Journal of Sport & Exercise Psychology, 2015, 37, 138-149
http://dx.doi.org/10.1123/jsep.2014-0212

Human Kinetics
ORIGINAL RESEARCH

Affective and Enjoyment Responses to High-Intensity Interval Training in Overweight-to-Obese and Insufficiently Active Adults

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High-intensity interval training (HIIT) has many known physiological benefits, but research investigating the psychological aspects of this training is limited. The purpose of the current study is to investigate the affective and enjoyment responses to continuous and high-intensity interval exercise sessions. Twenty overweight-to-obese, insufficiently active adults completed four counterbalanced trials: a 20-min trial of heavy continuous exercise and three 24-min HIIT trials that used 30-s, 60-s, and 120-s intervals. Affect declined during all trials ($p < .05$), but affect at the completion of trials was more positive in the shorter interval trials ($p < .05$). Enjoyment declined in the 120-s interval and heavy continuous conditions only ($p < .05$). Postexercise enjoyment was higher in the 60-s trial than in the 120-s trial and heavy continuous condition ($p < .05$). Findings suggest that pleasure and enjoyment are higher during shorter interval trials than during a longer interval or heavy continuous exercise.

Keywords: affect, enjoyment, intervals

Contemporary guidelines for adult physical activity (PA) from the American College of Sports Medicine recommend the accumulation of at least 500–1000 metabolic equivalents × minutes (MET·min) or more of PA per week (Garber et al., 2011). These guidelines note that the goal energy expenditure can be accomplished via combinations of exercise frequency, intensity, duration, and mode. The recommendations provide options for PA accumulation, including 30 min or more of moderate-intensity aerobic exercise at least 5 days per week, 20 min or more of vigorous-intensity aerobic exercise at least 3 days per week totaling at least 75 min, or a combination of moderate and vigorous aerobic exercise provided that the accumulation meets the established weekly MET·min criteria. The guidelines imply that the primary PA is to reach weekly energy expenditure recommendations and that lower volumes of exercise are reasonable when conducted at high intensities. Despite increased flexibility in achieving recommended levels of PA, epidemiological evidence continues to suggest that rates of participation are both low and largely unchanged in recent decades (Brownson, Boehmer, & Luke, 2005).

One relatively new approach to PA that has garnered significant attention in the scientific community and general public is high-intensity interval training (HIIT). The basic parameters of HIIT are linked to sport training but have been elaborated and adapted for both general and clinical populations. Importantly, a nearly infinite number of HIIT workouts can be created by manipulating intensity, duration, and work-to-rest ratios within sessions. A common theme across most popular interval training approaches, however, is that training is time-efficient, with durations that are typically no more than 20 min per session. Recent investigations have suggested that HIIT may be equally, if not more effective, for producing favorable performance and health benefits at considerably lower volumes of total work when compared with contemporary continuous exercise advocated by PA guidelines (Gibala et al., 2006). The resurgent interest in HIIT appears to stem from investigations demonstrating that all-out cycle sprinting leads to marked improvements in both health and performance parameters (Burgomaster, Hughes, Heigenhauser, Bradwell & Gibala, 2005; Little et al., 2011). However, concerns have been raised regarding the acute and long-term tolerability of these types of extreme training protocols (Coyle, 2005).

Concerns related to the tolerability of this form of HIIT led to the development of a more practical version

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that aimed to retain the physiological benefits and time efficiency of traditional HIIT, while also addressing the concerns related to tolerability (Little, Safdar, Wilkin, Tarnopolsky, & Gibala, 2010). These more practical HIIT protocols involve intensities that are less severe but still near-maximal and involve a 1:1 work-to-rest interval. Such sessions are 20 min in duration and include 60-s alternating intervals of intense work and very light recoveries. Recent investigations have shown the efficacy of this HIIT protocol for improving cardiometabolic risk factors in a variety of populations (Little et al., 2011; Hood, Little, Tarnopolsky, Myslik, & Gibala, 2011). While this form of HIIT is built around more manageable interval intensities that provide good physiological benefit, research has not yet adequately evaluated the acute psychological responses to this form of exercise training.

The affective response to exercise is one important aspect of the exercise experience that has received significant research attention in recent years. Affect is defined as the general valenced response of pleasure–displeasure (Ekkekakis & Petruzzello, 2000). Research in this area led to the development of the dual-mode theory, which describes the affective response to continuous exercise at varied intensities (Ekkekakis, 2005). This model suggests that (1) moderate intensities below the anaerobic threshold produce consistently positive affective responses, are sustainable and adaptive, and are more likely to facilitate behavioral maintenance; (2) severe intensities well above the anaerobic threshold produce consistently more negative responses linked to metabolic acidosis and significant exertional discomfort, are noxious, somewhat maladaptive, and may discourage behavioral maintenance; and (3) heavy intensities at and slightly above the anaerobic threshold and positioned between moderate and severe intensities, produce varied affective responses from pleasant to unpleasant because the sustainability of this intensity of exercise is uncertain and thus affective response is influenced by personal self-efficacy and motivation. An important assumption of dual-mode theory is that affect is primitive and limited to basic appraisals of pleasure and displeasure measured as affective valence. This valence is a reflection of the "hard-wired" response to an experience. As such, affective valence arises without significant thought or cognitive elaboration (Ekkekakis & Petruzzello, 2000). In contrast, enjoyment is emotionally based and involves significant cognition about the totality of the experience and environmental context (Wankel, 1993). While affective valence and enjoyment do overlap, they are not identical constructs and enjoyment is not an explicit consideration within dual-mode theory, both are important exercise perceptions and thus relevant considerations in efforts to understand the exercise experience.

