT OF INTEREST

Does any OSU investigator (including principal or co-investigator), key personnel, or their immediate family members have a significant financial interest (e.g., speaking and consultation fees, travel expenses, proprietary interest in the tested product, stock ownership or other equity or membership in the sponsor over $10,000 per year or representing greater than 5% ownership in the sponsor) with the entity supporting the research or any company that may benefit from the research? Yes No

All OSU investigators and key personnel must have a current COI disclosure form filed before IRB review. See http://orrrp.osu.edu/coi/index.cfm for more information.

10. FUNDING OR OTHER SUPPORT

a. Is the research funded or has funding been requested? Yes No

   If Yes → Specify sponsor: _________________________________ and provide OSU RF project number.

b. Is there any support other than monetary (e.g., drugs, equipment, etc.) being provided for the study? Yes No

   If Yes → Specify: _________________________________

If the research is federally funded and involves a subcontract to or from another entity, an IRB Authorization Agreement may be required. Contact ORRP for more information.

11. OTHER INSTITUTIONAL APPROVALS

Check all that apply and provide applicable documentation. See websites listed below for information on obtaining approvals.

X None

☐ Clinical Research Center (CRC) Scientific Advisory Committee (SAC) – Approval required for research sponsored by the CRC. Final IRB approval will be held pending receipt of SAC approval. See www.crc.osu.edu.

☐ Institutional Biosafety Committee (IBC) – Approval required for research involving bihazards (recombinant DNA, infectious or select agents, toxins), gene transfer, or xenotransplantation. See http://orrrp.osu.edu/ibc or contact ORRP.

☐ Comprehensive Cancer Center (CCC) Clinical Scientific Review Committee (CSRC) – Approval or exemption required for cancer-related research. See www.osucc.osu.edu/cacc or contact the CCC Clinical Trials Office.
Maternal-Fetal Welfare Committee – Approval required for some research involving pregnant women and fetuses. See http://orrp.osu.edu/ib/ospolicies/MFWreview.frm or contact ORRP.

Human Subjects Radiation Committee (HSRC) – Approval required for research involving radiological procedures for research purposes (e.g., non-clinical care X-rays, DEXA or CT scan, nuclear medicine procedures, etc.). See www.shs.ohio-state.edu or contact ORRP.

For the research described above, IRB review cannot be conducted until required institutional approvals or exemptions are obtained, except as noted.

12. LOCATION OF THE RESEARCH

a. List the specific site(s) at which the OSU research will be conducted (include both domestic and international locations).

<table>
<thead>
<tr>
<th>Location Name (or description)</th>
<th>Address (street, city and state, or country)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA83 Building (A41, A35 – biochemistry lab &amp; A39 – W. Michael Sherman Exercise Physiology Laboratory)</td>
<td>305 West 17th Ave. Columbus, OH</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b. Are all the sites named above on the OSU list of approved research performance sites? See http://orrp.osu.edu/ib/ospolicies/researchsites.cfm.

   X Yes → Go to Question #13

   ☐ No

   If No →

   ☐ Domestic sites → Provide a letter of support, as applicable
   ☐ International sites → Complete Appendix C

Research to be conducted at locations other than approved performance sites will minimally require a letter of support and may require another IRB’s approval if personnel are engaged. See http://www.hhs.gov/ohrp/humansubjects/insurance/engage.htm or contact ORRP for more information.

13. EXPEDITED REVIEW

Are you requesting Expedited Review?

   X Yes → Complete Appendix B

   ☐ No

14. SUMMARY OF THE RESEARCH

Summarize the proposed research using non-technical language that can be readily understood by someone outside the discipline. Explain briefly the research design, procedures to be used, risks and anticipated benefits, and the importance of the knowledge that may reasonably be expected to result. Use complete sentences (limit 300 words).

An understanding of stress and coping is important to health promotion and disease prevention. Previous research suggests that exercise can be beneficial for people who experience psychological distress. Moreover, psychological benefits following acute exercise have been frequently documented. However, there are mixed results for inactive individuals. Specifically, exercise intensity has been shown to moderate the psychological benefits of acute exercise in this population. In addition, the mechanisms responsible for improvements in affective states with acute exercise remain unclear.

The primary purpose of this study is to examine psychological responses to self-selected and imposed-intensity acute exercise in inactive women with high levels of stress. Women are more likely to be inactive than men, and women are at greater risk of depression, which has been associated with chronic stress. The secondary purpose of the study is to examine potential psychological mechanisms (i.e., HPA axis influences and self-efficacy) for changes in psychological states.

This study will utilize a 2 × 2 factorial within-subjects experimental design with 3 treadmill exercise conditions (self-selected intensity, 10% above and 10% below relative self-selected intensity). Affective responses and salivary cortisol will be measured at 6 time points, including pre-, during, & post-exercise, and self-efficacy will be measured at 3 time points.

No risks are expected to result from participation in the study. Each exercise condition is designed to produce the same workload (150 kcal), that is recommended for healthy adults. The results of this study will support the establishment of an optimal exercise program for psychological benefits for high stress women. Participants will benefit through increasing their knowledge and skills necessary to adopt and maintain regular physical activity.
16. SCIENTIFIC BACKGROUND & LITERATURE REVIEW

Summarize existing knowledge and previous work that support the expectation of obtaining useful results without undue risk to human subjects. *Use complete sentences (limit 300 words).*

Stress is a risk factor for mental disorders including depression and anxiety (USDHHS, 1990) and exercise is an effective stress management technique (e.g., Berger, 1984). Numerous research studies have shown that acute exercise is associated with post-exercise improvements in a variety of psychological responses, such as mood, state anxiety, affective responses, and self-efficacy beliefs. However, there are mixed findings for inactive individuals (e.g., Focht, Knapp, Garvin, Radakte, & Hickner, 2007). Exercise intensity may play a role in these results. Exercise intensity has been shown to moderate psychological benefits of acute exercise. Low to moderate intensity exercise sessions are consistently associated with post-exercise improvements in psychological states (e.g., Ekelakakis et al., 2000), while negative post-exercise responses to high intensity exercise have been reported. For example, after 15 min of high intensity cycling (100%), tension and anxiety increased immediately for both highly fit and moderately fit female college students (Staples & Bolton, 1988).

Encouraging self-selected or self-paced exercise (USDHHS, 2000 & ACSM 2006) has been proposed as one way to enhance the likelihood of positive psychological responses and future adherence. Lind, Joens-Nylof and Ekelakakis (2005) found that affect was positive and stable throughout exercise of self-selected intensity in previously sedentary women. However, there is limited mixed evidence examining the psychological benefits of self-paced acute exercise.

Improvements in mood typically emerge within 20 min of the cessation of acute exercise (Cox et al., 2001; Raglin & Wilson, 1996; Reed et al., 1998), and can last up to several hours post-exercise (Raglin, 1997). Although previous studies have focused on pre to post-exercise changes in psychological states, studies examining psychological responses during exercise suggest that there may be considerable heterogeneity (Bixby, Spalding, Bradley, and Hatfield, 2001 & Van Landuyt, Ekelakakis, Hall, & Petrazzello 2000), and affect responses during acute exercise should be examined.

16. RESEARCH OBJECTIVES

List the specific scientific or scholarly aims of the research study.

1. The primary purpose of this study is to examine psychological responses to self-selected and imposed-intensity acute exercise in inactive women with high levels of stress.

2. The secondary purpose of the study is to examine potential psychobiological mechanisms, specifically HPA axis response (salivary cortisol) and self-efficacy (mastery) associated with changes in psychological states.

17. RESEARCH METHODS & ACTIVITIES

a. Identify and describe all interventions and interactions that are to be performed solely for the research study. Distinguish research (i.e., experimental) activities from non-research activities.

*Initial telephone screening*

Before potential participants come to the lab for the baseline measurement, they will go through a telephone screening with the investigator to make sure of their general eligibility to participate in this study. They will be asked their age, height and weight for BMI criteria, and their exercise status with the Leisure Time Exercise Questionnaire (LTEQ) to estimate level of physical activity. The participants will be asked to rate their stress level from 1 to 10, with 1 indicating no stress at all and 10 indicating the most stress they have ever experienced. A score of 7 or greater will be considered as high level of stress. If participants meet these general criteria, they will be asked to schedule their first visit to the lab.

