COMPARISON OF THE AFFECTIVE RESPONSES TO CONTINUOUS AND HIGH-INTENSITY INTERVAL TRAINING PROTOCOLS:
APPLICATION OF THE DUAL-MODE MODEL

By

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ABSTRACT

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High-intensity interval training (HIIT) is time-efficient and has physiological benefits similar to or greater than that of continuous training (CT); however, there are mixed results regarding how HIIT protocols influence affect. The dual-mode model (DMM) is a framework for measuring this intensity-affect relationship. The purpose of this study was to compare acute affective responses between CT and HIIT protocols over time using the DMM as a theoretical framework.

Participants were healthy, fit females (N = 12) ages 19-28. Participants completed a CT protocol set at their RCP (~80% VO₂max) and a HIIT protocol consisting of a 2-min work interval (100% VO₂max) followed by a 2-min rest interval (~55% VO₂max) in a crossover design. Protocols were matched for average intensity using the rest interval, total duration, and energy expenditure (250 kcals).

A repeated measures ANOVA analysis revealed there were no significant differences in affect between CT (M = 2.5, SD = 2.1) and HIIT (M = 2.6, SD = 2.1) protocols $F(1.16,1.73) = .49, p = .648$ over time. There were no significant differences in average HR ($t = -.314, p = .759$), RPE ($t = .333, p = .745$), or post protocol enjoyment
\( t = -.288, \ p = .492 \) between CT and HIIT. A visual depiction of the DMM showed there were no differences in patterning between the two protocols. Altering work-to-rest ratio and rest interval intensity in the HIIT protocol could potentially produce different affective responses. Protocols that have less dependence on anaerobic metabolism should produce more pleasurable responses.
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INTRODUCTION

Physical activity has been shown to prevent cardiovascular disease, improve bone mineral density, and decrease the risk of osteoporosis, diabetes, and certain cancers (Warburton, Nicol, & Bredin, 2006), as well as reduce depression and anxiety (ACSM, 2014). Despite these benefits, in the US only one in three individuals are meeting the minimum exercise recommendations for health of 150 minutes per week of moderate intensity aerobic physical activity or 75 minutes per week of high intensity exercise (ACSM, 2014; National Center for Health Statistics, 2010). Lack of time has been cited as one of the main determinants of physical inactivity (Stutts, 2002). In order to reduce the amount of exercise time necessary to achieve health benefits, intensity can be increased (ACSM, 2014). However, an inverse relationship exists between intensity and pleasure; the higher the intensity, the lower the perceived pleasure (Ekkekakis, 2003; Ekkekakis, Parfitt, & Petruzzello, 2011; Parfitt & Hughes, 2009; Wankel, 1993). If both time and pleasure can be optimized within an exercise prescription, it may be possible to increase physical activity participation and procure the physiological and psychological benefits from exercise. However, the type of exercise protocol that elicits the greatest ratings of perceived pleasure is unknown.
REVIEW OF LITERATURE

Affect

Affect is thought to be the most elementary/basic response to stimuli and encompasses many varieties of emotions and feelings (Russell & Barrett, 1999). Affect can be viewed categorically as distinctive states (e.g., happy, calm, tired, nervous) or dimensionally along a continuum (i.e., pleasure to displeasure; Kwan & Bryan, 2010). Increases in feelings of pleasure (e.g., enjoyment, excitement, content) are described as having positive affect, whereas increases in feelings of displeasure (e.g., anger, depression, anxiety) are described as having negative affect (Batson, Shaw, & Oleson, 1992). This continuum from positive to negative affect is called the affective valence (Batson et al., 1992), which may change as the nature and intensity of the stimuli change (Ekkekakis, 2013). Affect may co-occur with antecedent appraisal (e.g., hearing a song and feeling happy) or it may be “free-floating” (e.g., waking up feeling happy). Affect can be found in emotions, attitudes, moods, traits, and physical sensations, such as exercise (Scherer, 1984). Affect is always present and functioning (Ekkekakis, 2013).
Affect-Adherence Connection

The very nature of affect supports the idea of an affect-adherence connection (Ekkekakis, 2013). Affect functions to guide individuals towards useful or pleasurable stimuli or to move away from harmful or unpleasant stimuli, as well as aiding in the formation of memories and preferences (Ekkekakis, 2013). This idea follows the Hedonic principle that an individual is motivated to seek pleasure and avoid pain (Higgins, 2006). Whether or not a behavior is repeated is influenced by our affective responses (Kahneman, Fredrickson, Schreiber, & Redelmeie, 1993). This affect-adherence connection can be seen in a variety of behaviors, such as exercise, and is believed to be influenced more by proximal consequences, than by distal consequences (Hall, 1976).

Perceptions of exercise experiences are thought to be what is driving the affect-adherence connection. Previous memories of exercise experiences can impact the desire to adhere to future exercise (Dishman, 1994). Specifically, the greater the pleasure during a given exercise experience (i.e., proximal consequence), unlike the feel good affect after exercise (i.e., distal consequence), the greater the likelihood that the experience will be repeated (Ekkekakis, 2003). Hence, it has been postulated that negative affective valence from perceived unpleasant stimuli during exercise should result in lower adherence to exercise, whereas a positive affective valence from perceived, pleasant stimuli during exercise should result in greater adherence (Ekkekakis,
Various researchers have found the affect-adherence connection evident during the exercise session only (Schneider et al., 2009; Williams et al., 2008; Williams et al., 2012). Measuring affect pre- and post-exercise session created a linear result, a straight line from one pre-measurement to one post-measurement time point; however, a much more dynamic picture arose when affect was measured during the exercise session (Schneider et al., 2009; Williams et al., 2008; Williams et al., 2012). Williams et al. (2008) examined affect as a predictor of future physical activity participation and demonstrated that individuals who perceived greater levels of pleasure during exercise were exercising more both 6 and 12 months later. Specifically, participants who had an increase of 1-unit on the 11-point rating scale of pleasure during moderate-intensity exercise were participating in an additional 38 minutes of exercise a week at the 6-month follow-up, and an additional 41 minutes of exercise at a 12-month follow-up. Pre-exercise affect was measured to use as a relative control. During-exercise affect was also measured; however, only one data-point was taken, which could undermine the variability that may occur at other time points during the exercise experience. Despite this limitation, acute affective responses to exercise were shown be a predictor of future physical activity participation, as well as concurrent participation (Williams et al., 2008).

Addressing the need to capture the dynamic nature of affect throughout an exercise protocol, Schneider et al. (2009), Williams et al. (2012), and Kwan and Bryan
(2010) measured affect at multiple time points and found it to be a moderate predictor of adherence. Individuals who reported an additional 27-29 minutes per week of exercise also had an affective valence of one additional unit on the Feeling Scale (FS) when compared to those individuals who exercised less (Williams et al., 2012). This increased affect was also tied to an additional 15 minutes of exercise per week after six months (Williams et al., 2012). Schneider et al. (2009) and Kwan and Bryan (2010) demonstrated similar results and also commented on the predictive nature of the acute affective responses to future exercise intentions. These studies support the idea of an affect-adherence connection; however, they provide little insight into underlying factors that might be impacting affect (Williams et al., 2012).

Dual-Mode Model (DMM)

Ekkekakis and Petruzzello (2002) tackled the need for a theoretical model that captures affect during exercise, explains various underlying mechanisms affecting affect, as well as offers a structure for future research by delineating physiologically based intensity domains. The theoretical model includes the intensity of physical activity as an integral factor by which human behavior has evolved and adapted. This idea is also in line with the Hedonic principle, that suggest that the positive affective responses from an exercise stimulus signify utility and negative affective responses to the exercise stimulus signify danger, therefore causing one to move towards or away from the stimulus (Ekkekakis, Hall, & Petruzzello, 2005). Addressing the aforementioned needs for
measuring affect, the DMM was created as a new conceptualization of the dose-response relationship between intensity (the stimulus) and affect. In addition, the dual mode model accounts for inter-individual variations in responses that are in line with the intensity domains (Ekkekakis et al., 2005).

The DMM is based on a circumplex model, which is used to illustrate the relationship between affect and intensity along two orthogonal/bipolar dimensions (Appendix A; Ekkekakis & Petruzzelo, 2002). Affective valence is measured on the horizontal axis using the 11-point FS (Hardy & Rejeski, 1989) and activation is measured on the vertical axis using the 6-point Felt Arousal Scale (FAS; Svebak & Murgatroyd, 1985). With this schema, the four quadrants of the DMM are: activated pleasant (+, +), un-activated pleasant (+, -), un-activated unpleasant (-, -), and activated unpleasant (-, +; Ekkekakis & Petruzzello, 2002). The brevity and efficiency of the two single-item scales permit continuous assessment during exercise and provide a real-time view of intensities and their influence on affect (Ekkekakis & Petruzzello, 2002).

The DMM demarcates three intensity domains (i.e., moderate, heavy, severe) based on distinct metabolic markers (Ekkekakis, 2003). The moderate intensity domain was delineated as being below the lactate/ventilatory threshold (VT). In this domain, aerobic metabolism allows for activity to be sustained for long periods of time. The heavy intensity domain extends from the VT up to critical power. Activity in this domain can be sustained for prolonged periods of time; however, the continued accumulation of lactate, lowering of pH, and the increasing stress on the cardiovascular and respiratory
systems eventually causes the cessation of exercise. The severe intensity domain extends from critical power up to maximal oxygen consumption (VO$_2$max) where activity can only be sustained for short periods of time until terminated due to exhaustion. In this domain if activity is not stopped after a short duration, the depletion of energy stores and the changes in lactate, calcium, and pH concentrations will eventually cause the body to go into a state of rigor. Preventing this state of rigor from happening are the prevailing perceptions of fatigue and displeasure ensuring that intense challenges to homeostasis can be avoided to ensure life (Ekkekakis, 2003).

Ekkekakis et al. (2005) theorized that affective responses to the three intensity domains were driven by dual modes: cognitive messages (e.g., self-efficacy, exercise goals, health needs) and interoceptive messages (e.g., body temperature, heart rate [HR], muscle fatigue). The message making the greatest impact at any given moment was posited to depend on the intensity of the exercise; interoceptive messages will become increasingly prominent as body temperature rises and muscles fatigue, especially at severe intensities where the limited supply of ATP results in rapid fatigue of skeletal muscle. Hence, cognitive messages were thought to be more salient at lower intensities and interoceptive messages were thought to be more salient at higher intensities, all dependent upon how much stress was being placed on homeostasis (Ekkekakis et al., 2005).