Research evaluations of dual-mode theory utilizing continuous exercise are numerous and support the basic premise that exercise intensities below the anaerobic threshold produce more favorable affective responses during exercise than intensities above the anaerobic threshold. These results have been observed in graded and constant load exercise conditions (e.g., Hall, Ekkekakis, & Petruzzello, 2002, Parfitt, Rose, & Burgess, 2006), on cycle ergometers and treadmills (e.g., Schneider & Graham, 2009; Kilpatrick, Kraemer, Bartholomew, Acevedo, & Jarreau, 2007), within trials of shorter and longer durations (e.g., Ekkekakis, Hall, & Petruzzello, 2008; Bixby, Spalding, & Hatfield, 2001), and within less and more fit individuals (e.g., Ekkekakis, Lind, & Vazou, 2010; Bixby & Lochbaum, 2006). While research is relatively plentiful and supportive of dual-mode theory within continuous exercise, studies investigating the impact of HIIT on acute affective and enjoyment responses are more limited, especially within population segments that represent the primary target of physical activity-related health promotion initiatives, namely, insufficiently active and overweight-to-obese individuals.

Three recent studies have considered HIIT exercise in relatively fit samples and offer equivocal findings. One such study compared an interval trial composed of alternating 3-min segments of 50% and 90% of peak work rate against a continuous trial that was near the anaerobic threshold among a group of fit, young adults on a treadmill (Bartlett et al., 2011). Though affective valence was not considered within the design, postexercise ratings of enjoyment were significantly higher in the interval trial. A separate study compared continuous cycle exercise at 50% of peak power against an interval trial composed of 90-s segments alternating between 100% peak power and passive recovery (Muller et al., 2011). Postexercise ratings of total mood disturbance indicated that mood was more positive immediately following the continuous exercise trial in comparison with the interval trial. Absent from both of these designs is the inclusion of in-task measures of affective or enjoyment responses. The only study to date to consider in-task responses compared continuous exercise just below anaerobic threshold against an interval trial that used 2-min segments at 100% of peak power and 1-min segments of low-intensity recovery (Oliveira, Slama, Deslandes, Furtado, & Santos, 2013). In-task ratings of affective valence were not different during the first half of the exercise trial but were significantly more negative in the interval trial near the end of the sessions. Similarly, postexercise ratings of fatigue were greater in the interval trial than the continuous trial, whereas all other mood-related measures did not differ after the completion of exercise. Even though these studies represent an important advance because of common efforts to investigate mood-related responses to HIIT, several design characteristics limit their capacity to inform the research literature more substantively. Design limitations for all studies include failure to include female participants, reliance on fit samples, and small sample sizes. Other limitations present in these studies include interval durations, recoveries, and intensities that are not consistent with the characteristics associated with contemporary evidence-based protocols, namely, 20 min of intervals employed at near-maximal intensities delivered by way of 1:1 work-to-rest ratios.

Given that high-intensity interval exercise represents an efficacious method for enhancing health and fitness, research that more comprehensively investigates the affective and enjoyment responses to HIIT is warranted. Research to date is clear that intense continuous exercise is not perceived as positively as moderately intense continuous exercise and is equivocal with respect to how enjoyable and pleasurable HIIT may be. As such, the purpose of the current study is to investigate the affective and enjoyment responses before, during, and after sessions of intense exercise that is known to convey potent health benefits. Namely, the current study compares intense continuous exercise and three trials of HIIT with varied interval durations in a mixed-sex sample of insufficiently active, overweight-to-obese adults. Given the dual-mode theory and the limited, but equivocal HIIT literature, it was tentatively hypothesized that HIIT exercise of varied durations would produce more favorable affective and enjoyment responses than vigorous exercise performed continuously.

Method

Participants

Participants were 20 adults (11 male, 9 female, mean age ± *SD* = 22 ± 4 years, mean BMI ± *SD* = 29 ± 3) at a large university in the southeastern United States. All participants were overweight-to-obese (BMI 25–35) and insufficiently active defined as not participating in at least 3 days per week of moderate-intensity PA (ACSM, 2010), but otherwise healthy. The sample size is a reflection of related research and is based on an anticipated medium-to-large effect size (i.e., ES = 0.5–0.8), a power level of 0.8, and an alpha criterion of 0.05 (Statistical Solutions, Cork, Ireland).