After initial telephone screening for eligibility, all participants will participate in four sessions in this study. Those four sessions include:

- Visit 1: Screening & baseline measurements
- Visit 2: Self-selected exercise condition
- Visit 3 or 4: Imposed intensity: 10% above relative self-selected exercise intensity
- Visit 3 or 4: Imposed intensity: 10% below relative self-selected exercise intensity
All exercise sessions are designed to have an equal workload expending 150 kcal. To minimize the potential influence of diurnal effects, all testing will be scheduled at the same time of day for each participant. All testing will occur between 8 am and 8 pm. Participants will be instructed to refrain from eating one hour prior to exercise sessions and avoid alcohol and caffeine 3 hours before exercise sessions. Each exercise session will be separated by a minimum of 48 hours and maximum of 7 days. A detailed description of each session is provided below.

Visit 1 (Subjects’ screening and baseline measurements)
Each potential participant will meet with the investigator at the lab (A40, PAES Building) for screening. The goals, objectives, and procedure of the study will be explained and discussed. During initial session, participants will have the opportunity to ask questions. If a volunteer agrees to participate, she will complete an informed consent. After signing the consent, participants will complete the health information form including demographic information, menstrual cycle pattern, pregnancy status, current medication use, smoking status, etc. Then, participants will be asked to complete the Physical Activity Readiness Questionnaire (PAR-Q), which measures whether the participant has any contraindications for participation in regular physical activity. Participants will also complete the Perceived Stress Scale (PSS-10), which assesses the level of stress, and the Godin Leisure-Time Exercise Questionnaire (LITEQ), which assesses level of physical activity for screening. Next, height and weight will be measured to determine Body Mass Index (BMI). Participants will be asked to take off their shoes for the measurement. Height will be measured using a stadiometer to the nearest quarter inch and weight will be measured on a medical weight scale to the nearest half pound. The units of the participant’s height and weight will then be converted to meter and kilogram, respectively. The BMI will be calculated by dividing body weight in kilograms by height in meters squared (kg/m²). In addition, the waist-to-hip ratio (WHR) will be measured to determine type of obesity present. A standard tape measure will be placed at the narrowest part of the torso to determine waist circumference, and at the maximal circumference of the hip to determine hip circumference. The WHR is calculated by dividing the waist circumference by the hip circumference. Participants scoring ≥ 23 on the PSS, reporting ≥ 2 session of moderate intensity or greater leisure time exercise sessions (energy expenditure from exercises must be less than 300 kcal per week) on the LITEQ with a BMI ≥ 34.9 will be eligible to participate in the study.

After the participation criteria are confirmed, each participant will complete the remaining baseline assessments, including information about what and how much food they have eaten before their visit to the lab. First, after the participant sits quietly for 5 min, a saliva sample will be collected to measure baseline cortisol level. Cortisol samples will be obtained by requesting participants to chew a small polyester swab for 45-60 seconds. The swab will be transferred into small plastic tube, stored in a suitable storage box in the refrigerator and subsequently analyzed. After cortisol sampling, resting blood pressure will be measured.

Next, the participant will perform a graded exercise test on a treadmill. The procedures for estimating VO2max will be explained to the participant. The investigator will provide 1 min active stretching instruction for injury prevention. The participant will be instructed to wear a heart rate monitor and a mouth piece which will be connected to a Cardiac Oxid Metabolic Card used to calculate oxygen consumption. The Bruce protocol will be used to estimate fur rate oxygen consumption (VO2max). The participant will start to walk on the treadmill at a speed of 1.7 mph with 10% grade for 3 minutes. Thereafter, the speed will be increased to 2.5 mph, 3.4 mph, 4.2 mph, 5.0 mph, and 5.5 mph every 3 minutes, while the grade will be increased by 2% every 3 minutes. During the VO2 max test, RPE will be measured at the beginning of every 3 minutes while increasing the treadmill grade and speed.

The VO2max test will be terminated when there is a plateau in oxygen uptake compared to the previous stage, respiratory exchange ratio (RER) is ≥ 1.1, and/or heart rate is within 10 bimn of the age-predicted maximum (220-age). The test can also be stopped by the participant at the point of volitional fatigue. She will be instructed to signal the investigator to stop the test by placing both hands on the support rails of the treadmill. Other general indications for stopping an exercise test include: leg cramps, light-headedness, confusion, pallor, nausea, cold skin, and failure of heart rate to increase with increased exercise intensity. A 5-minute recovery period will be started at 0% grade and 1.5 mph belt speed during which recovery heart rate and blood pressure will be taken. If criteria for VO2max are not met, test results will be recorded as VO2max. Lastly, the investigator and the participant will schedule the 2nd visit.

Visit 2 (Self-selected intensity condition)
Upon arriving at the lab for the second session, participants will sit in a chair quietly for 5 min. Following the 5-min rest period, the pre-test salivary sample will be obtained. This sample will be analyzed for levels of cortisol. Participants will be asked what and how much of food they have eaten before their exercise session, and then they will be asked how many days have passed since the beginning of their last menstrual cycle. Resting blood pressure will then be measured. Afterwards, participants will complete the pre-test affective assessments of the Self-Assessment Manikin (SAM) and the Exercise Feeling Inventory (EFI). During visit 2, participants will be asked to complete the self-selected intensity exercise condition. Before the exercise session, the investigator will provide 1 min active stretching for injury prevention. Then, participants will be instructed to: “select a comfortable walking speed and grade that you prefer. The intensity should be high enough so that you would get a good work-out but not so high that exercising daily or every day would be objectionable. It should be an intensity that feels appropriate for you.” The instruction is modified from the study by Dishman et al. (1994). Participants will be allowed to change the speed and grade for 5 min, but the speed should not exceed 4.0 mph so that they will remain walking throughout the exercise. After determining the most preferable intensity, the investigator will immediately compute the duration of exercise necessary to expend 150 kcal without stopping the participant’s exercise. The participant will remain at their preferred intensity throughout the
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exercise session.

The RPE will be recorded every 5 min during the exercise. In-task self-efficacy will be measured at 3 time points, the first 30 seconds of exercise, the middle of exercise, and 10 min post exercise.

The SAM and the EFI will be assessed at 6 time points, prior to, in the middle, in the last 5 min before the end of the exercise, at the end of the exercise, at 10 min post, and at 30 min post exercise. Salivary cortisol will be sampled after the participants complete the SAM and the EFI at each of the measurement time points.

On the completion of exercise session, the treadmill will be stopped and the participant will walk around to cool down, if necessary. As described earlier, self-efficacy will be assessed at 10 min post exercise and the SAM, the EFI, and cortisol will be assessed at 10 min and 30 min post exercise. In addition, future intentions for exercise will be measured at 10 min and 30 min post exercise.

At the end of this session, the investigator will schedule an appointment with the participants within the next week for the 3rd visit.

Visit 2 & Visit 4 (imposed exercise intensity conditions)

The imposed exercise intensity and duration will be determined in reference to the self-selected intensity by equating the same energy expenditure (150 kcal) in advance. For example, if participant A’s self-selected intensity is equivalent to 50% of VO2peak, one of her imposed intensities will be equivalent to 60% of VO2peak, and the other imposed intensity will be equivalent to 40% of VO2peak.

The order of the treatments will be randomized and participants will not be aware of which condition they are to perform each day. In fact, the investigator will prescribe the exercise intensity, either 10% above or 10% below the relative intensity at the self-selected exercise in the 3rd and 4th visit. Following the 5-min resting period, saliva sample will be collected for the baseline measurement of cortisol and resting blood pressure will be measured. The participants will be asked what and how much food they have eaten before the exercise session, and then they will be asked how many days have passed since the beginning of their last menstrual cycle. Next, the participants will complete the pre-test EFI and the SAM.

Before the exercise session, the investigator will provide 1 min active stretching for injury prevention. Then, participants will begin walking on the treadmill, and the speed and/or grade will be changed to either 10% above or 10% below intensity of exercise for the planned duration.

All parameters will be measured at the same designated measurement points as for the self-selected intensity condition during and after the exercise session. At the end of the 3rd visit, the investigator will schedule an appointment with the participants within the next week for the last exercise session.