Ekkekakis et al. (2005) reanalyzed four studies (Ekkekakis, Hall, Van Landuyt, & Petruzzello, 2000; Ekkekakis & Petruzzello, 2000, 2002; Van Landuyt, Ekkekakis, Hall,
Petruzzello, 2000) using both between and within groups to examine the variability and homogeneity in participant responses that were theorized to accompany the salience of the cognitive and interoceptive messages. In the four reanalyzed studies, participant responses were examined using the circumplex model from the DMM. Similar patterns between the mean FS and the FAS scores emerged over time within each of the three intensity domains in these five studies. In the moderate intensity domain, there was low inter-individual variability, with most participants reporting pleasure. In the heavy intensity domain, inter-individual variability was high with approximately 50% of participants experiencing relatively no change in affect and the other 50% experiencing a decline in affect. The variation in the heavy intensity domain is theorized to be due to the variability of when different individuals not only cross over the VT, but also how they perceive this transition. In the severe intensity domain, inter-individual variability was low with most participants reporting severe decreases in affective responses. Ekkekakis et al. (2005) noted that although this patterning of participant responses across intensity domains was strong, all participants used in the development of the DMM were healthy and active. Therefore, there may be varied patterning for different populations.

Results from further research showed varying participant characteristics altered the patterning of affective responses; specifically when there was change in the activity levels of the participants from active to inactive, a different pattern in the affective responses emerged (Welch, Hulley, Ferguson, & Beauchamp, 2007). Welch et al. (2007) examined 20 inactive (i.e., exercise less than 2 days/week) women using the DMM and
found that the transitional pattern of affective responses across the intensity domains
during incremental protocols was similar to that of previous research; however, when the
fitness level of the participant was included as a possible confounding variable, the
magnitude of this pattern changed. The inactive subjects in this study experienced the
shift from positive to negative affect prior to their VT (Welch et al., 2007), which
differed from the active subjects who experienced this shift at or after the VT (Ekkekakis
et al., 2005). The DMM was tested using continuous and incremental exercise protocols;
however, other exercise protocols, such as high-intensity interval training (HIIT), may
evoke a different patterning of affective responses (Welch et al., 2007).
HIIT is a method that allows for overall exercise duration to be decreased, as high-intensities can be reached, in addition to being tolerated due to intermittent low-intensity rest intervals (ACSM, 2014). The American College of Sports Medicine (ACSM) recommends that adults between the ages of 18 and 64 participate in at least 30 minutes five times a week for a total of 150 minutes for moderate intensity exercise or 25 minutes three times a week for a total 75 minutes for vigorous exercise. These recommendations indicate that, by increasing the intensity, time spent exercising can be decreased by 50% while still attaining the health benefits. The HIIT technique of reaching high intensities, then inserting periods of lesser intensity was the number two fitness trend for 2015 (Thompson, 2014). Improvements in performance, glucose control, and fat burning can be seen with this popular training trend that are similar to or greater than for continuous training (CT; ACSM, 2014). The popularity of HIIT is demonstrated in the many programs that utilize a high-intensity interval format, such as Crossfit®, Insanity®, as well as various Tabata-style programs offered on the web and at various fitness facilities.

A basic HIIT protocol consists of high-intensity intervals done near maximum intensity followed by recovery intervals of lesser intensity (Buchheit & Laursen, 2013a). Up to nine variables can be manipulated in a HIIT protocol: 1) work interval duration (< 2–3 minutes); 2) work interval intensity (typically a percentage of VO₂max, VO₂peak,
or HRmax); 3) recovery interval duration (< 5 minutes); 4) recovery interval intensity
(active recovery is a percentage of the exercise interval intensity, passive recovery has no
work); 5) rest interval duration (< 5 minutes); 6) rest interval intensity (typically 0%, but
can be active rest similar to active recovery as a percentage of the exercise interval
intensity); 7) number of intervals in a set; 8) number of sets or total duration; and 9)
modality (e.g., running, cycling, plyometrics; Buchheit & Laursen 2013a). The
magnitude of the physiological adaptations from HIIT depends on the work and recovery
interval durations, intensity, and frequency (Holloszy & Coyle, 1984). Duration and
intensity during a HIIT protocol can be varied depending on the individual’s physical
fitness level, as well as his/her goals and the goals of the training session (ACSM, 2014).

Numerous studies have demonstrated significant physiological benefits that can
be gained from HIIT (Buchheit & Laursen, 2013a, 2013e). When compared to
continuous training, the average intensity of an exercise session is higher for HIIT
participants, and cardiorespiratory fitness and cardiometabolic biomarkers are similar to,
if not greater for HIIT (ACSM, 2014). These physiological benefits have been found in
protocols as short as three seconds to protocols lasting up to four minutes with intensity
determined as a percentage, typically over 60% heart rate reserve (HRR) or VO2max
(Buchheit & Laursen, 2013a, 2013e). Improvements to fitness and biomarkers were also
found in many individuals from well-trained athletes to special populations (Laursen,
2010; Laursen & Jenkins, 2002; Little et al., 2011; Tabata et al., 1996; Talanian,
The physiological benefits from HIIT can be derived from different HIIT protocol configurations and from special populations to elite athletes. In a group of active adults, a HIIT protocol of 1-minute exercise intervals (90% VO2max) followed by a 3-minute recovery interval for a total of 20 minutes of work increased inspiratory muscle strength and improved performance (Dunham & Harms, 2012). Tabata et al. (1996) demonstrated a 28% increase in anaerobic capacity in physically active young males using a 20-second work interval, followed by a 10-second rest interval. Individuals with type 2 diabetes showed marked improvement in their glucose control, as well as skeletal muscle improvements using a HIIT protocol of 60-second work interval (~90% maximal HR) followed by a 60-second recovery interval (complete rest; Little et al., 2011). A group of patients with chronic heart failure improved their submaximal exercise capacity with a HIIT protocol of a 30-second work interval followed by a 60-second recovery interval at complete rest (Freyssin et al., 2012). Although the beneficial physiological effects of HIIT for a wide array of protocols and populations are well established, little is known about the psychological effects (Bartlett et al., 2011; Muller et al., 2011).

Psychological Responses to HIIT

Research into the psychological responses of HIIT is in its infancy, though interest in the topic is growing (Ekkekakis, Hargreaves, & Parfitt, 2013). In a group of individuals recuperating from heart failure, Wisloff et al. (2007) found marked improvements in quality of life (e.g., involvement in daily activities and physical,
emotional, and social functioning) for subjects in an interval training (IT) group compared to the continuous training (CT) group, even though intensity was not high during either protocol due to the physical limitations in this special population. In addition, participants in the IT group reported feeling motivated by the variety in the protocol, where participants in the CT group found the continuous protocol “quite boring” (Wisloff et al., 2007, p. 3092). Bartlett et al. (2011) demonstrated that perceived enjoyment was significantly higher for HIIT when compared to CT, even though participants reported higher rates of perceived exertion (RPE). Muller et al. (2011) reported that both HIIT and CT significantly reduced negative mood in the cold. In addition, CT was found to elicit greater reductions in negative mood states; however, the differences in mood reduction for HIIT and CT were not significant (Muller et al., 2011). Though these studies are important in understanding the effects of interval training on psychological responses, it is important to understand the affective responses to HIIT during exercise in order to be able to make the correlation with adherence.

HIIT and Affect

HIIT has the potential to increase affect, as the recovery periods may mitigate the displeasure associated with the high-intensity (Oliveira, Slama, Deslandes, Furtado, & Santos, 2013). To date there is only one published study (Oliveira et al., 2013) and two theses (Greeley, 2012; Martinez, 2013) assessing acute affective responses to HIIT. All three studies use the DMM as tool for the measurement and evaluation of affect during
exercise and lay a foundation from which future research can be conducted (Greeley, 2012; Martinez, 2013; Oliveira et al., 2013).

Greeley (2012) compared two HIIT cycling protocols to two continuous cycling protocols to examine affect. Ten low-risk participants (5 male, 5 female) underwent four counterbalanced trials, interval-severe, interval-heavy, continuous-moderate, and continuous-heavy all on a cycle ergometer. Exercise intensities were prescribed based on the metabolic markers (e.g., VO$_2$max, critical power) of each individual. The interval-severe (20% above the VT) trial consisted of 10 intervals; each interval was 1-minute of work followed by a 1-minute of recovery (10% of interval intensity) for a total of 20 minutes of HIIT cycling. The interval-heavy (at VT) trial consisted of 10 intervals; each interval was 1-minute of work followed by a 1-minute of recovery (10% of interval intensity) for a total of 20 minutes of HIIT cycling. The continuous-heavy (at VT) trial consisted of 20 minutes of continuous cycling. The continuous-moderate (20% below the VT) trial also consisted of 20 minutes of continuous cycling. Acute affective responses were measured throughout the four trials using the FS. Greeley (2012) revealed that the affect of participants was significantly greater during interval-heavy and continuous-moderate than during continuous-heavy. Affect of participants was also higher during interval-severe when compared to both continuous-moderate and continuous-heavy; however, these latter findings were not statistically significant possibly due to low power.

Martinez (2013) conducted a study similar to that of Greeley (2012) and found similar results; however, participants (7 males, 7 females) were sedentary and overweight
(Body Mass Index = 29±3). Participants completed various cycling protocols using a within-subject experimental design. Exercise intensities were prescribed based on the metabolic markers of each individual. There were four exercise sessions: three 24-minute severe-intensity interval sessions (78 ± 3% peak power) and one 20-minute continuous-heavy session (50 ± 4% of peak power). All recovery intervals for the HIIT protocols were 10-20% of peak power. The interval sessions were matched for total time, work, and recovery, but not overall energy expenditure. The protocols were designed as follows: 1) IS30 – 24 intervals x 30-second severe-intensity followed by 30-second recovery, 2) IS60 – 12 intervals x 60-second severe-intensity followed by 60-second recovery, 3) IS120 – 6 intervals x 120-second severe-intensity followed by 120-second recovery. During IS30 and IS60, affective responses were significantly greater than responses during continuous-heavy and IS120 (Martinez, 2013).