Instruments

The primary variables of interest for this study were affect and enjoyment. Affective valence was assessed using the single-item, 11-point Feeling Scale (FS; Hardy & Rejeski, 1989). The FS utilizes the stem "How do you currently feel?" and ranges from –5 to +5. Anchors are given at 0 (*Neutral*) and all odd integers, ranging from "*Very Bad*" at –5 to "*Very Good*" at +5. Enjoyment during exercise was assessed using the single-item, 7-point Exercise Enjoyment Scale (EES; Stanley & Cumming, 2009). The EES utilizes the stem "Use the following scale to indicate how much you are enjoying this exercise session" and ranges from 1 to 7. Anchors are given at every integer, ranging from "*Not at all*" at 1 to "*Extremely*" at 7. Enjoyment after exercise was assessed using the Physical Activity Enjoyment Scale (PACES; Kenzierski & DeCarlo, 1991). The PACES is an 18-item, 7-point bipolar rating scale that utilizes the stem "Please rate how you feel at this moment about the exercise you have been doing" and ranges from 1 to 7, with a minimum total score of 18 and a maximum total score of 126. Anchors were provided by two contrasting statements and respondents were asked to indicate strength of agreement.

Procedures

Participants completed a maximal exercise test, a familiarization session, and four experimental exercise trials, each separated by at least 48 hr. The first visit was a protocol to measure aerobic fitness. The second visit was used to familiarize the participants to the forthcoming experimental trials. The remaining experimental trials included one continuous session at a heavy intensity and three interval sessions of various interval lengths performed at severe intensities. All procedures were approved by the university institutional review board and participants provided written informed consent. The following sections describe the procedures in detail.

Screening. The first visit to the laboratory included the completion of informed consent, health history questionnaire, measurement of height, weight, resting heart rate, and resting blood pressure. Participants were medically screened to determine the presence of contraindications to exercise, with a specific focus on orthopedic, cardiovascular, and pulmonary conditions that would preclude participation in the research study. Participants were also instructed to avoid alcohol, caffeine, and tobacco for 3 hr before testing (ACSM, 2010).

Metabolic Testing. A progressive, ramp protocol was performed on an electronically braked cycle ergometer (Lode, Groningen, Netherlands). The protocol ramp rate varied between 15–25 W/min and was based on a standardized formula (Wasserman, Hansen, Sue, Casaburi, & Whipp, 1999). The test was terminated when the participant could not maintain a pedal cadence of 30 rpm. Heart rate (HR), blood pressure (BP), ratings of perceived exertion (RPEs), and expired gases were monitored in accordance with standard exercise testing guidelines (ACSM, 2010). Heart rate was measured using a HR monitor (Polar, Lake Success, NY) and BP was determined by auscultation. Ratings of perceived exertion were estimated each minute using the CR-10 Scale (Borg, 1998). Expired gases were collected through an air cushion mask and analyzed continuously using a metabolic cart (Vacumetrics, Ventura, CA). Peak oxygen consumption (VO_{2peak}) was identified as the largest volume of O_2 consumed per minute during the test. Criteria for verifying maximal exertion were as follows: a peak HR of at least 90% of age-predicted maximal HR (based on 220 – age), a peak RPE of at least 9 (on a 0–10 scale), and a peak respiratory exchange ratio of at least 1.15 (Maud, 1995). Ventilatory threshold was identified through visual inspection of ventilatory equivalents for oxygen and carbon dioxide (Whipp, 2007).

Familiarization. The second visit to the laboratory focused on familiarizing the research participants to the laboratory procedures and experimental sessions. The objective of the familiarization trial was threefold: (1) to confirm the intensity prescriptions for experimental trials as determined by interpretation of maximal testing data, (2) to provide the participants with an opportunity to experience the intensities of the forthcoming interval and continuous exercise sessions, and (3) to provide the participants with an opportunity to become familiar with all experimental data collection procedures. Procedure familiarization included the use of a HR monitor and a tablet computer, which was used for data collection at baseline and postexercise.