At the end of the last exercise session, the investigator will congratulate the participant for successfully completing the exercise sessions. A personalized exercise program will be sent to each participant after the last exercise session.

b. Check all research activities that apply:

- Anesthesia (general or local) or sedation
- Audio, video, digital, or image recordings
- Biobehaviors (e.g., sDNA, infectious agents, select agents, toxins)
- Biological sampling (other than blood)
- Blood drawing
- Coordinating Center
- Data, not publicly available
- Data, publicly available
- Data repositories → Complete Appendix C
  (future unspecified use, including research databases)
- Deception → Complete Appendix B & Appendix M1
- Devices → Complete Appendix E
- Diet, exercise, or sleep modifications
- Drugs or biologics → Complete Appendix F
- Emergency research
- Materials that may be considered sensitive, offensive, threatening, or degrading
- Non-invasive medical procedures (e.g., EKG, Doppler)
- Observation of participants (including field notes)
- Oral history (does not include medical history)
- Placebo
- Pregnancy testing
- Program Protocol (Umbrella Protocol)
- Radioisotopes or other sources of ionizing radiation
- Radioactive materials (requires approval from Radiation Safety Committee)
- Randomization
- Record review (which may include PHI)
- Specimen research
- Stem cell research
- Storage of biological materials → Complete Appendix H
  (future unspecified use, including repositories)
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- Focus groups
- Food supplements
- Gene transfer
- Genetic testing → Complete Appendix G
- Internet or e-mail data collection
- Magnetic Resonance Imaging (MRI)
- Surgeries (including biopsies)
- Surveys, questionnaires, or interviews (one-on-one)
- Surveys, questionnaires, or interviews (group)
- X-rays or microwaves
- Other
- Specify:

18. DURATION

Estimate the time required from each participant, including long-term follow-up, if any. Describe the time commitment in detail.

Interested participants will contact the investigator for a brief telephone screening (10 minutes). Eligible participants will then be asked to attend a 40 minute session, including orientation and participant screening to verify eligibility for the study. If the participant is eligible, she will complete baseline measurements (20 minutes) and complete an exercise test on a treadmill (approximately 45 minutes). On the second visit, the participants will be required to complete pre-test measurements (15 minutes). Then, participants will perform 30 to 60 minutes exercise session. Participants will be required to complete post-test measures (30 minutes). Likewise, on the 3rd and 4th visit, participants will be required to complete pre-test measurements (15 minutes). Then, participants will perform 30 to 60 minutes exercise session. Participants will be required to complete post-test measures (30 minutes).

<table>
<thead>
<tr>
<th>Visit 1</th>
<th>Telephone screening</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Orientation and screening</td>
<td>40 minutes</td>
</tr>
<tr>
<td></td>
<td>Baseline measurements</td>
<td>20 minutes</td>
</tr>
<tr>
<td></td>
<td>Exercise testing</td>
<td>40 minutes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Visit 2</th>
<th>Pre-test measurements</th>
<th>15 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exercise session</td>
<td>30-40 minutes</td>
</tr>
<tr>
<td></td>
<td>Post-test measurements</td>
<td>30 minutes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Visit 3</th>
<th>Pre-test measurements</th>
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<tr>
<td></td>
<td>Exercise session</td>
<td>30-40 minutes</td>
</tr>
<tr>
<td></td>
<td>Post-test measurements</td>
<td>30 minutes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Visit 4</th>
<th>Pre-test measurements</th>
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<tbody>
<tr>
<td></td>
<td>Exercise session</td>
<td>30-40 minutes</td>
</tr>
<tr>
<td></td>
<td>Post-test measurements</td>
<td>30 minutes</td>
</tr>
</tbody>
</table>

Including the time spent in screening and pre- and post- exercise assessment, the total time commitment for the participants will be from 3 hours 30 minutes to 6 hours 20 minutes.

19. NUMBER OF PARTICIPANTS

a. Provide the maximum number of participants (or number of participant records, specimens, etc.) for whom you are seeking OSU IRE approval.

The number of participants is defined as the number of individuals who agree to participate (i.e., those who provide consent or whose records are accessed, etc.) even if they do not complete the study. The proposed maximum should include the number of participants who are required (considering participation criteria, withdrawals, etc.) to obtain the desired outcome of the study.

b. Explain how this number was derived.

Based on previous literature, a moderate effect size for differences in psychological status among exercise conditions is expected. Therefore, we selected an effect size of 0.25. G'Power 2.0.8 software (Bradley & Lang, 1994) was used to determine the required sample size for alpha level of .05, a power of .80, and a moderate effect of 0.25. In addition, G'Power requires the correlation between outcome variables over time to estimate power for within-subjects design. The data from a study by Rozon & Lang (2007) showed that the smallest correlation for affective variables over time during the moderate intensity exercise condition was .774 and the smallest correlation during the high intensity exercise condition was .366. The average correlation for data from the high intensity condition was .62. Therefore, we used .62 for correlation estimate. Using the stipulations described above, G'POWER software indicated that the number of subjects needed for this study is 15. We expect some participants may not be able to complete all exercise sessions, therefore we will recruit 20 participants.
c. Is this a multi-center study?  □ Yes  → Indicate the total number of participants to be enrolled across all sites:  
   X No

*The total number of research participants may be increased only with prior IRB approval.*

<table>
<thead>
<tr>
<th>20. PARTICIPANT POPULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Specify the age(s) of the individual(s) who may participate in the research:</td>
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<tr>
<td>Age(s): 18-45</td>
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<tr>
<td>b. Specify the participant population(s) to be included (check all that apply):</td>
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<tr>
<td>X Adults</td>
</tr>
<tr>
<td>□ Adults unable to consent for themselves</td>
</tr>
<tr>
<td>□ Children (&lt; 18 years) → Complete Appendix J</td>
</tr>
<tr>
<td>X Healthy volunteers</td>
</tr>
<tr>
<td>□ Neonates (uncertain viability/observable) → Complete Appendix K</td>
</tr>
<tr>
<td>□ Non-English speaking → Complete Appendix J</td>
</tr>
<tr>
<td>□ Pregnant Women/Fetuses → Complete Appendix K</td>
</tr>
<tr>
<td>□ Prisoners → Complete Appendix I</td>
</tr>
<tr>
<td>□ Students from participant pools (e.g., REP)</td>
</tr>
<tr>
<td>□ Unknown (e.g., research using secondary data/specimen, non-targeted surveys, program protocols)</td>
</tr>
</tbody>
</table>

*Specify*

c. Describe the characteristics of the population(s) and explain how the nature of the research requires/justifies inclusion of the proposed population(s):

Eligible participants will be volunteers and have the following characteristics:

- Female
- Aged 18 through 45 years
- Experiencing high stress as determined by scores ≥ 25 on The Perceived Stress Scale (PSS-10)
- Pre-menopausal
- Not pregnant, nursing, or planning for pregnancy within 8 months
- Physically inactive at least 1 month (exercise < 3 times per week, < 20 minutes per session)
- Not engaged in weight training
- Energy expenditure from exercise that is less than 500 kcal per week
- Not diagnosed with depression or anxiety disorders
- Not taking antidepressants or receiving psychotherapy
- No physical contradictions to exercise (e.g., orthopedic problems)
- Non-smoker
- BMI ≤ 34.9

These criteria are set to ensure the selection of participants from a population most affected by stress symptoms. In addition, these criteria help to minimize confounding effects on cortisol responses to exercise. Last, these criteria ensure that participants can participate in the 4 exercise sessions described previously.

d. Will pregnant women be excluded from participation in the research?  
   X Yes  
   □ No

*If Yes → Explain how the nature of the research requires/justifies their exclusion. Address means of pregnancy screening.*
Pregnant women are excluded because the study involves exercising at high intensity. In addition, hormonal changes during pregnancy may confound cortisol responses. Pregnancy will be addressed during the screening process for all potential participants. Potential participants will be asked to self-report if they are currently pregnant or intending to become pregnant during the next 6 months. Potential participants will also be asked to self-report the date of their last menstrual cycle.

21. PARTICIPANT IDENTIFICATION, RECRUITMENT, & SELECTION

a. Describe how potential participants will be identified (e.g., advertising, individuals known to investigator, record review, etc.). Explain how the method(s) for identifying potential participants respects their privacy.