Like Greeley (2012), Martinez (2013) demonstrated that the acute affective responses by participants were significantly higher during the 60-second intervals when compared to continuous-heavy protocols. In addition, IS120 produced higher affective valence from participants when compared to continuous-heavy, although these findings were not statistically significant. Due to CT and HIIT protocols not being matched for overall energy expenditure, it is unclear as to whether the differences in affect were a result of the CT and HIIT protocol variations or the differences in energy expenditure. Martinez (2013) also mentioned that the exercise protocols on the cycling ergometer were
unfamiliar to participants and considered to be uncomfortable, possibly influencing the affective responses.

Oliveira et al. (2013) addressed the issue of the uncomfortable ergometer and compared acute affective responses of 15 men between two counterbalanced treadmill protocols. Participants were excluded from the study if unable to perform a 4-minute time test at 100% VO$_2$peak and/or not characterized as being at low-risk for cardiovascular disease according to ACSM. After time and VO$_2$peak test to determine eligibility for study, participants attended two training sessions, one consisting of a HIIT protocol with a work duration of 2 minutes at 100% VO$_2$peak and an average recovery time of 57 seconds at 0% intensity. The CT protocol was set at the individual’s respiratory compensation point (RCP), which averaged 80.3% of VO$_2$peak. The number of intervals completed during the HIIT protocol was adjusted to allow for the same total duration as the CT session. Both time and intensity were based on metabolic markers for CT and HIIT protocols. When comparing HIIT to CT, there was a significant shift towards negative affect during the HIIT protocol. Oliveira et al. (2013) postulated that it is possible for longer recovery periods to provide better preservation of perceived affect during high intensity exercise. Oliveira et al. (2013) also noted that other factors such as personal goals or exercise that causes “less suffering” might influence training preference (p. 5).

These three studies provide insight into how affect is being influenced by HIIT; they also create room for future investigations of affect and HIIT. Both Greely (2012)
and Martinez (2013) found that for work to rest ratios of 1:1 with intensity no greater than 80% VO$_2$peak and duration no greater than 60 seconds, affect for HIIT was significantly higher than CT. In addition, intervals of severe intensity and intervals greater than one minute also demonstrated higher affect compared to CT, though these results were not significant. Due to CT and HIIT protocols not being matched for overall energy expenditure, it is unclear as to whether the differences in affect were a result of the CT and HIIT protocol variations or the differences in energy expenditure. When Oliveira et al. (2014) matched protocols for total energy expenditure and time, and used work to rest ratio of 2:1 with intensity at 100% VO$_2$peak, participants displayed significantly decreased affect in HIIT when compared to CT. In addition, eight of the fifteen participants were unable to complete protocol due to fatigue. Intensity and duration were greater in the Oliveira study, therefore it is difficult to say to which, if not both (e.g., intensity and duration) the decreased affect can be attributed. Due to the variation in HIIT work to rest ratios, intensities, and modalities used, the protocol that elicits the highest positive affective responses is unknown.

**Purpose/Hypotheses**

With the growing popularity of HIIT programs and the ties between affect and adherence, it becomes increasingly important to understand not only the physiological responses to HIIT, but the psychological responses as well. These psychological responses can be evaluated using the DMM, which allows for comparison of different
types of exercise protocols by providing a framework from which the dose-response relationship to a specific protocol can be assessed. Due to the increased adherence to physical activity correlated to increased acute affect, knowing the exercise protocol that elicits the greatest affective responses would be valuable to researchers and exercise practitioners alike; however, little is known in regards to affect and HIIT. To this end, the purpose of this study was to compare acute affective responses between CT and HIIT protocols over time using the DMM as a theoretical framework.

**Hypothesis 1**

There will be significant differences in acute affective responses of participants between CT and HIIT protocols over time.

**Hypothesis 2**

There will be significant differences in enjoyment for participants between CT and HIIT protocols.
MATERIALS AND METHODS

Research Design

A crossover design was used to investigate the relationship between CT and HIIT protocols over time. The crossover design allowed for all participants to receive the same number of treatments. Participants were recruited following Institutional Review Board approval. For a schematic of the study design, see Appendix O.

Participants

A total of 12 healthy and fit females, ages 19 to 28 participated in the study. Based on an *a priori* power analysis using GPowerMac, 20 participants were needed to achieve a power of 0.95 with an alpha level of $r < .05$; however, only 15 participants volunteered for the study. Female participants were chosen to eliminate any potential variation due to gender differences. In addition, females have demonstrated improved recovery compared to men during high-intensity exercise (Laurent, Vervaecke, Kutz, & Green, 2014).

Participants met all inclusion criteria prior to participation. Inclusion criteria comprised: (a) classification as ‘Low Risk’ according to ACSM’s Cardiovascular Disease (CVD) Risk Factor Assessment (see Appendix B); (b) VO$_2$max greater than 40 mg/kg/min; (c) not currently on any type of restricted diet or on any medication; (d) no
musculoskeletal conditions or injuries, and no flu or illness during study; (e) non-smokers
for at least the past 6 months; (f) classification as non-obese (BMI < 30 and waist
circumference < 102); and (g) completion of both HIIT and CT protocols. Although 15
participants originally volunteered for the study, one participant did not meet low-risk
inclusion criteria, one participant dropped out, and one participant was unable to
complete the protocols.

Measures

Rate of Perceived Exertion (RPE)

Rate of perceived exertion (RPE) was measured using the 15-point Borg scale
with anchors from ‘No exertion to ‘maximal exertion’ (Borg, 1998). RPE scale validity
has been demonstrated with HR, ventilation, oxygen update, breathing frequency, blood
lactate, and carbon dioxide production (Noble & Robertson, 1996), in addition to being
the most widely used measurement for perceived exercise effort (Watt & Grove, 1993). A
representation of this scale can be found in Appendix C.

Feeling Scale (FS)

The FS was originally developed based on the affect circumplex and has been
used by numerous researchers to measure affective valence (Ekkekakis, 2013).
Additionally, FS, alongside RPE, demonstrated a strong, negative correlation ($r = -.80$) to
high intensities (Acevedo, Rinehardt, & Kraemer, 1994). The FS is an 11-point measure
of affective valence, scaled from negative five to five with ‘very good’ (+5), ‘good’ (+3),
‘fairly good’ (+1), ‘neutral’ (0), ‘fairly bad’ (-1), ‘bad’ (-3), and ‘very bad’ (-5) used as verbal anchors (Hardy & Rejeski, 1989). A representation of this scale can be found in Appendix D.

**Felt Arousal Scale (FAS)**

The FAS was originally developed and validated to measure the construct of arousal for the Telic Measure and later adapted for the DMM (Ekkekakis, 2013; Svebak & Murgatroyd, 1985). The FAS is a 6-point measure of perceived activation, scaled from 1 to 6 with ‘low arousal’ (1) and ‘high arousal’ (6) used as verbal anchors (Svebak & Murgatroyd, 1985). A representation of this scale can be found in Appendix E.

**Physical Activity Enjoyment Scale (PAES)**

Perceived enjoyment following exercise protocols was measured using the 18-item Physical Activity Enjoyment Scale (PAES). A 7-point bipolar scale is used to indicate level of enjoyment. The lower the score the higher the enjoyment. An average is used to calculate score, a score of one indicates high enjoyment, a score of 7 indicates low enjoyment levels. Cronbach’s coefficient alpha was .96 for test-retest reliability (Kendzierski & DeCarlo, 1991). A representation of the PAES scale can be found in Appendix F.

**Heart Rate (HR)**

HR was measured using Polar S810 HR monitors (USA), which included a wristwatch, cadence and shoe clip, and chest band. The wrist monitors were fitted to the comfort level of the participants. The chest bands were fitted directly below the chest line
and to the comfort level of the participants. Previous researchers have found support for the validity of the Polar S810 HR monitors; these HR monitors have a high correlation ($r > .98, p < .05$) to an electrocardiogram (Gamelin, Berthoin, & Bosquet, 2006; Nunan et al., 2009).

**Resting Blood Pressure (BP)**

Resting BP was measured to assure that it would not be a contraindication to high-intensity exercise. Measurements were taken after participants were seated comfortably for a minimum of five minutes. Procedures for assessment of BP at rest using an aneroid sphygmomanometer can be found in Appendix G (ACSM, 2014). Two measurements were taken with a 2-minute break in between each measurement. Resting blood pressure was recorded as the average of the two measurements.

**Anthropometrics and Body Composition**

Weight, height, BMI and waist measurements were taken as part of the participant assessments. Weight was measured with a balance-beamscale (Health-o-Meter, Illinois) in pounds. Participants were barefoot, wearing comfortable workout attire. Height was measured using a stadiometer (Seca, Ohio). Participants’ heels were together with heels and buttocks touching the wall, and height was recorded in inches to the nearest quarter inch. All measurements were taken without shoes, while holding in a full inhalation, and looking straight ahead. Body mass index (BMI) was calculated using weight and height measurements [$BMI = \frac{\text{body mass (kg)}}{\text{height squared (m}^2\text{)}}$]. Waist measurements were taken while participants were standing, with arms at sides, feet together, and abdomen
relaxed. Using a spring-loaded Gulick tape measure, three horizontal measurements were taken immediately above the umbilicus; the smallest measurement recorded was used.

Body fat percentage was calculated using ACSM’s 3-site formula for the triceps, suprailliac, and thigh (ACSM, 2014). For the triceps, a vertical fold was made two centimeters to the right of the umbilicus (ACSM, 2014). The suprailliac fold is a diagonal fold in line with the natural angle of the iliac crest. A vertical fold is used on the anterior midline of the thigh, halfway between the top of the patella and the inguinal crease. All measurement were made on the right side of the body with participant’ standing upright arms relaxed at sides (ACSM, 2014). Three measurements were made at each site. The median of the three measurements was used for calculation.