Experimental Trials. The remaining visits to the laboratory included the completion of all experimental trials. Design of the experimental trials yielded sessions of cycle ergometer exercise that fit within contemporary descriptions of exercise intensity that suggest the presence of three intensity domains: moderate, heavy, and severe (Gaesser & Poole, 1996). Moderate considers intensities up to the anaerobic threshold, heavy spans anaerobic threshold and critical power, and severe considers intensities above critical power, whereby critical power is estimated to be as the midpoint between anaerobic threshold and maximal capacity (Vanhatalo, Jones, & Burnley, 2011). Each participant completed one continuous trial within the heavy domain and three interval trials within the severe domain. Continuous and interval trials differed on total duration but were matched for total external work. The continuous trial was 20 min in duration and conducted at 10% of the distance between anaerobic threshold and maximal capacity (heavy continuous, or HC). The interval trials were 24 min in duration. The work portion of the three interval sessions was conducted at 60% of the difference between anaerobic threshold and maximal capacity and the recovery portion was conducted at 10–20% of maximal capacity, based on calculations designed to ensure total work was equal for all trials. Each interval used a 1:1 work:recovery ratio and varied only in interval segment duration: 30, 60, and 120 s. The design yielded three different intervals within the severe intensity domain (severe interval-30 [SI-30], SI-60, and SI-120). For example, for the SI-30 session, participants pedaled for 30 s at the high-intensity level, and then pedaled for 30 s at the lower intensity. This work:recovery sequence was repeated 24 times for a total of 12 min of work and 12 min of recovery during the 24-min session. All sessions were preceded by a 2-min warm-up and followed by a 2-min cool-down on the cycle ergometer. Participants were randomly assigned to one of four experimental trial orders. The four orders were determined using a balanced Latin square such that each trial appeared in each position (1st, 2nd, 3rd, 4th) once and only once across orders and each trial directly preceded and followed every other trial once and only once across orders.

Data Collection. Affect was assessed before, during, and after exercise, whereas enjoyment was assessed during and after exercise. Baseline affect was taken immediately after the participant was provided with a description of the upcoming trial at approximately 5 min before the start of exercise. In-task affect and enjoyment were assessed six times during the continuous trial and 12 times during the interval trials (six times each for the work and recovery phases). All of these assessments occurred during the last 10 s of both the work and recovery intervals approximating 1/6, 1/3, 1/2, 2/3, 5/6, and 6/6 of trial completion. Postexercise affect and enjoyment were assessed immediately following cool-down and again 10 min later. All assessments taken outside of the exercise trial occurred while seated comfortably in a reclining chair in a partitioned area adjacent to the exercise equipment and were entered by the participant into a tablet computer. All assessments during the exercise trial were taken by asking the participant to verbalize their perceptions while being provided with the scale as visual reference.

Heart rate was assessed using a monitor and was recorded at the same time points as affect and enjoyment. As such, HR served as the objective measure of exercise intensity. Workload changes were controlled by software linked to the testing system. Interactions between the research staff and participant were limited to required data collection and members of the research staff remained largely out of view of the participant during trials.

Statistical Analysis. Data were analyzed using the SPSS 22 and proceeded in several phases. The first phase included a descriptive analysis of the sample and characteristics of the exercise trials. The second phase focused on HR responses: a repeated-measures ANOVA compared grand mean HR values with experimental trial as the within-subjects factor. The third and fourth phases focused on affective and enjoyment responses, respectively: a repeated-measures ANOVA with time and trial as the within-subjects factors, separate repeated-measures ANOVAs for each trial with time as the within-subjects factor, and a repeated-measures ANOVA with trial and phase (pre- and postexercise) as the within-subjects factors. Given that the repeated measures employed within the current design included more than two levels, Greenhouse–Geisser corrected *p*-values are reported. Significant differences were followed by post hoc comparisons. Criterion for significance was set at $p < .05$. Mean differences were used to calculate Cohen's *d* as an effect size (ES) indicator where appropriate (Cohen, 1992).

Results

Descriptive Data

Participants had a VO_{2peak} of 28 ± 5 mL·kg·min^{-1}, a peak workload of 199 ± 42 W, and a ventilatory threshold at 44 ± 5% peak workload. Testing data revealed the participants had a mean maximal test HR of 188 ± 10 beats·min^{-1} (95% age-predicted maximum) and a mean maximal RPE of 9.8 ± 0.5, suggesting that maximal effort was achieved. Furthermore, results indicate that 95% of participants ($n = 19$) reached the criterion for perceived effort (RPE ≥ 9), 90% of participants ($n = 18$) reached the criterion for maximal heart rate (HR ≥ 90% age-predicted maximum), and 100% of participants ($n = 20$) reached the criterion for maximal respiratory exchange ratio of ≥ 1.15. Analysis of work performed during experimental trials revealed the following: (a) the HC trial was performed at 50 ± 4% peak workload, (b) interval trials alternated between 78 ± 2% peak workload for the work segments and 5 ± 4% peak workload for the recovery segments, and (c) all trials were similar to each other in terms of total energy expenditure ($p > .05$; approximately 165 kcals).

Heart Rate Responses

Consideration of heart rate responses was primarily intended to provide a description of the work demands for the experimental sessions. The development of a grand mean HR value from all in-task and recovery HR time points allowed for a description of the average cardiovascular work associated with the sessions. A one-way repeated-measures ANOVA of these grand means (HC = 158 ± 14 beats·min^{-1}, SI-30 = 142 ± 18 beats·min^{-1}, SI-60 = 150 ± 13 beats·min^{-1}, and SI-120 = 153 ± 12 beats·min^{-1}) revealed significant HR differences between trials, $F(3,57) = 12.91$, $p < .001$. Post hoc analyses revealed that the HC trial was significantly higher than SI-30, $t(19) = 5.49$, $p < .001$, ES = 1.0; SI-60, $t(19) = 4.82$, $p < .001$, ES = 0.6; and SI-120, $t(19) = 2.44$, $p = .025$, ES = 0.4. In addition, SI-30 was significantly lower than SI-60, $t(19) = 2.68$, $p = .015$, ES = 0.5, and SI-120, $t(19) = 2.85$, $p = .01$, ES = 0.7.