Volunteers will be recruited through email and web-newsletters from the College of Education and Human Ecology and from academic classes upon instructor’s approval. Volunteers will also be recruited through posted flyers and e-mail. Potential participants will be instructed to e-mail or call the co-investigator (Kyoko Wardwell). All information and communication with potential participants will be confidential.

b. State who (investigators and/or key personnel) will recruit participants and what process will be used to determine participant eligibility.

Kyoko Wardwell (co-investigator) will be responsible for the recruitment of all participants. Recruitment materials will state the inclusion and exclusion criteria (see attached flyers, email notice, and recruitment script). Kyoko Wardwell (co-investigator) will also be responsible for conducting the screening interview. During initial telephone screening, the inclusion and exclusion criteria will be repeated by Kyoko Wardwell (co-investigator). The Physical Activity Readiness Questionnaire (PAR-Q) will be used to screen for any contradictions for participation in physical activity. If a potential participant has one or more contradictions for physical activity, she will not be eligible to participate in the study. During the initial telephone screening, volunteers will be asked to rate their stress on a 10-point investigator developed scale where 1 = no stress at all and 10 = the most stress ever experienced. If they rate their current stress at 7 or greater on this pre-screening scale, they will be eligible to attend visit 1 for verification of eligibility.

At visit 1, stress levels will be measured using Perceived Stress Scale (PSS-10). In this study, scores ≥ 25 will be considered as high stress. If a potential participant has less than 25 scores of PSS-10, she will not be eligible to participate in this study. Eligibility will also be assessed through responses to questions in the health information form. If a potential participant is a smoker, she will not be eligible. Also, if a potential participant is diagnosed with depression or anxiety, taking antidepressant or receiving psychotherapy, she will not be eligible to participate in this study. Participants aged between 18 and 45 years old and with a BMI ≤ 34.9 will be eligible to participate. Participants will also be asked using the health information form if they are currently pregnant, nursing, or are intending to become pregnant during the next 6 months and the date of their last menstrual cycle. Participants who are pregnant, nursing, or are intending to become pregnant during the next 6 months will not be eligible to participate.

Potential participants should be inactive at least 3 months. This will be determined by responses to Godin Leisure-time Exercise Questionnaire (LITEQ). Inactive will be defined as engaging in no more than two 20 min exercise sessions of moderate or greater intensity during a typical week. Participant’s weekly energy expenditure from exercise should be less than 500 kcal. This will be estimated from the responses to the LITEQ using reports of typical weekly exercise intensity and duration. Exercise intensity will be used to calculate minutes of energy expenditure using the following formula: METs(exercise intensity) x 3.5 x body weight in kg / 200 = kcal/min. The result of this calculation will be multiplied by the duration (in minutes) of exercise per week to calculate the weekly energy expenditure from exercise.

c. Describe the recruitment process; including how and where recruitment will take place. Provide copies of proposed recruitment materials (e.g., ads, flyers, website postings, recruitment letters, and oral/written scripts).

The recruitment will be done through flyers posted around the campus, word of mouth, and academic classes upon the instructor's approval. Flyers will be posted in various locations on the OSU Campus, including Wilce Student Health Center and Stress and Anxiety Disorder Clinic located in the Psychology building. The posting of the flyers will have to be approved by each institution. Adds for the study will also be include in electronic newsletters distributed through the College of Education and Human Ecology.
22. INCENTIVES TO PARTICIPATE

Will participants receive compensation or other incentives (e.g., free services, cash payments, gift certificates, parking, classroom credit, travel reimbursement) to participate in the research study? X Yes No

If Yes → Describe the incentive. **Compensation should be pro-rated (e.g., per visit) and not contingent upon study completion.**

The participant will receive a personal exercise program after she completes all exercise testing conditions.

23. INFORMED CONSENT PROCESS

a. Indicate the consent process(es) and document(s) to be used in the study. Check all that apply.

- [ ] Assent – Form
- [ ] Parental Permission – Form
- [x] Assent – Verbal Script
- [ ] Parental Permission – Verbal Script → Complete Appendix M2
- [ ] Informed Consent – Form
- [ ] Translated Consent/Assent – Form(s) → Complete Appendix J
- [x] Informed Consent – Verbal Script
- [ ] Waiver or Alteration of Consent Process → Complete Appendix M1
- [ ] Complete Appendix M2
- [ ] Informed Consent – Addendum
- [ ] Waiver of Consent Documentation → Complete Appendix M2

Prove copies of documents (using OSU templates) and/or complete relevant appendices, as needed. See http://orrp.osu.edu/orb/consent/index.cfm or contact ORRF for more information.

b. Describe the consent process. Explain when and where consent will be obtained and how subjects and/or their legally authorized representatives will be provided sufficient opportunity (e.g., waiting period, if any) to consider participation.

An informed consent form that details the purposes and both risks and benefits of this study will be administered to all eligible participants prior to any data collection. The consent form will be administered to all participants during the first visit prior to completion of questionnaires. Participants will be given the time to read the consent form and given time to ask and receive responses to any questions or concerns in a private room (A40) in PAES Building.

c. List the investigator(s) and/or key personnel who will obtain consent from participants or their legally authorized representatives.

Kyoko Wardwell (co-investigator)
Yating Hsu (key personnel)

Explain how the possibility of coercion or undue influence will be minimized in the consent process.

N/A

Participation in this study is entirely voluntary. All questions and concerns raised by the participants will be answered prior to the participants completing the consent form. Participants will be informed during the orientation session that it is their right to drop out at any point in the study if they choose and no negative consequences will occur as a result of not participating in the study. There will be no attempt to persuade participants who do not wish to participate in the study.

e. Will any other tools (e.g., quizzes, visual aids, information sheets) be used during the consent process to assist participant comprehension?

Yes → Provide copies of these tools
X No

f. Will any other consent forms be used (e.g., for clinical procedures such as MRI, surgery, etc. and/or consent forms from other institutions)?

Yes → Provide copies of these forms
X No

24. CAPACITY TO CONSENT

Will adult participants with limited decision-making capacity or who lack the ability to consent be recruited in this research study?

X Yes
X No
25. PRIVACY & CONFIDENTIALITY

a. Does the research require access to personally identifiable private information? ☐ Yes ☑ No

If Yes → Describe the steps you will take to ensure protection of the participants’ privacy.

b. Will personal or sensitive information (e.g., relating to illegal behaviors, alcohol or drug use, sexual attitudes, mental health, etc.) be accessed or collected from participants? ☑ Yes ☐ No

If Yes → Describe information.

information related to mental health – high levels of stress

c. Could disclosure of information be potentially damaging to participants’ financial standing, employability or reputation, or place the participants at risk of criminal or civil liability? ☐ Yes ☑ No

If Yes → Explain.

d. Explain how you will protect the confidentiality of identifiable data, including where data will be stored, what security measures will be applied, and who will have access to the data.

All collected data will be confidential and safely secured in a locked file cabinet, accessible only to individuals involved in the study. To further ensure confidentiality and to provide identity safeguards, all participants will be assigned an identification number. Any and all the data collected will be filed and analyzed according to this number. Only the primary investigator and the co-investigator will have access to the participant’s name and corresponding number assignment, which will be kept separately from collected data. All data will be entered into a database on a password-protected encrypted personal computer. Following data analysis, identity records will be destroyed. Publication and presentations from this study will not include the name or reveal the identity of any participation in any other way. Participants will be informed of the procedures that will be taken to ensure confidentiality prior to participation in the study.

e. Will you be obtaining a NIH Certificate of Confidentiality? ☐ Yes → Provide a copy before you begin the research ☑ No


f. Explain any circumstances (ethical or legal) where it would be necessary to break confidentiality. ☑ N/A

g. Indicate what will happen to the identifiable data at the end of the study. Check all that apply:

☐ Identifiers separated or permanently removed from the data
☐ Identifiable/coded data is retained
☐ Other, specify: _____________________________
☐ N/A

h. Indicate how study results might be disseminated. Check all that apply:

☐ Conference/Presentation
X Dissertation/Thesis
X Publication/Journal article
☐ Other, specify: __________

26. HIPAA RESEARCH AUTHORIZATION

Will individually identifiable Protected Health Information (PHI) subject to the HIPAA Privacy Rule be accessed, used, or disclosed in the research study?  
☐ Yes  ☑ No ➔ Go to Question #27

If Yes ➔ Will a written authorization be used?
☐ Yes ➔ Provide a copy of the Authorization Form

a. Describe the PHI involved in the research (e.g., demographic information, health history, diagnosis, test results). Be as specific as possible. Provide a copy of the data collection form(s) to be used.

b. List the source(s) of the PHI (e.g., OSUMC Information Warehouse, physician’s own records, etc.), including whether any information will be obtained from sources external to OSU.