**VO₂max**

All graded exercise tests (GXT) were performed on the Elevation Series Treadmill (LifeFitness, Chicago, IL) to assess VO₂max. Expired gas ratios from GXT were analyzed by TrueOne 2400 metabolic cart (ParvoMedics, Sandy, UT). Initial speed of protocol was 4.0 mph, which increased every 30 seconds until 6.0 mph was attained, at this point the grade was increased every 30 seconds until volitional exhaustion by participant. Grade increased every 30 seconds to aid in the assessment of RCP. HR and cadence measurements were continuous; however, recorded every minute. RPE, FS, and FAS were recorded immediately prior to initiation of protocol, during the last ten seconds of every two minutes, at the 2-min, 5-min, and 10-min marks after termination of protocol. An example of this GXT protocol used can be found in Appendix N. VO₂max
of participants was established as the highest VO2 value attained during GXT. Maximal HR was established as the highest HR attained during the GXT. GXT results were used to determine RCP for each participant as proposed by Beaver, Wasserman, and Whipp (1986).

Procedures

Participants were recruited through flyers (Appendix H) distributed on the HSU college campus and posted on Facebook. Initial contact with potential participants consisted of a telephone interview briefly outlining the study, verbal verification of inclusion criteria, an explanation of general pre-session guidelines (Appendix I). Pre-session guidelines and a schedule of session dates and expectations were emailed or mailed to pre-approved participants. Each participant was scheduled for three individual sessions.

Session One

The purpose and procedures of the study were described to each participant. Opportunities for participants to ask questions regarding the study and their participation were offered throughout session(s). All procedures were explained to participants, who then were instructed to read and sign the Informed Consent form (see Appendix L). The participants completed the Human Performance Lab and Institute of Wellness and Health Medical/Health History Form (Appendix M), which was used to screen for
contraindications and for verification that participants were characterized as low-risk per ACSM guidelines (ACSM, 2014).

Upon completion of paperwork, participants rested for five minutes, then resting HR and BP were then recorded. Weight, height and waist circumference were measured, followed by skinfold measurements. Participants then performed the GXT. Affect via the FS and arousal via the FAS were recorded prior to initiation of GXT, during the last 10 seconds of every two minutes during GXT, and at time points 2-, 5-, and 10-minutes post GXT. HR was monitored continuously prior to and throughout protocol. HR was also monitored post-protocol until values returned to near baseline and participants indicated they were ready to leave (ACSM, 2014). Before participants left, they scheduled their remaining sessions and were reminded of the pre-session guidelines.

Sessions Two and Three

Participants were counterbalanced into one of the two protocols (e.g., CT or HIIT) in session two. The remaining protocol was completed in the following session. CT and HIIT protocols were matched total duration, average intensity and for total energy expenditure for each participants.

Each session, CT or HIIT, was conducted in a similar manner. Participants verbally verified that all pre-session guidelines were followed and were fitted with HR and cadence monitor. All protocols began with a 2-minute warm up at 45% of participant’s measured VO₂max. The CT protocol intensity was set at the RCP value for each participant, which ensured that each participant was working at a similar level above
the VT (Beaver et al., 1986), in addition, it allowed for comparisons to be made to previous studies regarding HIIT and affect. The HIIT protocol was created based on recommendations from the National Strength and Conditioning Association (NSCA; Baechle & Earle, 2008). The intervals were each two minutes in duration, creating a 1:1 work-to-rest ratio and the intensity of the work interval was set at 100% VO$_2$max (Baechle & Earle, 2008). An active rest was used for the rest interval, due to the ability of active rests to be more efficient than passive rests at lactate clearance (Baldari, Videira, Madeira, Sergio, & Guidetti, 2004). Specifically, active rests of 80 to 100% of the lactate threshold are ideal for lactate removal (Menzies et al., 2010); however, because the rest interval intensity was used to keep the overall intensity between the two protocols consistent for each participant, the ideal active rest intensity could not be targeted. Due to the work interval intensity of HIIT and the CT intensity, the rest interval intensity of HIIT will be approximately 50 to 60% of the VO$_2$max for each participant. Thus, the rest interval intensity has the potential to fall within the ideal range for lactate clearance.

The total duration of CT and HIIT were the same for each participant; however, due to the effect of body mass on energy expenditure, total duration between participants differed. Reed and Ones (2006) demonstrated in a meta-analysis that it is the dose, not the duration of physical activity that influences affect; therefore, protocols were matched between participants for total energy expenditure, not total duration. Total energy expenditure was set at 250 kcals using participant’s body weight and VO$_2$max, and based
on ACSM recommendations for exercise volume (ACSM, 2014). An example of these protocols can be found in Appendices O and P. All protocols (e.g., GXT, CT, and HIIT) were performed on a treadmill (LifeFitness, Chicago, IL).

In an attempt to keep psychological variables similar between sessions and assure that no training or detraining effect occurred, time constraints were implemented for the exercise sessions. All protocols were conducted no sooner than 48 hours and no longer than five days after the previous session. Sessions were scheduled around the same time of day.

Data Analysis

Statistical Package for the Social Sciences (SPSS) 21 was used to analyze the data. Means, standard deviations, and ranges were calculated for age, weight, height, body fat percentage, VO₂max, RCP, average HR, RPE, and enjoyment. A dependent t-test was then used to compare the differences in average HR, RPE, and enjoyment ratings means between exercise protocols. A 2x4 repeated measures analysis of variance (ANOVA) was used to determine any differences in FS between the two exercise protocols and across time points set at 25%, 50%, 75% and 100% of protocol duration. Protocol duration was broken down into percentages to assure that measurements were taken at similar time points between participants, as protocol lengths varied between participants. In addition, to capture more of the during protocol affective responses (i.e., work and rest interval affective responses), both the interval at the designated time point
and the previous interval affective responses were averaged. Follow-up paired sample $t$-tests were used to identify where specific differences occurred within the protocols. Effect sizes were identified in order to estimate the magnitude of any differences between the two exercise protocols. Outliers were removed from data analyses. A criterion of $p < .05$ was set for significance. FS and FAS averages were analyzed for patterning and analysis using the DMM.
RESULTS

Participant characteristics, CT and HIIT protocol characteristics, physiological responses, and psychological responses were examined. Means, standard deviations, and ranges of participant characteristics (i.e., age, weight, height, body fat %, VO$_2$max, and RCP) were calculated in Table 1. A VO$_2$max greater than 40 ml/kg/min for women aged 20-29 years old is quantified as “good”, and over 43 ml/kg/min is considered “excellent” (ACSM, 2014).

| Table 1. Means for Participant Characteristics (N = 12) |
|-----------------|------------|----------|------------|
| Variable        | Mean       | SD        | Min        | Max        |
| Age (years)     | 22.3       | 1.8       | 20.0       | 26.0       |
| Weight (lbs.)   | 131.5      | 12.8      | 113.0      | 155.0      |
| Height (in)     | 64.4       | 1.8       | 61.5       | 88.0       |
| Body Fat %      | 21.3       | 3.0       | 17.5       | 26.3       |
| VO$_2$max (mL/kg/min) | 44.7    | 2.23      | 41.2       | 49.0       |
| RCP* (Represented as VO$_2$) | 35.9 | 2.3       | 32.0       | 40.0       |

*Respiratory compensation point.

Exercise protocols were designed based on the specific metabolic markers for each participant. The mean values of each protocol variable (i.e., VO$_2$, RCP, speed, interval durations, total duration, and total calories) for both HIIT and CT are shown in Table 2. Both protocols were matched for overall intensity, total time, and total calories.
Table 2. Means of CT & HIIT Protocol Variables (N = 12)

<table>
<thead>
<tr>
<th></th>
<th>HIIT M (SD)</th>
<th>HIIT M (SD)</th>
<th>CT M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO2 (ml/kg/min)</td>
<td>44.7 (2.2)</td>
<td>26.6 (3.0)</td>
<td>35.9 (2.3)</td>
</tr>
<tr>
<td>% VO2max</td>
<td>100</td>
<td>55.8 (9.3)</td>
<td>80.0 (2.6)</td>
</tr>
<tr>
<td>Speed (mph)</td>
<td>7.6 (.4)</td>
<td>4.4 (.5)</td>
<td>6.0 (.5)</td>
</tr>
<tr>
<td>Interval Time (min)</td>
<td>2</td>
<td>2</td>
<td>29.5 (3.6)</td>
</tr>
<tr>
<td>Total Time (min)</td>
<td>29.5 (3.6)</td>
<td>29.5 (3.6)</td>
<td></td>
</tr>
<tr>
<td>Total Calories (kcal)</td>
<td>250</td>
<td>250</td>
<td></td>
</tr>
</tbody>
</table>

HR and RPE

There was not a significant difference between protocols for HR ($t = -.314$, $p = .759$) or RPE ($t = .333$, $p = .745$). Prior to the initiation of the protocol HR & RPE responses were lowest and continued to increase until completion of the protocol where all values fell, but remained above or similar to resting values. Mean HR and Mean RPE for participants over time are displayed in Figures 1 and 2, respectively.

Figure 1. Mean HR across time for both the HIIT and CT protocols.
Figure 2. Mean RPE across time for both the HIIT and CT protocols.