Affective Responses

Analysis of affect considered responses taken before, during, and after trials of cycle exercise. A one-way repeated-measures ANOVA comparing preexercise affect revealed no significant differences between trials, $F(3,57) = 1.15$, $p = .33$, ES < 0.5. A two-way repeated-measures ANOVA considering all time points revealed a significant effect for Trial, $F(3,57) = 9.01$, $p < .001$; Time, $F(8,152) = 17.86$, $p < .001$; and a Time × Trial interaction, $F(24,456) = 6.31$, $p < .001$. Follow-up one-way ANOVAs revealed several differences within trials, with in-task affect decreased over time in all trials. Specifically, affect declined during the HC, $F(5,95) = 18.60$, $p < .001$, ES = 1.4; SI-120, $F(5,95) = 18.57$, $p < .001$, ES = 1.3; SI-60, $F(5,95) = 4.98$, $p = .01$, ES = 0.5; and SI-30 trials, $F(5,95) = 3.17$, $p = .047$, ES = 0.5. Post hoc analysis indicated that affect was similar between trials during the first two measurements ($p > .05$), sometimes different during the third measurement (some p-values above and below 0.05), and consistently different for the final three measurements, whereby SI-30 and SI-60 trials produced more positive affect than SI-120 and HC trials ($p < .05$; ES range = 0.5–1.4). Likewise, post hoc analysis in the immediate postexercise period revealed that the SI-60 trial produced more positive affect than the SI-120 trial, $t(19) = 2.82$, $p = .011$, ES = 1.4. Similarly, the SI-30 trial produced more positive affective responses than the HC trial 10 min after exercise, $t(19) = 2.22$, $p = .039$, ES = 0.5. As hypothesized, interval trials produced more favorable affective responses but only when the interval segments were 30 and 60 s. In contrast to the hypothesis, the 120-s interval trial was not significantly different from the continuous trial. Results related to affect are reported in Table 1 and Figure 1.

Enjoyment Responses

Analysis of enjoyment considered responses taken during and after trials of cycle exercise. A two-way repeated-measures ANOVA for in-task responses revealed a significant effect for Trial, $F(3,57) = 5.58$, $p = .003$, and Time, $F(5,95) = 5.73$, $p = .012$, but not for the Time × Trial interaction, $F(15,285) = 1.21$, $p = .309$. Follow-up one-way ANOVAs revealed that in-task enjoyment decreased over time in the HC, $F(5,95) = 3.42$, $p = .045$, ES = 0.5, and the SI-120 trials, $F(5,95) = 6.42$, $p = .007$, ES = 0.6, but was maintained within the SI-60, $F(5,95) = 1.99$, $p = .14$, ES = 0.3, and SI-30 trials, $F(5,95) = 1.81$, $p = .16$; ES = 0.4. Post hoc analysis indicated that enjoyment was similar between trials during the first two measurements ($p > .05$), sometimes different during the third and fourth measurement (some p-values above and below 0.05), and consistently different for the final two measurements, whereby SI-30 and SI-60 trials produced more enjoyment than SI-120 and HC trials ($p < .05$; ES range = 0.5–0.6). A two-way repeated-measures ANOVA for postexercise enjoyment responses revealed a significant effect for Trial, $F(3,51) = 3.99$, $p = .027$, but not for Time, $F(1,17) = 0.15$, $p = .482$, or the Time × Trial interaction, $F(3,51) = 1.69$, $p = .103$. Post hoc analyses for enjoyment in the postexercise period revealed that the SI-60 trial was more enjoyable than the SI-120, $t(19) = 2.85$, $p = .011$, ES = 0.8, and HC trials, $t(19) = 2.64$, $p = .02$, ES = 0.8, immediately after exercise. Likewise, the SI-60 trial was more enjoyable than the SI-120, $t(19) = 3.23$, $p = .004$, ES = 0.8; SI-30, $t(19) = 2.68$, $p = .01$, ES = 0.5; and HC trials, $t(19) = 3.33$, $p = .004$, ES = 0.9, 10 min after exercise. As hypothesized, interval trials were perceived as more enjoyable, but only when the interval segments were 30 and 60 s. In contrast to the hypothesis, the 120-s interval trial was not significantly different from the continuous trial. Results related to enjoyment are reported in Table 2 and Figure 2.