☐ No ➔ Indicate the type of waiver or alteration requested (check all that apply) and complete Appendix N.
☐ Partial Waiver (recruitment purposes only)
☐ Full Waiver (entire research study)
☐ Alteration (written documentation)

27. REASONABLY ANTICIPATED BENEFITS

a. List the potential benefits that participants may expect as a result of this research study. State if there are no direct benefits to individual participants. Compensation is not to be considered a benefit.

Exercise is often cited as effective stress management technique. Moreover, it is frequently documented that acute exercise produces psychological benefits. Following this study, all participants will be given their individual research results, an explanation of the study’s findings and exercise guidelines that may improve their general health. A personalized exercise program will be provided to all participants following the study.

b. List the potential benefits that society and/or others may expect as a result of this research study

The optimal exercise intensity required to elicit psychological benefits would be useful to exercise and health psychologists and other professionals involved in the promotion and prescription of exercise program in inactive women with high levels of stress.

28. RISKS, HARMS, & DISCOMFORTS

a. Indicate all reasonably expected risks/harms/discomforts that may apply to the research study:

☐ Breach of confidentiality ☑ Psychological stress
☐ Discovery of previously unknown condition ☐ Risk to reputation
☐ Economic risk ☐ Social or legal risk
☐ Invasion of privacy (participants or other individuals) ☐ Other
☐ Physical injury or discomfort Specify: ___________________________
For each category of risk checked above, describe the specific risk. For physical injury or discomfort include the following:

- Frequency/likelihood of occurrence
- Potential severity of the harm/discomfort
- Possible consequences (including long-term effects)

Reference the section of this application (e.g., Appendix F for drugs) if the risks are described elsewhere.

1. Risk: Breach of confidentiality
   Likelihood of occurrence: very unlikely
   Potential severity of harm/discomfort: Psychological distress from breach of confidentiality could be mild to moderate depending on the participant and the information revealed.
   Possible long term consequences are minimal considering the general nature of the information being gathered in this study.

2. Risk: Psychological stress
   Likelihood of occurrence: very unlikely
   Potential severity of harm/discomfort: Psychological distress from responding to questionnaires could be mild to moderate depending on the participant and the information asked.
   Possible long term consequences are minimal considering the general nature of the information being gathered in this study.

3. Risk: Physical injury or discomfort
   Likelihood of occurrence: injury is unlikely; physical discomfort is possible for the first session.
   Potential severity of harm/discomfort: Muscle soreness from unaccustomed physical activity may occur after exercise sessions. This discomfort usually goes away as our body adapts to the physical activity. The risks associated with a test for maximal aerobic capacity (the first session) are synonymous with those possible during any strenuous physical activity. Apparently healthy adults who will be recruited for this study with a normal health history rarely experience negative physiological effects. Exercise physiology laboratory personnel have been trained in all measurement procedures included in this study. All physiological measurements are noninvasive techniques associated with minimal risk. The American College of Sport Medicine exercise guidelines for testing and training will be followed. The PAES Building, where data collection will take place, is equipped with an Automatic External Defibrillator (AED) and an Emergency response protocol.
   There are no long term consequences.

Describe the specific protections that will be used to minimize the identified risks and harms.

- Protection for breach of confidentiality: All collected data will be confidential and safely secured in a locked filing cabinet, accessible only to individuals involved in the study. To further ensure confidentiality and to provide identity safeguards, all participants will be assigned an identification number. Any and all data collected will be filed and analyzed according to this number. Only the primary investigator and the co-investigator will have access to the participant's name and corresponding number assignment, which will be kept separately from collected data. All data will be entered into a database on a password protected encrypted personal computer. Following data analysis, identity records will be destroyed. Publication and presentations from this study will not include the same or reveal the identity of any participation in any other way. Participants will be informed of the procedures that will be taken to ensure confidentiality prior to participation in the study.

- Protection for risk of psychological stress from responding to questionnaires: All participants will complete questionnaires on a voluntary basis. The co-investigator will emphasize during the pretest, posttest and follow up sessions that the participant does not have to answer any questions she is not comfortable answering, and can discontinue participation at any time.

- Protection for physical injury or discomfort: Stretching before and after each exercise session will be provided. Also, the exercise sessions will be held at least 48 hours apart in order to lessen any discomfort and allow enough time for recovery.

### 29. Monitoring

Does the research involve greater than minimal risk (i.e., are the harms or discomforts described in Question #28 beyond what is ordinarily encountered in daily life or during the performance of routine physical or psychological tests)?

- Yes
- No
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**30. ASSESSMENT OF RISKS & BENEFITS**
Discuss how risks to participants are reasonable when compared to the anticipated benefits to participants (if any) and the importance of the knowledge that may reasonably be expected to result.

The potential benefits of this study significantly outweigh any risks. The risk of the peak oxygen consumption test and acute aerobic exercise sessions is considered minimal. The investigator's experience, the subject's age, and the non-invasive nature of each procedure reduce the chance that adverse effects and incidents will occur.

Acute exercise has been shown to be effective to improve psychological states. However, an optimal exercise prescription for inactive population has not been well established. Determining the intensity that provides most psychological benefits could lead future adherence.

Following the study, all participants will be given their individual research results, an explanation of the study's findings and exercise guidelines that may improve their general health. A personalized exercise program will be provided to all participants following the study. The intensity required to elicit positive psychological effects would be useful to exercise and health psychologists and other professionals involved with the promotion and prescription of exercise in low active population with high levels of stress.

**31. ALTERNATIVES TO STUDY PARTICIPATION**
Other than choosing not to participate, list any specific alternatives, including available procedures or treatments that may be advantageous to the subject.

N/A: there will be no alternatives to study participation

**32. PARTICIPANT COSTS/REIMBURSEMENTS**

a. List any potential costs subjects (or their insurers) will incur as a result of study participation (e.g., parking, study drugs, diagnostic tests, etc.).

Participation will incur no costs as a result of study participation.

b. List any costs to participants that will be covered by the research study.

There will be no costs to participants covered by the research study itself.
### 33. APPLICATION CONTENTS

Indicate what documents are being submitted for this research project. Check all appropriate boxes and provide the version number and date, if available.

<table>
<thead>
<tr>
<th>Document Description</th>
<th>Version</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Review of Human Subjects Research Application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X Appendix A1: OSU Co-Investigators &amp; Key Personnel (questions 4 &amp; 5)</td>
<td></td>
<td></td>
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<tr>
<td>X Appendix A2: External (non-OSU) Co-Investigators &amp; Key Personnel (question 6)</td>
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<tr>
<td>X Appendix B: Expedited Review – Initial Review (question 13)</td>
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<td>X Appendix C: Data Repositories (question 17b)</td>
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<td>X Appendix D: Deception (question 17b)</td>
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<td>X Appendix E: Devices (question 17b)</td>
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<td>X Appendix F: Drugs or Biologics (question 17b)</td>
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<td>X Appendix G: Genetic Testing (question 17b)</td>
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<td>X Appendix H: Storage of Biological Materials (question 17b)</td>
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<td>X Appendix I: Children (question 20b)</td>
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<td>X Appendix J: Non-English Speaking Participants (questions 20b and 23a)</td>
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<td>X Appendix K: Pregnant Women/Fetuses/Neonates (question 20b)</td>
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<td>X Appendix L: Prisoners (question 30b)</td>
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<td>X Appendix M: Waiver or Alteration of Consent Process (questions 17b &amp; 23a)</td>
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<td>X Appendix M': Waiver of Consent Documentation (question 23a)</td>
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<td>X Appendix N: Waiver of HIPAA Research Authorization (question 26)</td>
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<td>X Appendix U: Research in International Settings (question 12)</td>
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<tr>
<td>X Consent form(s), Assent Form(s), Permission Form(s), and Verbal Script(s), including translated documents (question 23a)</td>
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<tr>
<td>X HIPAA Research Authorization Form(s) (question 26)</td>
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<td>X Data Collection Form(s) involving protected health information (question 26a)</td>
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<td>X Recruitment Materials (e.g., ads, flyers, telephone or other oral script, radio/TV scripts, internet solicitations) (question 21a)</td>
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<tr>
<td>X Script(s) or Information Sheet(s), including Debriefing Materials (question 23a)</td>
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<td>X Instruments (e.g., questionnaires or surveys to be completed by participants) (question 17b)</td>
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<tr>
<td>X Other Committee Approvals/Letters of Support (questions 11 &amp; 12)</td>
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<td>X Research Protocol</td>
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<td>X Complete Grant Application</td>
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<tr>
<td>X Drug Manufacturer’s Approved Labeling/Investigator’s Drug Brochure (Appendix F)</td>
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<td>X Device Manufacturer’s Approved Labeling (Appendix E)</td>
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<td>X Other supporting documentation and/or materials</td>
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**For Multi-Center Clinical Trials supported by DHHS, the submission will also include:**