FS

The first hypothesis was not supported, as there were no significant differences in acute affective responses of participants between CT and HIIT over time. Mauchly’s test indicated that the assumption of sphericity for the HIIT ($x^2(5) = 31.20, p = .000$) and CT ($x^2(5) = 14.95, p = .011$) protocols has been violated; therefore, Greenhouse-Geisser corrected tests are reported ($\varepsilon = .38$). A small effect was represented, $d = .20$. The results from the ANOVA showed that FS scores were not significantly influenced over time by the type of protocol, $F(1.16,1.73) = .49, p = .541$. There was a general decline in FS scores from baseline to 100% of protocol completion and then a sharp rebound in FS scores from 100% to 5-minute post. Average FS scores are shown Table 3. In addition, there were no significant differences between pairwise comparisons of FS scores at any time point for either protocol.
Table 3. Mean FS Scores Over Time

<table>
<thead>
<tr>
<th>Time</th>
<th>HIIT Mean</th>
<th>HIIT SD</th>
<th>CT Mean</th>
<th>CT SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>3.0</td>
<td>1.8</td>
<td>3.1</td>
<td>1.7</td>
</tr>
<tr>
<td>25%</td>
<td>2.6</td>
<td>1.8</td>
<td>2.9</td>
<td>1.6</td>
</tr>
<tr>
<td>50%</td>
<td>2.0</td>
<td>2.2</td>
<td>2.4</td>
<td>2.0</td>
</tr>
<tr>
<td>75%</td>
<td>1.8</td>
<td>2.3</td>
<td>2.0</td>
<td>2.1</td>
</tr>
<tr>
<td>100%</td>
<td>1.4</td>
<td>2.6</td>
<td>1.4</td>
<td>2.6</td>
</tr>
<tr>
<td>Post</td>
<td>3.8</td>
<td>1.7</td>
<td>4.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Means</td>
<td>2.5</td>
<td>2.1</td>
<td>2.6</td>
<td>2.1</td>
</tr>
</tbody>
</table>

FS, FAS, & The DMM

Based on visual inspection, general patterning of the mean FS and FAS values for all participants between HIIT and CT were similar within a circumplex model. All participants in both protocols started in the un-activated/pleasant quadrant. During the protocols FS shifted left towards greater displeasure at each time point. FAS shifted up during the protocols, reaching the activated quadrant by the first quartile. Both FS and FAS continued to increase until the end of each protocol where both FS and FAS returned to the un-activate/pleasant quadrant. Post protocol values for FS and FAS were slightly higher than initial values for both CT and HIIT. Results are depicted in Figure 3 and Figure 4.
Figure 3. Circumplex model of mean FS and FAS values for CT protocol.
The second hypothesis stated that there would be significant differences in enjoyment between CT and HIIT protocols; however, no significant differences were found in the current study. On average, the HIIT protocol had greater levels of enjoyment ($M = 1.97, SE = 0.26$) than the CT protocol ($M = 2.25, SE = 0.109$). This difference, $0.28$, BCa 95% CI [-0.81, 0.24], was not significant $t(11) = -1.19, p = .26$, and represented a medium-sized effect, $d = .58$. Figure 5 displays comparisons between
protocols. When CT and HIIT protocols are matched for overall calories and intensity, post-protocol enjoyment is relatively similar between protocols.

![Figure 5. Mean PAES scores for each protocol.](image)
DISCUSSION

The purpose of this study was to compare acute affective responses between CT and HIIT protocols over time using the DMM as a theoretical framework. Based on previous research, it was hypothesized that there would be differences in acute affective responses between CT and HIIT protocols; however, no differences were found. The protocols were matched for duration, average overall intensity, and calories for each participant. Therefore, the protocol, CT or HIIT, was the only factor potentially influencing the participant. No differences were found between the two protocols, which lends to the possibility that the rest period during HIIT is mitigating the negative affect associated with the high-intensity of the HIIT protocol. In the end, the protocols were also ultimately matched for HR, RPE, affect, arousal, and enjoyment.

The results from this study differ from that of previous research regarding HIIT and affect (Greeley, 2012; Martinez, 2013; Oliveira et al., 2013). Both Greely (2012) and Martinez (2013) demonstrated greater affect for HIIT when compared to CT, where Oliveira (2013) demonstrated greater affect for CT when compared to HIIT. Yet in the current study, there were no differences in affect between CT and HIIT protocols. These contradictions among the results can potentially be explained by examining the protocol variables between the studies.

The intensity of the CT protocol was a likely factor that drove the affective responses. The CT protocol was set at the RCP value of the individual, which correlated
to approximately 80% the VO\(_2\)max of each participant. Intensities at this level were considered to be severe (above the VT) according to Ekkekakis (2005), thus increasing the likelihood for negative affective response. RCP value was used to be able to make comparisons to Oliveira (2013), the only published study regarding affect and HIIT; however, this intensity was potentially why affect was less pleasurable for the current study and Oliveira (2013) when compared to Greely (2012) and Martinez (2013).

Another factor driving the acute affective responses to the protocols was the high-intensity (work) interval of HIIT is one variable that is possibly driving the acute affective responses, which is in line with what Ekkekakis (2005) proposed in the DMM that as intensity increases, affect decreases. Acute affective responses were greater for HIIT than for CT in both the theses; however, the work interval of the HIIT in these studies was 78-85% VO\(_2\)max. The intensity was even decreased at times in the Martinez (2013) study to assure that participants were able to complete the protocol. Both Oliveira (2013) and the current study had the work interval intensity set at a 100% VO\(_2\)max. The high intensity of the work interval in the HIIT protocol was a potential reason why acute affective responses were greater for Greely (2012) and Martinez (2013) than they were for the current study and Oliveira (2013).

Another variable that may explain the differences in acute affect responses between the previous studies (Greeley, 2012; Martinez, 2013; Oliveira et al., 2013) and the current study is the intensity of the low-intensity (rest) interval of HIIT. In the current study, no differences were found in acute affective responses when the rest
interval intensity averaged 55.8% of the intensity of the work interval. The reason no differences were found is potentially due to lactate production being similar to lactate removal at this rest interval intensity (Baldari et al., 2004), thus decreasing interoceptive cues. When the rest interval intensity was set at 0% in previous research, acute affective responses to the HIIT protocol were more negative than affective responses to CT (Oliveira et al., 2013); however, in previous research when the rest interval intensity was at 20% of the work interval intensity, acute affective responses were more positive than affective responses to CT (Greeley, 2012; Martinez, 2013). Based on all four studies, the rest interval intensity influenced acute affective responses; however, due to the discrepancies in results and other variables like work-to-rest ratio, it is difficult to postulate a rest interval intensity that would evoke the greatest affect. The only definitive conclusion that can be made is that the rest period did positively influence affect.

The work interval to rest interval duration ratio (work-to-rest ratio) in HIIT is another potential variable influencing acute affective responses. The greater the work-to-rest ratio, the greater the reliance on the anaerobic glycolytic energy system (Buchheit & Laursen, 2013a) which may lead to an increase in negative acute affective responses (Ekkekakis et al., 2005). Hence when Oliveira (2013) used a work-to-rest ratio of 2:1, HIIT was perceived as less pleasurable than in the current study with a 1:1 work-to-rest ratio. A work-to-rest ratio with an active rest allowed for the utilization of lactate, as opposed to its accumulation from high-intensities (Baldari et al., 2004). When the body is able to utilize lactate as fuel, it prevents metabolic acidosis (Brooks, Fahey, &
Baldwin, 2005), and ultimately the muscle fatigue that would lead to enhanced interoceptive cues and thus negative affective responses (Ekkekakis et al., 2005). The DMM postulated that at high-intensities interoceptive cues, like muscle fatigue are thought to be more salient, thus causing greater displeasure (Ekkekakis et al., 2005), but this utilization of lactate as fuel likely inhibits the saliency of the interoceptive cues by decreasing lactate concentrations. Hence a work-to-rest ratio of 1:1 with an active recovery, should elicit more pleasurable responses, which was found in the current study.

Post protocol psychological responses (i.e., affect and enjoyment) are similar between the current study and previous studies despite differences in work-to-rest ratio or active recovery. In all aforementioned studies, as well as in the current study, post protocol affect returned to near or slighter greater than baseline values. This rebound from more negative to more positive acute affective responses can be seen in previous studies that used graded exercise protocols (Parfitt & Hughes, 2009; Welch et al., 2007), as well as in all previous studies that used CT and HIIT protocols (Greeley, 2012; Martinez, 2013; Oliveira et al., 2013). This patterning demonstrating the rebound in affect post protocol strengthens the rationalization for the DMM by Ekkekakis (2005) that once interoceptive cues become less salient, pleasure will increase. However, no connection can be made to adherence, as the affect-adherence has only been demonstrated during the exercise protocol, not both (Kwan & Bryan, 2010; Williams et al., 2008; Williams et al., 2012).
The general patterning of both affect and arousal illustrated the similarities between the current study and previous studies assessing affect using the DMM. As in previous studies (Ekkekakis et al., 2005; Greeley, 2012; Martinez, 2013; Oliveira et al., 2013; Welch et al., 2007), the pattern that emerged in the current study started at low arousal and positive affect, gradually shifted towards high arousal and negative affect, and then rebounded to low arousal and positive affect upon cessation of the protocol. This patterning similarity was not only seen among studies, but also between protocols. However, like previously mentioned, it is the acute affective responses that tie to adherence, not the post protocol psychological responses. Though post protocol psychological responses do not have a relationship with adherence, previous research that has demonstrated higher levels of affect for HIIT protocols has also demonstrated higher levels of post protocol enjoyment.

A second hypothesis for this study postulated that there would be significant differences in perceived enjoyment between CT and HIIT; however, no differences were found. Several studies have analyzed post protocol enjoyment responses and these studies, unlike the current study, highlighted the psychological favorableness of HIIT compared to CT (Bartlett et al., 2011; Muller et al., 2011; Wisloff et al., 2007). The factor influencing perceived enjoyment was intended to be the protocol, but as previously mentioned with affect, it was the variables within the HIIT protocol, the work-to-rest ratio and the rest interval intensity, that were ultimately influencing enjoyment. These
ratio and interval intensity differences are then postulated to be why post protocol enjoyment was similar between CT and HIIT for the current study.

Despite differences in quantitative responses for enjoyment and affect between the current study and previous studies, anecdotal responses were similar. Participants in the current study commented on the of the HIIT protocol, saying that the rest interval felt like a “reward” and that they felt “re-energized” after a rest. One participant commented after her HIIT protocol that she felt “euphoric”. It is unclear exactly why the anecdotal responses differ from the quantitative data, but based on the tenants of the DMM cognitive factors could be more salient in HIIT due to the rest interval mitigating the displeasure associated with the high-intensity. It is unclear if anecdotal responses were recorded for HIIT in previous studies (Tjonna et al., 2009; Wisloff et al., 2007), but CT was referred to as quite boring, potentially supporting the psychological favorableness of the HIIT protocols in those studies. Though it would be difficult to assess as to whether or not adherence could be tied to these participant responses, it does lend some potential support to the popularity of HIIT programs. A qualitative study with follow-up interviews could prove advantageous.

Limitations & Future Research

There were several limitations in the current study. While internal validity was controlled in the laboratory setting, external validity was poor; participants were a convenience sample of college-aged females with similar body compositions and fitness...
levels, hence it would be difficult to extrapolate results to other populations. 

Assessments of affect and HIIT would be more generalizable if diverse populations were used, such as males and females, various body compositions, and/or various fitness levels to see if these variables change the patterning, the magnitude of the patterning, or both.