Discussion

The present experiment was designed to investigate the affective and enjoyment responses associated with high-intensity continuous and interval exercise. The experimental manipulation yielded an intense continuous trial and three near-maximal intensity interval trials that varied in duration from 30 to 120 s. Given that each trial was configured to provide a physiological stimulus that is known to provide many cardiometabolic benefits, the primary research question centered on which trial would be considered most pleasurable and enjoyable both during

Table 1 Affective Responses to Exercise

	Experimental Conditions			
Time	Severe Interval-30 (SI-30)	Severe Interval-60 (SI-60)	Severe Interval-120 (SI-120)	Heavy Continuous (HC)
Preexercise	3.4 ± 1.4	3.1 ± 1.5	3.7 ± 1.1	3.6 ± 1.4
1/6 Work	3.4 ± 1.1	3.2 ± 1.4	2.8 ± 1.2	3.0 ± 1.2
1/3 Work	3.0 ± 1.0	2.7 ± 1.3	2.2 ± 1.8	2.5 ± 1.3
1/2 Work	3.0 ± 1.2†	2.6 ± 1.4	1.6 ± 1.9	1.8 ± 1.6
2/3 Work	2.7 ± 1.4†	2.2 ± 1.3†	1.0 ± 2.4	1.4 ± 2.0
5/6 Work	2.9 ± 1.4†	2.2 ± 1.1†	0.4 ± 2.7	0.7 ± 2.4
6/6 Work	2.9 ± 1.2†*	2.5 ± 1.4†*	0.2 ± 2.8*	0.6 ± 2.4*
1/6 Recovery	3.4 ± 1.0	3.3 ± 1.4	3.2 ± 1.1	—
1/3 Recovery	3.2 ± 1.0	3.2 ± 0.9	2.8 ± 1.7	—
1/2 Recovery	3.0 ± 1.3	2.8 ± 1.2	2.8 ± 1.2	—
2/3 Recovery	2.7 ± 1.4	2.8 ± 1.1	2.3 ± 1.9	—
5/6 Recovery	3.0 ± 1.3	2.7 ± 1.1	2.0 ± 2.4	—
6/6 Recovery	3.0 ± 1.2	3.1 ± 1.1	2.4 ± 2.1	—
Post-0	3.2 ± 1.5	3.5 ± 1.5#	2.4 ± 1.3	3.0 ± 1.9
Post-10	3.7 ± 1.2‡	3.6 ± 1.4	3.1 ± 1.8	3.0 ± 1.4

Note. Data are presented as mean affect ± standard deviations. Affective responses scale from –5 (*very bad*), –3 (*bad*), –1 (*fairly bad*), 0 (*neutral*), +1 (*fairly good*), +3 (*good*), +5 (*very good*). All notations indicate statistically significant differences at $p < .05$.

*Significantly lower from beginning to end of trial.

†Significantly higher than SI-120 and HC during exercise.

#Significantly higher than SI-120 after exercise.

‡Significantly higher than HC after exercise.

and after the exercise session. The present findings from the 30-s and 60-s trials support the research hypothesis that interval exercise well above ventilatory threshold can be pleasurable, while findings from the 120-s trial suggest that very long intervals provide no advantage over heavy continuous exercise for overweight-to-obese adults who do not exercise regularly. As such, the findings provide new insight into ongoing efforts to develop exercise approaches that maximize physiological benefit without compromising the perceptual response.

The finding that the continuous heavy intensity exercise produced dramatic reductions in affect over time during the trial is consistent with previous research studies employing bouts of exercise at a similar exercise intensity (Ekkekakis, Parfitt, & Petruzzello, 2011). As such, the current finding provides further support for the dual-mode theory (Ekkekakis, 2005), which theorizes that continuous exercise at and above the anaerobic threshold negatively impacts affect. Current findings that heavy continuous exercise produced affective responses that approached affective neutrality (i.e., FS of 0) but did not become negative are consistent with some existing research (Kilpatrick et al., 2007), while other studies have demonstrated a fully negative affect in response to continuous heavy exercise (Parfitt et al., 2006). Interestingly, results from the 120-s trial in the current study are almost identical to what was observed in the continuous trial. Both trials resulted in affective responses near the end of each trial that were about 3 FS units lower than baseline and more than 2 FS units from a point early in exercise. Also similar to most published research considering continuous exercise at or above the anaerobic threshold, the affective response in the postexercise period rebounded significantly from late exercise values during the postexercise period. Importantly, findings from the 30-s and 60-s intervals are notably different when compared with the 120-s and continuous trials. While affect was reduced during the shorter interval trials, the magnitude and effect size of the change was considerably different from the reduction observed in the longer interval and continuous trials. Specifically, affect within the two shorter interval trials was reduced by approximately 0.5 FS unit from