- DHHS-approved Sample Informed Consent Document (if one exists)
- DHHS-approved Protocol (if one exists)
34. ASSURANCE

PRINCIPAL INVESTIGATOR (or Advisor)

I agree to follow all applicable policies and procedures of The Ohio State University and federal, state, and local laws and guidance regarding the protection of human subjects in research, as well as with professional practice standards and generally accepted good research practice guidelines for investigators, including, but not limited to, the following:

- The research will be performed as approved by the IRB under the direction of the Principal Investigator (or Advisor) by appropriately trained and qualified personnel with adequate resources;
- The research will not be initiated until written notification of IRB approval has been received;
- Informed consent and HIPAA research authorization from human subjects (or their legally authorized representatives) will be obtained and documented (unless waived) prior to their involvement in the research using the currently IRB-approved consent form(s) and process;
- Promptly report to the IRB events that may represent unanticipated problems involving risks to subjects or others;
- Significant new findings that develop during the course of the study that may affect the risks or benefits of participation will be reported;
- The IRB will be informed of any proposed changes in the research or informed consent process before changes are implemented, and no changes will be made until approved by the OSU IRB (except where necessary to eliminate apparent immediate hazards to participants);
- A Continuing Review of Human Subjects Research application will be completed and submitted before the deadline for review at intervals determined by the IRB to be appropriate to the degree of risk (but not less than once per year) to avoid expiration of IRB approval and cessation of all research activities;
- Research-related records (and source documents) will be maintained in a manner that documents the validity of the research and integrity of the data collected, while protecting the confidentiality of the data and privacy of participants;
- Research-related records will be retained and available for audit for a period of at least three years after the research has ended (or longer, according to sponsor or publication requirements) even if I leave the University;
- The Office of Responsible Research Practices will be contacted for assistance in amending (to request a change in Principal Investigator) or terminating the research if I leave the University or am unavailable to conduct or supervise the research personally (e.g., sabbatical or extended leave);
- A Final Study Report will be provided to the IRB when all research activities have ended (including data analysis with individually identifiable or coded private information); and
- All Co-Investigators, research staff, employees, and students assisting in the conduct of the research will be informed of their obligations in meeting the above commitments.

I verify that the information provided in this Initial Review of Human Subjects Research application is accurate and complete.

______________________________ Date

Signature of Principal Investigator (or Advisor)

______________________________

Printed name of Principal Investigator (or Advisor)

DEPARTMENT CHAIR (or Signatory Official)

As Department Chair (or Signatory Official) for the Principal Investigator, I acknowledge that this research is in keeping with the standards set by our unit and that it has met all Department/College requirements for review.

If the PI or any Co-Investigator is also the Department Chair, the signature of the Dean or other appropriate Signatory Official, such as the Associate Dean for Research, must be obtained.

______________________________ Date

Signature of Department Chair

______________________________

Printed name of Department Chair
Appendix S

The Ohio State University Consent to Participate in Research
The Ohio State University Consent to Participate in Research

Effects of self-selected and imposed intensity of acute exercise on the HPA axis response and psychological well-being in inactive women with high levels of stress

Principal Investigator: Janet Buckworth

Sponsor: N/A

1. This is a consent form for research participation. It contains important information about this study and what to expect if you decide to participate. Please consider the information carefully. Feel free to discuss the study with your friends and family and to ask questions before making your decision whether or not to participate.

2. Your participation is voluntary. You may refuse to participate in this study. If you decide to take part in the study, you may leave the study at any time. No matter what decision you make, there will be no penalty to you and you will not lose any of your usual benefits. Your decision will not affect your future relationship with The Ohio State University. If you are a student or employee at Ohio State, your decision will not affect your grades or employment status.

3. You may or may not benefit as a result of participating in this study. Also, as explained below, your participation may result in unintended or harmful effects for you that may be minor or may be serious depending on the nature of the research.

4. You will be provided with any new information that develops during the study that may affect your decision whether or not to continue to participate. If you decide to participate, you will be asked to sign this form and will receive a copy of the form. You are being asked to consider participating in this study for the reasons explained below.

1. Why is this study being done?

The purpose of this study is to understand effects of three exercise sessions on psychological well-being in physically inactive women with high levels of stress. You will participate in all exercise sessions, but will not know any differences we expect between the exercise sessions until the study is over to keep from influencing the results.

2. How many people will take part in this study?

The approximate number of participants is 20.

3. What will happen if I take part in this study?
Visit 1: Screening and baseline measurements

First, we will explain the goals and procedures involved in participating in this study to you. To see if you are eligible to participate, you will complete four kinds of questionnaires, including: 1) Health information form including demographic information, menstural cycle pattern, pregnancy status, current medication use, smoking status, etc., 2) the Physical Activity Readiness Questionnaire (PAR-Q), which measures whether there are any reasons you should not participate in regular physical activity, 3) the Perceived Stress Scale (PSS-10), which measures your level of stress, and 4) the Godin Leisure-Time Exercise Questionnaire (LTELQ), which measures how physically active you are. Next, your height and weight will be measured to determine your Body Mass Index (BMI) and we will take measures of your waist and hips to determine your waist-hip ratio (WHR).

If you are eligible for the study, you will complete the remaining baseline assessments, including cortisol in your saliva and your resting blood pressure. To measure cortisol, which is a stress hormone, you will chew a small polyester swab for 45-60 seconds and then place the swab in a plastic tube. We will also ask you what and how much food you have eaten before your visit to the lab.

Next, your capacity for doing aerobic activities will be estimated from an exercise test on a treadmill. You will start to walk on the treadmill at a speed of 1.7 mph with 10% grade for 3 minutes. Thereafter, the speed will be increased to 2.5 mph, 3.4 mph, 4.2 mph, 5.0 mph, and 5.5 mph every 3 minutes, while the grade will be increased by 2% every 3 minutes. In each stage, your heart rate and blood pressure will be recorded and you will be asked how hard you feel that you are working (ratings of perceived exertion [RPE]). You will be instructed to perform to the best of your ability. Afterwards, we will schedule your second visit.

Visit 2: Self-selected intensity condition

Upon arriving at the lab for the second session, you will complete pre-test measurements (saliva sample collection and resting blood pressure). We will also ask you what and how much food you have eaten before your exercise session. Next, you will complete the pre-test questionnaires, which are the Self-Assessment Mankin (SAM) and the Exercise Feeling Inventory (EFI).

During visit 2, you will perform the self-selected intensity exercise condition. You will be instructed to: “select a comfortable walking speed and grade that you prefer. The intensity should be high enough so that you would get a good work-out but not so high that exercising daily or every day would be objectionable. It should be an intensity that feels appropriate for you.” You will be allowed to change the speed and grade for 5 min, but the speed should not exceed 4.0 mph so that you will remain walking throughout the exercise. After determining the most preferable intensity, we will immediately compute
the duration of exercise necessary to expend 150 kcal without stopping your exercise. Then, you will remain at your preferred intensity throughout the exercise session.

Your perception of exertion (RPE) will be recorded every 5 min during the exercise. Your exercise self-efficacy will be measured at 3 time points, the first 30 seconds of exercise, the middle of exercise, and 10 min after exercise. The SAM and the EFI will be assessed at 6 time points, prior to, in the middle, in the last 5 min before the end of the exercise, at the end of the exercise, 10 min and 30 min after exercise. Cortisol in your saliva will be sampled after you complete the SAM and the EFI at each of the measurement time points.