In the current study only one HIIT protocol was assessed, which limits the ability to examine what variables of the HIIT protocol are specifically influencing affect and of those variables, which one is having the greatest impact. There is high variability in HIIT protocol configurations between studies limiting the generalizability. This variation is largely due to number of ways in which the nine variables of a HIIT protocol can be manipulated. As we have seen in the current study and in previous research it is not exactly clear what part of a HIIT protocol (i.e., the work interval intensity, the rest interval intensity, or the work-to-rest ratio) is mitigating the effect of work interval the most. Additionally, breaking down the protocols into quartiles has limited the ability to be able to evaluate how much rest interval is mitigating the displeasure associated with the work interval. Future research would benefit from assessing a variety of HIIT protocol configurations, in which differences in intensity and work-to-rest ratios can be tested against one another to see which variable has the greatest impact on acute affective responses. In addition, testing two HIIT protocols will allow for easy assessment of the changing affective responses between and within the protocols, thus allowing measurement of the impact of the rest interval on the affective responses of the work interval.
Another limitation was the protocol creation, which was based on a visual representation of ventilatory variables from GXT data of each participant, which left room for error in the selection of the RCP. Unless participants have a high VO2max, the increasing ventilatory values can be so slight that the exact point where the slope starts to dramatically increase might be too slight to determine, and therefore, potential errors in RCP estimation could occur, causing a protocol to be too challenging or not quite challenging enough. An attempt was made to limit this error by having the RCP data analyzed by an ACSM Registered Clinical Exercise Physiologists (RCEP); however, there is still potential for human error. In the future, participants with maximal oxygen uptakes greater than 50 ml/kg/min would make RCP identification easier and potentially more accurate. In addition, to improve the reliability of the RCP data, two clinically trained physiologists should analyze data. This inter-rater reliability will enhance the accuracy of the RCP estimation.

The researcher was trained and had the opportunity to practice tasks to assure accurate data collection and participant treatment, though due to the multiple responsibilities (i.e., monitoring participant and HR while running measures and recording data) of the researcher, mistakes were possible. For example, the researcher would sometimes be responsible for monitoring HR and assessing psychological variables, in addition to recording data. This multitasking increases the potential for measurement and recording errors. Also, in an attempt to keep researcher-participant interactions similar between participants and protocols, the researcher and the research
assistants practiced giving similar encouragement; however, there was still potential for variation due to researchers mood or their desire to encourage a participant in distress. Future research could eliminate verbal encouragement or have standard phrases. In addition, it would be ideal to have a research assistant to cover every task while testing to help ensure greater accuracy while monitoring and recording.

Due to the time constraints, acute affective responses to CT and HIIT were not assessed over an extended period of time. In the future to test the affect-adherence connection, CT and HIIT protocols could be prescribed two to three times a week for six months. This type longitudinal design could lend insight into whether the anecdotal responses have any type of impact on adherence; however, such finding would be in contrast to the hedonic principal and therefore unlikely.

The FS has been used extensively by exercise psychologists (Ekkekakis, 2013); however, no reliability data was found. There is no evidence in the current study or in any of the previous studies that affective responses would be similar within participants if assessed again with an identical protocol. Therefore, the reliability of FS cannot be established for the current study. The test-retest reliability of the FS at various intensities will need to be investigated in future studies.

Lastly, participants self-reported that all pre-session guidelines were followed; however, there was no guarantee that all guidelines were followed. Failure to refrain from strenuous exercise for 24 hours and/or not eating for at least two hours had the potential to influence acute affective responses as they could change the physiological
responses to the exercise stimulus. It could only be guaranteed that participants followed all pre-session guidelines if 24 hours monitoring of participant was in place which is impractical in most settings.

Practical Application

Although there were limitations in the current study, there are two main findings from the current study and previous research that have potential to lead to practical applications, work-to-rest ratios, and the intensity of the rest interval. To elicit the greatest affective responses from a HIIT protocol, both rest interval intensity and work-to-rest ratio can be altered. The greater the rest interval intensity and the longer the rest interval duration, the greater the ability of the rest interval to mitigate the displeasure associated with exercise. Based on this study for these participants, a work-to-rest ratio of 1:1 and active rests prescribed at an intensity of approximately 55% of the high-intensity interval (100% VO₂max) will elicit affective responses similar to a CT protocols prescribed at 80% of VO₂max. To maximize affective responses to exercise, individuals should work at intensities below the VT to prevent significant declines in affect responses (Ekkekakis et al., 2005). In general, protocols less dependent upon anaerobic metabolism allow for greater acute affective responses, and potentially greater adherence. Future research would benefit from examining various HIIT protocols that have different rest interval and overall intensities.
CONCLUSIONS

In an attempt to find a way to help increase adherence to exercise the differences in acute affective responses were analyzed between a CT and HIIT protocol. When protocols were matched for time and total energy expenditure there were no differences found; however, the similarities between the protocols is notable. Both physiological (e.g., HR) and psychological (e.g., affect, arousal, RPE, enjoyment) variables followed the same general patterning between CT and HIIT protocols; therefore, overall intensity is still what is driving patterning of variables and not the protocol. Both CT and HIIT appear to be equally beneficial at eliciting positive affective responses, depending on variation in the CT and HIIT variables. HIIT could potentially be used in future exercise prescriptions and if so, it is recommended that intervals of a 1:1 work-to-rest ratio and active rest be used. Further investigations of various HIIT protocol configurations and the long-term implications of HIIT are necessary.
REFERENCES


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APPENDIX A. DUAL-MODE MODEL (DMM)

(Ekkekakis & Petruzzello, 2002)
APPENDIX B. ACSM’S CARDIOVASCULAR DISEASE (CVD) AND RISK FACTOR ASSESSMENT

(ACSM, 2014)
APPENDIX C. RPE SCALE (RPE)

<table>
<thead>
<tr>
<th></th>
<th>Maximal exertion</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Very hard</td>
</tr>
<tr>
<td>16</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Hard</td>
</tr>
<tr>
<td>14</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Somewhat hard</td>
</tr>
<tr>
<td>12</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Light</td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Very light</td>
</tr>
<tr>
<td>6</td>
<td>No exertion</td>
</tr>
</tbody>
</table>

(Borg, 1998)
APPENDIX D. FEELING SCALE (FS)

FEELING SCALE (FS)

While participating in exercise, it is common to experience changes in mood and emotion. Some individuals find exercise pleasurable, whereas others find it to be unpleasant. Additionally, feeling may fluctuate across time. That is, one might feel good and bad a number of times during exercise. Scientist have developed this scale to measure such responses.

+5 Very good
+4
+3 Good
+2
+1 Fairly good
0 Neutral
-1 Fairly bad
-2
-3 Bad
-4
-5 Very bad

(Hardy & Rejeski, 1989)
APPENDIX E. FELT AROUSAL SCALE (FAS)

FELT AROUSAL SCALE (FAS)

Estimate your “arousal” by how “worked-up” you feel. You might experience high arousal in one of a variety of ways, for example as excitement or anxiety or anger. Low arousal might also be experienced by you in one of a number of ways, for example as relaxation or boredom or calmness.

1 LOW AROUSAL
2
3
4
5
6 HIGH AROUSAL

(Svebak & Murgatroyd, 1985)
APPENDIX F. PHYSICAL ACTIVITY ENJOYMENT SCALE (PAES)

Physical Activity Enjoyment Scale (PAES)

Instructions:
Please rate how you feel at this moment about the exercise you have been doing by circling the number that seems most appropriate.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>1 2 3 4 5 6 7</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I enjoy it</td>
<td></td>
<td>I hate it.</td>
</tr>
<tr>
<td>2</td>
<td>I feel bored</td>
<td></td>
<td>I feel interested</td>
</tr>
<tr>
<td>3</td>
<td>I dislike it</td>
<td></td>
<td>I like it</td>
</tr>
<tr>
<td>4</td>
<td>I find it pleasurable</td>
<td></td>
<td>I find it unpleasurable</td>
</tr>
<tr>
<td>5</td>
<td>I am very absorbed in this activity</td>
<td></td>
<td>I am not at all absorbed in this activity</td>
</tr>
<tr>
<td>6</td>
<td>It’s no fun at all</td>
<td></td>
<td>It’s a lot of fun</td>
</tr>
<tr>
<td>7</td>
<td>I find it energizing</td>
<td></td>
<td>I find it tiring</td>
</tr>
<tr>
<td>8</td>
<td>It makes me depressed</td>
<td></td>
<td>It makes me happy</td>
</tr>
<tr>
<td>9</td>
<td>It’s very pleasant</td>
<td></td>
<td>It’s very unpleasant</td>
</tr>
<tr>
<td>10</td>
<td>I feel good physically while doing it</td>
<td></td>
<td>I feel bad physically while doing it</td>
</tr>
<tr>
<td>11</td>
<td>It’s very invigorating</td>
<td></td>
<td>It’s not invigorating at all</td>
</tr>
<tr>
<td>12</td>
<td>I am very frustrated by it</td>
<td></td>
<td>I am not at all frustrated by it</td>
</tr>
<tr>
<td>13</td>
<td>It’s very gratifying</td>
<td></td>
<td>It’s not gratifying at all</td>
</tr>
<tr>
<td>14</td>
<td>It’s very exhilarating</td>
<td></td>
<td>It’s not at all exhilarating</td>
</tr>
<tr>
<td>15</td>
<td>It’s not at all stimulating</td>
<td></td>
<td>It’s very stimulating</td>
</tr>
<tr>
<td>16</td>
<td>It gives me a strong sense of accomplishment</td>
<td></td>
<td>It does not give me a strong sense of accomplishment</td>
</tr>
<tr>
<td>17</td>
<td>It’s very refreshing</td>
<td></td>
<td>It’s not at all refreshing</td>
</tr>
<tr>
<td>18</td>
<td>I felt as though I would rather be doing something else</td>
<td></td>
<td>I felt as though there was nothing else I would rather be doing</td>
</tr>
</tbody>
</table>

(Kendzierski & DeCarlo, 1991)
APPENDIX G. PROCEDURES FOR ASSESSMENT OF BLOOD PRESSURE (BP)

AT REST

- Subject seated for at least 5 minutes with the elbow slightly flexed. It is expected that the subject has not just ingested foods or drugs that alter the heart function, e.g. caffeine, nicotine, or alcohol. The subject should wait at least one hour after exercise to get a resting blood pressure measurement.