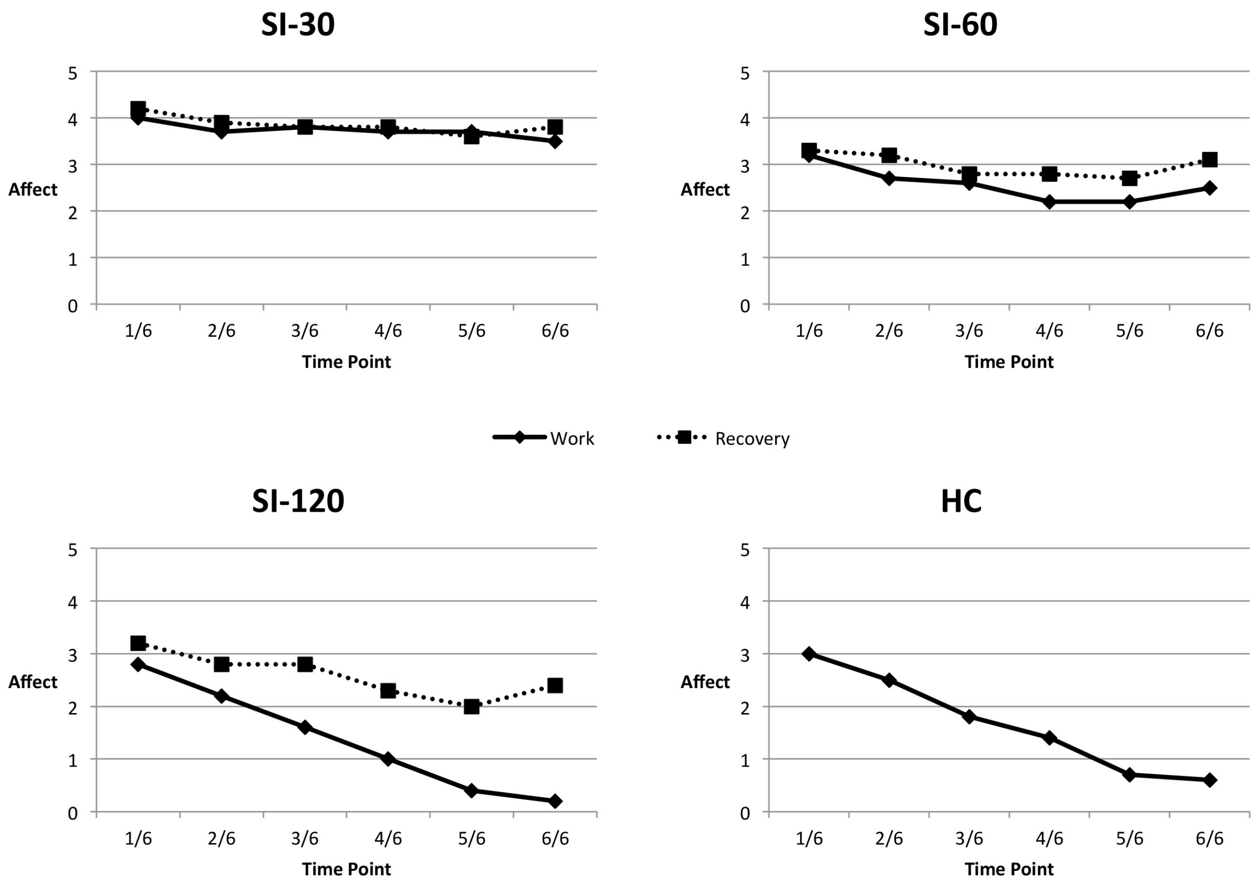

Figure 1 — Affective responses during exercise: Trials being compared are hard continuous (HC) and severe intervals (SIs) varied on duration from 30 to 120 s (SI-30, SI-60, SI-120). Time points represent fractional completion of prescribed, equal work exercise trials.

baseline and the first measurement point during exercise and the final affect near the end of exercise remained well above neutrality. Findings related to postexercise affect are in general agreement with published research indicating that postexercise mood states are generally similar across interval and continuous exercise (Muller et al., 2011; Oliveira et al., 2013). Collectively, the findings provide additional support for the utility of dual-mode theory for continuous exercise and serves to extend the model tenets with respect to shorter intervals.

Findings related to enjoyment responses were somewhat similar to affective responses, with a few notable differences. Specifically, enjoyment levels declined throughout exercise for all trials, but not all decreases were significant. Reductions within the continuous and 120-s trials were approximately 1 full EES unit, representing a moderate effect size change. In contrast, the reductions within the shorter intervals (i.e., SI-30 and SI-60) were no greater than one-half EES unit and not significant, representing a small effect size change. Collectively, these findings suggest that enjoyment was maintained during the shorter intervals but not the continuous or longest interval conditions. Importantly, enjoyment within the continuous and 120-s trials was "slightly to moderately" in the early stages of the trial and became "very little to slightly" near the end of the exercise session. In contrast, enjoyment within the shorter interval trials was "moderately" in the early stages of the trial and only dropped to "slightly to moderately" near the end of the exercise session. These findings indicate that enjoyment was both maintained during the shorter intervals and did not decline to a point that could be described as unpleasant, which is consistent with the findings related to affective response.