On the completion of this exercise session, the treadmill will be stopped and you will walk around to cool down, if necessary. As described earlier, your exercise self-efficacy will be assessed at 10 min after exercise and the SAM, the EFI, and cortisol in your saliva will be assessed at 10 min and 30 min after exercise. In addition, we will ask you about your future intentions for exercise 10 min and 30 min after exercise.

At the end of this session, we will schedule an appointment with you within the next week for the 3rd visit.

Visit 3 & 4: Prearranged intensity conditions

From visit 3 to 4, you will participate in two prearranged intensity exercise sessions. The exercise intensity and duration will be determined before each exercise session. You will exercise to expend 150 kcal in both exercise sessions at two different intensities. Therefore, the total amount of work you do will be the same in all exercise sessions.

Before each exercise session, you will complete pre-test measurements (saliva sample collection, resting blood pressure, the SAM & the EFI). All measures will be taken at the same time before, during, and after exercise as in the self-selected intensity exercise session.

You will not be audio or videotaped during the study, and your educational or medical records will not be accessed.

4. How long will I be in the study?

During your first visit, you will attend a 40 minute orientation and screening meeting to verify your eligibility for the study. If you are eligible, we will complete the baseline measurements (20 minutes) and complete an exercise test on a treadmill (approximately 40 minutes). On the second visit, you will complete pre-test measurements (15 minutes) and you will exercise from 30 to 60 minutes. Afterwards, you will be asked to complete post-test measures (30 minutes). Likewise, on the 3rd and 4th visit, you will complete a
15 minutes pre-test measurement, 30 to 60 minutes exercise session, and 30 minutes of post-test measures.

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<tr>
<th>Visit 1</th>
<th>Telephone screening</th>
<th>10 minutes</th>
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<tbody>
<tr>
<td></td>
<td>Orientation and screening</td>
<td>40 minutes</td>
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<tr>
<td></td>
<td>Baseline measurements</td>
<td>20 minutes</td>
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<td></td>
<td>Exercise testing</td>
<td>40 minutes</td>
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<tr>
<th>Visit 2</th>
<th>Pre-test measurements</th>
<th>15 minutes</th>
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<tbody>
<tr>
<td></td>
<td>Exercise session</td>
<td>30-60 minutes</td>
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<td>Post-test measurements</td>
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<table>
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<tr>
<th>Visit 3</th>
<th>Pre-test measurements</th>
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<tr>
<td></td>
<td>Exercise session</td>
<td>30-60 minutes</td>
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<td></td>
<td>Post-test measurements</td>
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<tr>
<th>Visit 4</th>
<th>Pre-test measurements</th>
<th>15 minutes</th>
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<td>Exercise session</td>
<td>30-60 minutes</td>
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<td></td>
<td>Post-test measurements</td>
<td>30 minutes</td>
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The study will take between 3 hours, 35 minutes and 4 hours, 5 minutes over 1 to 4 weeks.

5. Can I stop being in the study?

You may leave the study at any time. If you decide to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with The Ohio State University.

6. What risks, side effects or discomforts can I expect from being in the study?

The risks associated with this study are minimal. The most frequent risk is related to muscle soreness from unaccustomed physical activity. This is most likely to happen during the first exercise session. There are no long-term effects. To prevent muscle soreness, you will be provided proper stretching before and after each exercise session. It is possible but very unlikely that you will experience some temporary psychological stress from answering the questionnaires. Please remember that your participation is entirely voluntary, and you can choose not to answer any questions.

7. What benefits can I expect from being in the study?

It has been reported that acute exercise produces psychological benefits. After the study, you will be given your research results, an explanation of the study's findings, and exercise guidelines that may improve your general health. You will be provided a personalized exercise program later.

8. What other choices do I have if I do not take part in the study?
9. Will my study-related information be kept confidential?

Efforts will be made to keep your study-related information confidential. However, there may be circumstances where this information must be released. For example, personal information regarding your participation in this study may be disclosed if required by state law. Also, your records may be reviewed by the following groups (as applicable to the research):

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- U.S. Food and Drug Administration;
- The Ohio State University Institutional Review Board or Office of Responsible Research Practices;
- The sponsor supporting the study, their agents or study monitors; and
- Your insurance company (if charges are billed to insurance).

If the study involves the use of your protected health information, you may also be asked to sign a separate Health Insurance Portability and Accountability Act (HIPAA) research authorization form.

10. What are the costs of taking part in this study?

There will be no additional costs to participate in this study.

11. Will I be paid for taking part in this study?

No, you will not be paid for taking part in this study.

12. What happens if I am injured because I took part in this study?

If you suffer an injury from participating in this study, you should notify the researcher or study doctor immediately, who will determine if you should obtain medical treatment at The Ohio State University Medical Center.

The cost for this treatment will be billed to you or your medical or hospital insurance. The Ohio State University has no funds set aside for the payment of health care expenses for this study.
13. What are my rights if I take part in this study?

If you choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights you may have as a participant in this study.

You will be provided with any new information that develops during the course of the research that may affect your decision whether or not to continue participation in the study.

You may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled.

An Institutional Review Board responsible for human subjects research at The Ohio State University reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

14. Who can answer my questions about the study?

For questions, concerns, or complaints about the study you may contact Kyoko Wardwell at phone number (937) 243-5256 or e-mail wardwell.5@osu.edu, or the Principal Investigator Janet Buckworth, at phone number (614) 292-0757 or e-mail buckworth.1@osu.edu.

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

If you are injured as a result of participating in this study or for questions about a study-related injury, you may contact OSU Sports Medicine at (614) 293-3600.
CONSENT
Biomedical/Cancer

IRB Protocol Number: 2009H0085
IRB Approval date: 
Version: 2

Signing the consent form

I have read (or someone has read to me) this form and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study.

I am not giving up any legal rights by signing this form. I will be given a copy of this form.

Printed name of subject

Signature of subject

Date and time

Printed name of person authorized to consent for subject (when applicable)

Signature of person authorized to consent for subject (when applicable)

Relationship to the subject

Date and time

Investigator/Research Staff

I have explained the research to the participant or his/her representative before requesting the signature(s) above. There are no blanks in this document. A copy of this form has been given to the participant or his/her representative.

Kyoko Wariwell or Ya-Ting Hsu

Printed name of person obtaining consent

Signature of person obtaining consent

Date and time

Witness(es) - May be left blank if not required by the IRB

Printed name of witness

Signature of witness

Date and time

Printed name of witness

Signature of witness

Date and time

Page 7 of 7
Form date: 10/07/08
Appendix T

Biomedical Lab Approval Letter for Initial Review
May 14, 2009

Protocol Number: 2009H0085
Protocol Title: EFFECTS OF SELF-SELECTED AND IMPOSED INTENSITY OF ACUTE EXERCISE ON THE HPA-AXIS RESPONSE AND PSYCHOLOGICAL WELL-BEING IN INACTIVE WOMEN WITH HIGH LEVELS OF STRESS, Janet Buckworth, Kyoko K. Wardwell, School of Physical Activity and Educational Services - School Administration

Type of Review: Initial Review – expedited
IRB Staff Contact: Carolyn Hagopian
614-292-0569
Hagopian.5@osu.edu

Dear Dr. Buckworth,

The Biomedical IRB APPROVED BY EXPEDITED REVIEW the above referenced research. The Board was able to provide expedited approval under 45 CFR 46.110(b)(1) because the research presents minimal risk to subjects and qualifies under the expedited review category(s) listed below.

Date of IRB Approval: May 14, 2009
Date of IRB Approval Expiration: April 15, 2010
Expedited Review Category: 3 and 4

If applicable, informed consent (and HIPAA research authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. The IRB-approved consent form and process must be used. Changes in the research (e.g., recruitment procedures, advertisements, enrollment numbers, etc.) or informed consent process must be approved by the IRB before they are implemented (except where necessary to eliminate apparent immediate hazards to subjects).

This approval is valid for one year from the date of IRB review when approval is granted or modifications are required. The approval will no longer be in effect on the date listed above as the IRB expiration date. A Continuing Review application must be approved within this interval to avoid expiration of IRB approval and cessation of all research activities. A final report must be provided to the IRB and all records relating to the research (including signed consent forms) must be retained and available for audit for at least 3 years after the research has ended.