- Wrap the cuff around the upper arm and support the arm at the level of the heart; align the cuff with the brachial artery.

- Place the stethoscope bell below the antecubital space over the brachial artery.

- Quickly inflate the cuff pressure to 200 mm Hg or 20 mm Hg above the estimated systolic BP.

- Slowly release the pressure at a rate equal to 2-3 mm Hg/sec. Note the first Korotkoff sound.

- Continue releasing the pressure, noting when the sound becomes muffled (4th phase diastolic BP) and when the sound disappears (5th phase diastolic BP). The 5th Korotkoff sound is the measurement used for the diastolic score.

- The blood pressure is generally written as 120/80 mm Hg, with the systolic score written first. Occasionally, the 5th Korotkoff sound never disappears completely or it may finally diminish at a very low pressure. An accepted way to record the BP when the pressure between Korotkoff 4 and 5 is greater than 10 mm Hg is to mark it as SBP/IV/V, for example 120/75/20 mm Hg.

(ACSM, 2014)
APPENDIX H. RECRUITMENT FLYER

Volunteers Wanted

for Research Study

- FREE Body Comp and CV Fitness Assessments
- FREE Individualized Exercise Protocols

To qualify:
- Healthy, non-smoking females age 18-28 years
- Physically active (≥150 minutes of moderate intensity exercise/week)
- Not currently on medication or restricted diet

What you will do:
- Attend one 2-hour body comp & cardiovascular (CV) fitness assessment session
- Attend two 1-hour exercise sessions (on treadmill)

Interested? For more information, contact:
April Parrott, B.A., ACE Certified Personal Trainer
Candidate, MS in Kinesiology
Phone: (541) 255-5134
Email: adp448@humboldt.edu
APPENDIX I. PRE-SESSION GUIDELINES

Pre-session Guidelines

Please follow pre-test guidelines for each testing session.

- Do not eat or drink anything besides water for at least 2 hours
- Do not perform strenuous exercise for at least 24 hours
- Do not use alcohol for at least 24 hours
- Do not use cold medicines for at least 24 hours
- Do not use tobacco products of any kind
- Come in comfortable exercise clothes and running shoes
- Bring water
- Arrive a few minutes early
- Use restroom prior to coming into your appointment
- Turn your cell phone to silent

(ACSM, 2014)
APPENDIX J: INFORMED CONSENT

Informed Consent: AFFECT AND HIIT

COMPARING THE ACUTE AFFECTIVE RESPONSES TO CONTINUOUS AND HIGH-INTENSITY INTERVAL TRAINING PROTOCOLS

INFORMED CONSENT

PROJECT DESCRIPTION:
The purpose of this study is to compare the acute affective responses between a continuous training exercise protocol and high-intensity interval training protocol.

WHO MAY TAKE PART IN THE STUDY?
Must be:
• Between 18 and 28 years old.
• Physically active and fit (participate in greater than 150 minutes of moderate exercise per week and VO2 max > 40 ml O2/kg/min)
• Low-risk for cardiovascular event according to American College of Sports Medicine (ACSM)
Must NOT be:
• On a restrictive diet or medication

HOW MUCH TIME MUST SUBJECTS VOLUNTEER?
Participants will be expected to volunteer 4 hours total (one 2-hour session and two 1-hour sessions).

PROCEDURE:
Participants will have their height, weight, and waist circumference measured and have skin fold measurements taken for body fat percentage. Participants will perform a graded exercise test on a treadmill from which an individualized continuous training and high-intensity interval training protocol will be created. Participants will perform both continuous and high-intensity interval protocols on a treadmill. Participants may be directly quoted before, during and after protocols. Procedure will be conducted in the Human Performance Lab (HPL) at Humboldt State University (HSU).

To assess the health and fitness status participants will complete a set of questionnaires and assessments, which include: 1) Health History Questionnaire, which is used to determine the cardiovascular disease risk factors; 2) Continuous and High-intensity interval training (HIIT) Questionnaire is used to determine previous and current continuous training HIIT participation; 3) Weight and height will be measured for body mass index (BMI) calculation Body Mass Index (BMI) is used to determine body composition and is needed for risk factor assessment; 4) Waist circumference is used to determine health status for inclusion criteria; 5) Resting blood pressure (BP) is used to determine health status for inclusion criteria; research assistant will measure resting after the participant has been sitting quietly for 5 minutes; 6) Resting heart rate (HRrest) is used to determine health status for inclusion criteria; 7) Skinfold measurements are used to assess body fat %.

Participants skin will have skin pinched at designated sites and thickness of the skin measured with skinfold calipers; 8)
Informed Consent: AFFECT AND HIIT

Graded Exercise Test (GXT) is used to measure the maximum cardiovascular ability (VO2max) of the participant. The measurement will be used to assess the fitness level of the participant, as well as for prescription of protocol intensities. During GXT, participant will have HR continuously monitored. The GXT protocol increases speed and grade at specified intervals until VO2max attainment or volitional exhaustion. Standard lab protocols will be followed for all assessments.

In order to evaluate pleasure, arousal during exercise, participants will perform two exercise protocols during two separate sessions, separated by a minimum of 48 to no more than 108 hours. There will be two exercise protocols individualized for the participant. 1) High-intensity interval training (HIIT) protocol: The HIIT protocol is 2 minutes of running at high intensity based and 2 minutes of running at low intensity both based as a percentage of VO2max; 2) Continuous training (CT) protocol: The CT is the same duration as the HIIT protocol, but with continuous running at a moderate intensity, based as a percentage of VO2max.

Before, during, and after the protocols participants will answer questionnaires and assessments regarding their experience with the protocols. Physical Activity Enjoyment Scale (PAES) will be used to assess the level of enjoyment for each exercise protocol. The Feeling Scale (FS) will be used to measure acute affective responses to the exercise protocol. The Felt Arousal Scale (FAS) will be used to measure the arousal level of the participant. Heart Rate (HR) will be monitored continuously with a HR monitor to measure of the effect of the exercise protocol.

BENEFITS:
Participants receive a full body composition analysis and individualized continuous and high-intensity interval training treadmill protocols.

POSSIBLE RISKS AND DISCOMFORTS:
Moderate intensities can cause mild discomfort in muscles and heightened breathing. High-intensities can cause moderate to high discomfort in muscles and labored breathing. In rare cases, high intensities can cause a cardiovascular event.

RISK MANAGEMENT:
To mediate the discomfort felt in muscles, participants are asked to follow pre-session guidelines in which the participant must be well hydrated and rested, which may help mitigate the mild to moderate discomfort felt at moderate and high intensities. All participants must be low-risk, thus reducing the probability of a cardiovascular event. In addition, trained personnel will monitor participants at all times during graded exercise test and both exercise protocols for signs or symptoms of a cardiovascular event.

RESPONSIBILITIES AS A PARTICIPANT:
Participants are responsible for following pre-session guidelines. In addition, participants are responsible for attending all three sessions and participation in all measures and exercise protocols. Participants are free to withdrawal from participation at any time.
Informed Consent: AFFECT AND HIIT

MAINTAINING CONFIDENTIALITY OF YOUR INFORMATION:

All researchers and assistants will maintain confidentiality to the fullest extent of the law.

- All measurements will remain confidential, in locked file cabinets, and no individual results will be revealed or posted. Participant names will not be included with any measurements, excluding health history.
- Electronic information will be stored on password-protected computers. Only the principal investigators will have access to the individual results.
- Information will only be presented as group data.
- Data will be destroyed after 3 years.

QUESTIONS:

- If you have any questions about the study, please ask the following investigators.

Principal Investigators:

April Parrott, B.A.
HSU Department of Kinesiology and Recreation Administration
(541) 255-5134
adp448@humboldt.edu

Sheila Alicea, Ph.D.
HSU Department of Kinesiology and Recreation Administration
(707) 826-3811
skk41@humboldt.edu

Please read and sign below verifying that you read and understand the following:

I understand that the principal investigators will answer any questions I may have concerning the investigation or the procedures at any time. I also understand that my participation in any study is entirely voluntary and that I may decline to enter this study or may withdraw from it at any time without jeopardy. I understand that the investigator may terminate my participation in the study at any time.

If you have any concerns regarding this project, or any dissatisfaction with any part of this study, you may contact the IRB Chair, Dr. Ethan Gaitan, at eg31@humboldt.edu or (707) 826-4545.

If you have questions regarding your rights as a participant, you may report them to IRB Institutional Official at Humboldt State University, Dr. Rhea Williamson at rhea.williamson@humboldt.edu or (707) 826-5169.

Retain a copy of this informed consent for your future reference. If you have read and understand pages one and two of the informed consent and agree to voluntarily participate in this research as described, please sign below. Thank you for your participation in this research.
Informed Consent: AFFECT AND HIIT

Signature:

Your signature below indicates your voluntary participation in this study.

Participant’s Signature    (Date)    Researcher’s Signature    (Date)
APPENDIX K. HSU MEDICAL/HEALTH HISTORY FORM

Human Performance Lab and Institute of Wellness and Health
Humboldt State University
Department of Kinesiology and Recreation Administration

Medical/Health History

Name: ___________________________ Date: ____________

Address: ____________________________________________________________

Phone (home or cell?): Work Phone: Email: _____________________________

Age ______ Date of Birth ______ Gender ______ Height ______ Weight ______

Student ( ) Staff/Psych ( ) Community ( ) Athlete ( )

The following questions are designed to help us tailor the health and fitness assessment and follow-up counseling to your personal situation. It is extremely important for us to know if you have any medical conditions which may affect your testing process or your progress in our program. Please take the time to answer these questions accurately.