It is the responsibility of all investigators and research staff to promptly report to the IRB any serious, unexpected and related adverse events and potential unanticipated problems involving risks to subjects or others.

This approval is issued under The Ohio State University’s OHRP Federal Assurance #0000378.

All forms and procedures can be found on the ORRP website – www.orrp.osu.edu. Please feel free to contact the IRB staff contact listed above with any questions or concerns.

[Signature]

Karla Zadnik, OD, PhD, Chair
Biomedical Institutional Review Board

In-017-09 Exp Approval New CR
Version 01/13/09
Appendix U

Biomedical Lab Approval Letter for Amendment 1
July 7, 2009

Protocol Number: 2009H0085
Protocol Title: EFFECTS OF SELF-SELECTED AND IMPOSED INTENSITY OF ACUTE EXERCISE ON THE HPA-AXIS RESPONSE AND PSYCHOLOGICAL WELL-BEING IN INACTIVE WOMEN WITH HIGH LEVELS OF STRESS, Janet Buckworth, Kyoko K. Wardwell, PAES - School Administration

Request for changes dated June 16, 2009 (addition of a question about stress and depression on the telephone and email screening materials)

Type of Review: Amendment
Approval Date: July 2, 2009
IRB Staff Contact: Kim Kovarik
614-292-9804
Kovarik 9@osu.edu

Dear Dr. Backworth,

The Biomedical IRB APPROVED the above referenced research.

Note that if applicable, informed consent (and HIPAA research authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. The IRB-approved consent form and process must be used. Changes in the research (e.g., recruitment procedures, advertisements, enrollment numbers, etc.) or informed consent process must be approved by the IRB before they are implemented (except where necessary to eliminate apparent immediate hazards to subjects).

It is the responsibility of all investigators and research staff to promptly report to the IRB any serious, unexpected and related adverse events and potential unanticipated problems involving risks to subjects or others.

This approval is issued under The Ohio State University’s OERP Federally Assurance #00006378.

All forms and procedures can be found on the OERP website – www.orpr.osu.edu. Please feel free to contact the IRB staff contact listed above with any questions or concerns.

[Signature]

Karl Zadnik, OD, PhD, Chair
Biomedical Institutional Review Board

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Appendix V

Biomedical Lab Approval Letter for Amendment 2
October 29, 2009

Protocol Number: 2009H0085
Protocol Title: EFFECTS OF SELF-SELECTED AND IMPOSED INTENSITY OF ACUTE EXERCISE ON THE HPA-AXIS RESPONSE AND PSYCHOLOGICAL WELL-BEING IN INACTIVE WOMEN WITH HIGH LEVELS OF STRESS, Janet Backworth, PAES - School Administration

Request for change(s) to the protocol dated October 19, 2009 (add key personnel: Nilges & Stanton).

Type of Review: Amendment
Approval Date: October 29, 2009
IRB Staff Contact: Jennifer Spohn
247-1562
spohn.31@osu.edu

Dear Dr. Backworth,

The Biomedical IRB APPROVED the above referenced research.

Note that if applicable, informed consent (and HIPAA research authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. The IRB-approved consent form and process must be used. Changes in the research (e.g., recruitment procedures, advertisements, enrollment numbers, etc.) or informed consent process must be approved by the IRB before they are implemented (except where necessary to eliminate apparent immediate hazards to subjects).

It is the responsibility of all investigators and research staff to promptly report to the IRB any serious, unexpected and related adverse events and potential unanticipated problems involving risks to subjects or others.

This approval is issued under The Ohio State University’s OERP Federal Assurance #00006378.

All forms and procedures can be found on the ORRP website – www.orrp.osu.edu. Please feel free to contact the IRB staff contact listed above with any questions or concerns.

Karla Zadnik, OD, PhD, Chair
Biomedical Institutional Review Board
Appendix W

Biomedical Lab Approval Letter for Continuing Review 1
March 30, 2010

Protocol Number: 2009H0085
Protocol Title: EFFECTS OF SELF-SELECTED AND IMPOSED INTENSITY OF ACUTE EXERCISE ON THE HPA-AXIS RESPONSE AND PSYCHOLOGICAL WELL-BEING IN INACTIVE WOMEN WITH HIGH LEVELS OF STRESS, Janet Backworth, Kyoko K. Wardwell, PAES - School Administration

Type of Review: Continuing Review — expedited
IRE Staff Contact: Kristin Kalina
Phone: (614) 247-4736
Email: kalina.8@osu.edu

Dear Dr. Backworth,

The Biomedical IRB APPROVED BY EXPEDITED REVIEW the above referenced research. The Board was able to provide expedited approval under 45 CFR 46.110(b)(1) because the research meets the applicability criteria and one or more categories of research eligible for expedited review, as indicated below.

Date of IRB Approval: March 28, 2010
Date of IRB Approval Expiration: March 29, 2011
Expedited Review Category: 3, 4

If applicable, informed consent (and HIPAA research authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. The IRB-approved consent form and process must be used. Changes in the research (e.g., recruitment procedures, advertisements, enrollment numbers, etc.) or informed consent process must be approved by the IRB before they are implemented (except where necessary to eliminate apparent immediate hazards to subjects).

This approval is valid for one year from the date of IRB review when approval is granted or modifications are required. The approval will no longer be in effect on the date listed above as the IRB expiration date. A Continuing Review application must be approved within this interval to avoid expiration of IRB approval and cessation of all research activities. A final report must be provided to the IRB and all records relating to the research (including signed consent forms) must be retained and available for audit for at least 3 years after the research has ended.

It is the responsibility of all investigators and research staff to promptly report to the IRB any serious, unexpected and related adverse events and potential unanticipated problems involving risks to subjects or others.

This approval is issued under The Ohio State University’s OERP Federalwide Assurance #0000678.

All forms and procedures can be found on the OERP website — www.orp.osu.edu. Please feel free to contact the IRB staff contact listed above with any questions or concerns.

Karla Zadnik, OD, PhD, Chair
Biomedical Institutional Review Board
Appendix X

Biomedical Lab Approval Letter for Continuing Review 2
February 25, 2011

Protocol Number: 2009H0085
Protocol Title: EFFECTS OF SELF-SELECTED AND IMPOSED INTENSITY OF ACUTE EXERCISE ON THE HPA-AXIS RESPONSE AND PSYCHOLOGICAL WELL-BEING IN INACTIVE WOMEN WITH HIGH LEVELS OF STRESS, Janet Backworth, Kyoko Wardwell, PAES – School Administration
Type of Review: Continuing Review – expedited
IRB Staff Contact: Kristin Kalina
(614) 291-5958
Kalina.8@osu.edu

Dear Dr. Backworth,

The Biomedical Sciences IRB APPROVED BY EXPEDITED REVIEW the above referenced research. The Board was able to provide expedited approval under 45 CFR 46.110(b)(1) because the research meets the applicability criteria and one or more categories of research eligible for expedited review, as indicated below.

Date of IRB Approval: February 22, 2011
Date of IRB Approval Expiration: February 22, 2012
Expedited Review Category: 4

If applicable, informed consent (and HIPAA research authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. The IRB-approved consent form and process must be used. Changes in the research (e.g., recruitment procedures, advertisements, enrollment numbers, etc.) or informed consent process must be approved by the IRB before they are implemented (except where necessary to eliminate apparent immediate hazards to subjects).

This approval is valid for one year from the date of IRB review when approval is granted or modifications are required. The approval will no longer be in effect on the date listed above as the IRB expiration date. A Continuing Review application must be approved within this interval to avoid expiration of IRB approval and cessation of all research activities. A final report must be provided to the IRB and all records relating to the research (including signed consent forms) must be retained and available for audit for at least 3 years after the research has ended.

It is the responsibility of all investigators and research staff to promptly report to the IRB any serious, unexpected and related adverse events and potential unanticipated problems involving risks to subjects or others.

This approval is issued under The Ohio State University’s OHRP Federalwide Assurance #00006378. All forms and procedures can be found on the OHRP website: www.orhp.osu.edu. Please feel free to contact the IRB staff contact listed above with any questions or concerns.

[Signature]

Karl Zaden, OD, PhD, Chair
Biomedical Sciences Institutional Review Board

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