Medical History

YES NO In the past five years have you had:

1. Pain or discomfort in chest, neck, jaw, or arms
2. Shortness of breath or difficulty breathing at rest or with mild exertion (e.g., walking)
3. Dizziness or fainting
4. Asthma (swelling)
5. Heart palpitations (forceful or rapid beating of heart)
6. Pain, burning, or cramping in leg with walking
7. Heart murmur
8. Unusual fatigue with mild exertion

Have you ever had:

9. Heart disease, heart attack, and/or heart surgery
10. Abnormal EKG
11. Stroke
12. Uncontrolled metabolic disease (e.g., diabetes, thyrotoxicosis, or myxedema)
13. Asthma or any other pulmonary (lung) condition
14. Heart or blood vessel abnormality (e.g., suspected or known aneurysm)
15. Liver or kidney disease
16. Thyroid disorder
17. Heart or blood vessel abnormality (e.g., suspected or known aneurysm)
18. Heart disease, heart attack, and/or heart surgery
19. Abnormal EKG
20. Stroke
21. Uncontrolled metabolic disease (e.g., diabetes, thyrotoxicosis, or myxedema)
22. Asthma or any other pulmonary (lung) condition
23. Heart or blood vessel abnormality (e.g., suspected or known aneurysm)
24. Liver or kidney disease
25. Thyroid disorder
26. Heart disease, heart attack, and/or heart surgery
27. Abnormal EKG
28. Stroke
29. Uncontrolled metabolic disease (e.g., diabetes, thyrotoxicosis, or myxedema)
30. Asthma or any other pulmonary (lung) condition
31. Heart or blood vessel abnormality (e.g., suspected or known aneurysm)
32. Liver or kidney disease
33. Thyroid disorder
34. Heart disease, heart attack, and/or heart surgery
35. Abnormal EKG
36. Stroke
37. Uncontrolled metabolic disease (e.g., diabetes, thyrotoxicosis, or myxedema)
38. Asthma or any other pulmonary (lung) condition
39. Heart or blood vessel abnormality (e.g., suspected or known aneurysm)
40. Liver or kidney disease
41. Thyroid disorder
42. Heart disease, heart attack, and/or heart surgery
43. Abnormal EKG
44. Stroke
45. Uncontrolled metabolic disease (e.g., diabetes, thyrotoxicosis, or myxedema)
46. Asthma or any other pulmonary (lung) condition
47. Heart or blood vessel abnormality (e.g., suspected or known aneurysm)
48. Liver or kidney disease
49. Thyroid disorder
50. Heart disease, heart attack, and/or heart surgery

If you answered yes to any of these questions, please explain.

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________
CAD Risk Factors

YES NO DON'T KNOW
1. Are you a male 45 years of age or older? ( ) ( ) ( )
2. Are you a female 55 years of age or older? ( ) ( ) ( )
3. Do you have a father or brother who had a heart attack or heart surgery before age 55? ( ) ( ) ( )
4. Do you have a mother or sister who had a heart attack or heart surgery before age 65? ( ) ( ) ( )
5. Do you smoke cigarettes or have you quit less than 6 months ago? ( ) ( ) ( )
6. Do you exercise regularly? ( ) ( ) ( )
7. Do you have a BMI of 30 or more? ( ) ( ) ( )
8. Do you have a waist circumference of greater than 35 inches (female) or 40 inches (male)? ( ) ( ) ( )
9. Do you know your blood pressure? mmHg Date: ( ) ( ) ( )
10. Are you taking blood pressure lowering medication? ( ) ( ) ( )
11. Do you know your blood total cholesterol? mg/dL Date: ( ) ( ) ( )
12. Do you know your blood LDL cholesterol? mg/dL Date: ( ) ( ) ( )
13. Do you know your blood HDL cholesterol? mg/dL Date: ( ) ( ) ( )
14. Do you know your blood triglyceride levels? mg/dL Date: ( ) ( ) ( )
15. Are you taking cholesterol lowering medication? ( ) ( ) ( )
16. Do you know your fasting blood glucose? mg/dL Date: ( ) ( ) ( )
17. Do you have a mother, father, brother, or sister who has/had diabetes? ( ) ( ) ( )

If you answered yes to any of these questions, please explain.

________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

Office Use Only: Date:

Age ______ Ht____ Wt____ BMI____ Waist____ BP____ Total Chol____ LDL____ HDL____ TAG____ Fbg____

Health-Related Questions

YES NO
1. Do you have any other medical conditions/injuries/surgeries? Discuss below ( ) ( )
2. Are you pregnant? ( ) ( )
3. Are allergic to isopropyl alcohol (rubbing alcohol) or latex? ( ) ( )
4. Do you have any allergies to medications, bees, foods, etc.? ( ) ( )
5. Do you have any skin problems? ( ) ( )
6. Are you currently taking vitamin or mineral supplements? ( ) ( )

If you are here for an exercise test, an ECG, or a body composition test, please answer the following 3 questions:

( ) ( ) 6. Have you had any caffeine, food, or alcohol in the past 3 hours?
( ) ( ) 7. Have you exercised today?
( ) ( ) 8. Are you feeling well and healthy today?

If you answered yes to any of these questions, please explain.

________________________________________________________________________________________
________________________________________________________________________________________
**Medications**

Please identify any medications you are currently using:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Diabetics</td>
<td>☐ Other Cardiovascular</td>
</tr>
<tr>
<td>☐ Beta Blockers</td>
<td>☐ NSAIDS/Anti-Inflammatory (Motrin, Advil)</td>
</tr>
<tr>
<td>☐ Vasodilators</td>
<td>☐ Cholesterol</td>
</tr>
<tr>
<td>☐ Alpha Blockers</td>
<td>☐ Diabetes/Insulin</td>
</tr>
<tr>
<td>☐ Calcium Channel Blockers</td>
<td>☐ Other Drugs (record below)</td>
</tr>
</tbody>
</table>

Please list the specific medications (name, dosage, frequency of dosage) that you currently take:

__________________________________________________________________________

__________________________________________________________________________

What are your health and fitness goals?

Health?

CV Fitness?

Muscular Fitness?

Flexibility?

Body Composition or Weight Management?

Nutrition?

Blood Pressure? Lipids? Blood Glucose?

Other?

I certify that the information I have provided is complete and accurate to the best of my knowledge.

Signature of Subject ___________________________ Date ____________

Printed Name of Subject ___________________________

Signature of Witness ___________________________ Date ____________

Printed Name of Witness ___________________________

**Office Use Only**

[ ] Low Risk  [ ] Moderate Risk  [ ] High Risk

Special Considerations: ________________________________
APPENDIX L: GRADED EXERCISE TEST (GXT) PROTOCOL

GXT Data Collection: 6.0 mph

<table>
<thead>
<tr>
<th>TIME</th>
<th>SPEED</th>
<th>%</th>
<th>VO2</th>
<th>HR</th>
<th>RPE</th>
<th>FS</th>
<th>FAS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>0.0</td>
<td>4</td>
<td>0</td>
<td>24.94</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>4.0</td>
<td>0</td>
<td>24.94</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>4.0</td>
<td>0</td>
<td>24.94</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>4.0</td>
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<td></td>
<td></td>
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<td></td>
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</tr>
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<td>2.5</td>
<td>5.0</td>
<td>0</td>
<td>30.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
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<td>0</td>
<td>32.98</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
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**VO2 max = 42 to 47**

**Recovery**

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Subject: ___________________________  Weight (lb): ___________________________

Age: __________  Predicted HR max: __________  Height (in): __________
## APPENDIX M. CONTINUOUS TRAINING (CT) PROTOCOL EXAMPLE

### CT Protocol

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Recovery:

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# APPENDIX N. HIGH INTENSITY INTERVAL TRAINING (HIIT) PROTOCOL

**EXAMPLE**

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APPENDIX O. DIAGRAM OF STUDY DESIGN

**Session 1**
- Overview of study
- Informed consent
- Medical/fitness screening
- CT & HIIT Questionnaire
- Verification of pre-session guidelines
- Resting HR & BP
- Height, weight, and waist measurements
- Risk assessment
- Skinfolds
- GXT
- Remaining sessions scheduled
- Inclusion criteria verified

Minimum of 48 hours between sessions, no more than 5 days.

**Session 2 & 3**
- Verification of pre-session guidelines
- CT or HIIT protocol (counterbalanced)
- HR, affect & arousal measured throughout sessions
- Enjoyment measure pre- and post- protocols
APPENDIX P. KEY TERMS

1. Affect (core affect): a neurophysiological state always available to the conscious as a basic, elementary feeling present in mood and emotion (Ekkekakis, 2013)

2. High-intensity exercise (i.e., vigorous-intensity): encompasses intensities below beyond the lactate threshold to VO\textsubscript{2}max; the predominant source of energy at this intensity is anaerobic metabolism (Ekkekakis, et al., 2005)

3. High-intensity interval training (HIIT): repeated bouts of high-intensity exercise intervals, separated by recovery intervals of lesser intensity (Laursen & Jenkins, 2002)

4. HIIT protocol: a combination of nine exercise-related variables (exercise interval duration and intensity, recovery interval duration and intensity, rest period duration and intensity, number of intervals, number intervals in a set, and modality), typically of short duration (Buchheit & Lausen, 2013)

5. Interval training: a single bout of exercise consisting of intervals of fixed duration and varied intensity (ACSM, 2014)

6. Low-risk individuals: individuals without known disease, with no signs or symptoms of disease, and less than two risk factors (i.e., age, family history, smoker, obesity, sedentary lifestyle, hypertension, dyslipidemia, pre-diabetes (ACSM, 2014)
7. Moderate-intensity exercise: encompasses intensities below the lactate threshold; the predominant source of energy at this intensity is aerobic metabolism (Ekkekakis, et al., 2005)

8. Moderate-risk individuals: individuals without signs or symptoms of CVD and two or more risk factors (i.e., age, family history, smoker, obesity, sedentary lifestyle, hypertension, dyslipidemia, pre-diabetes; ACSM, 2014)

9. Recovery interval: an interval of a specified duration following an exercise interval in which the intensity of recovery is a percentage of the exercise interval intensity (Buchheit & Lausen, 2013)

10. Rest interval: an interval of specified duration and usually zero percent intensity following a series of exercise/recovery intervals (Buchheit & Lausen, 2013)

11. Ventilatory threshold (VT): is the point at which ventilation increases more rapidly than oxygen can be consumed in response to increasing work rate (Brooks et al., 2005)

12. VO$_2$max: the maximal rate at which oxygen can be consumed (Powers, 2012)

13. VO$_2$peak: the maximal rate at which oxygen can be consumed; however, not all the criteria for maximal effort are reached (ACSM, 2014)

14. Work interval: a specified duration and intensity of physical activity (Buchheit & Lausen, 2013)