Results for enjoyment within the recovery period followed a similar pattern whereby participants reported that the longer interval and continuous trials were less enjoyable than the 60-s trial (13- to 15-unit differential on the PACES scale; representing a large effect size difference). Likewise, all postexercise values were above the midpoint within the scale and thus suggest that all trials were at least somewhat enjoyable. In fact, enjoyment levels observed in this relatively unfit sample were similar to those observed in the single published study that directly compared postexercise enjoyment for vigorous continuous exercise and a session that used several 180-s intervals in a very fit and active sample (Bartlett et al., 2011). Findings from that study noted that enjoy-

Table 2 Enjoyment Responses to Exercise

Time	Experimental Conditions			
	Severe Interval-30 (SI-30)	Severe Interval-60 (SI-60)	Severe Interval-120 (SI-120)	Heavy Continuous (HC)
1/6 Work	4.0 ± 1.1	3.9 ± 1.3	3.6 ± 1.3	3.5 ± 1.2
1/3 Work	3.7 ± 1.2	3.8 ± 1.3	3.4 ± 1.3	3.4 ± 1.4
1/2 Work	3.8 ± 1.2	3.6 ± 1.5	3.2 ± 1.3	3.2 ± 1.5
2/3 Work	3.7 ± 1.7	3.6 ± 1.4	2.9 ± 1.5	3.1 ± 1.3
5/6 Work	3.7 ± 1.4†	3.4 ± 1.4†	2.8 ± 1.5	2.8 ± 1.5
6/6 Work	3.5 ± 1.5†	3.5 ± 1.3†	2.7 ± 1.7*	2.8 ± 1.6*
1/6 Recovery	4.2 ± 1.1	4.0 ± 1.2	4.0 ± 1.2	—
1/3 Recovery	3.9 ± 1.2	3.9 ± 1.1	3.8 ± 1.1	—
1/2 Recovery	3.8 ± 1.2	3.8 ± 1.3	3.8 ± 1.2	—
2/3 Recovery	3.8 ± 1.5	3.7 ± 1.3	3.2 ± 1.4	—
5/6 Recovery	3.6 ± 1.5	3.7 ± 1.2	3.2 ± 1.7	—
6/6 Recovery	3.8 ± 1.6	4.0 ± 1.4	3.6 ± 1.8	—
Post-0	91 ± 13	96 ± 14‡	81 ± 24	83 ± 21
Post-10	91 ± 14	98 ± 15	83 ± 24	82 ± 19

Note. Data are presented as enjoyment affect ± standard deviations. Enjoyment responses during exercise scale from 1 (*not at all*), 2 (*very little*), 3 (*slightly*), 4 (*moderately*), 5 (*quite a bit*), 6 (*very much*), 7 (*extremely*). Enjoyment responses postexercise scale from 18 (*not at all*), 126 (*extremely*). All notations indicate statistically significant differences at $p < .05$.

*Significantly different from beginning to end of trial.

†Significantly higher than SI-120 and HC during exercise.

‡Significantly higher than SI-120 after exercise.

ment was greater for the interval trial (and at enjoyment levels similar to those observed in the current study), when compared with the vigorous continuous trial that was considered less enjoyable than any of the trials in the current study. Therefore, while the current findings are in partial agreement with the prior study, the greater intensity of the continuous trial and higher fitness level of participants in the previously published study may explain some of the differences between findings.

The finding that affect and enjoyment responses were not entirely parallel is noteworthy. The shorter interval trials resulted in significant reductions in affect but not significant reductions in enjoyment. This finding is consistent with emotion research suggesting a distinction between core affect (i.e., hedonic pleasure/pain) and more distinct emotional experience that requires cognitive appraisal (Russell & Barrett, 1999). Similar distinctions have been made between hedonic pleasure (i.e., affect) and more distinct experiences including "value" (Higgins, 2006), "flow" (Csikszentmihalyi, 1990), and "wanting" (Berridge & Robinson, 2003; Salamone & Correa, 2002), all of which involve incentive motivation and relate to activities that people report enjoying. In the current study, the more hedonically based response to "How do you currently feel?" is likely driven by immediate bodily sensations occurring during the trials. Assessing "how much you are enjoying this exercise session," while involving core affective responses, should also require cognitive appraisal to categorize the feelings into an emotion label (Russell & Barrett, 1999; Lazarus, 1991). Labeling a feeling as an emotion such as enjoyable requires additional appraisals of self-relevance, goal relevance, responsibility for the event, and abilities to achieve goals (Lazarus, 1991). The assessment of enjoyment in the current study, while drawing upon the declining core affect, may have been better preserved because the exercise was perceived as goal relevant, goal congruent, and achievable. The differences in enjoyment between the shorter and longer interval trials suggest that at least some of these appraisals were more positive for the shorter interval trials. This conclusion is highly speculative because appraisals were not measured in the current study in part because the current study design prohibited detailed appraisal assessments during the exercise sessions. Future research may benefit from attempts to understand the distinction between in-task hedonic affect and motivationally relevant enjoyment when examining psychological responses to exercise.

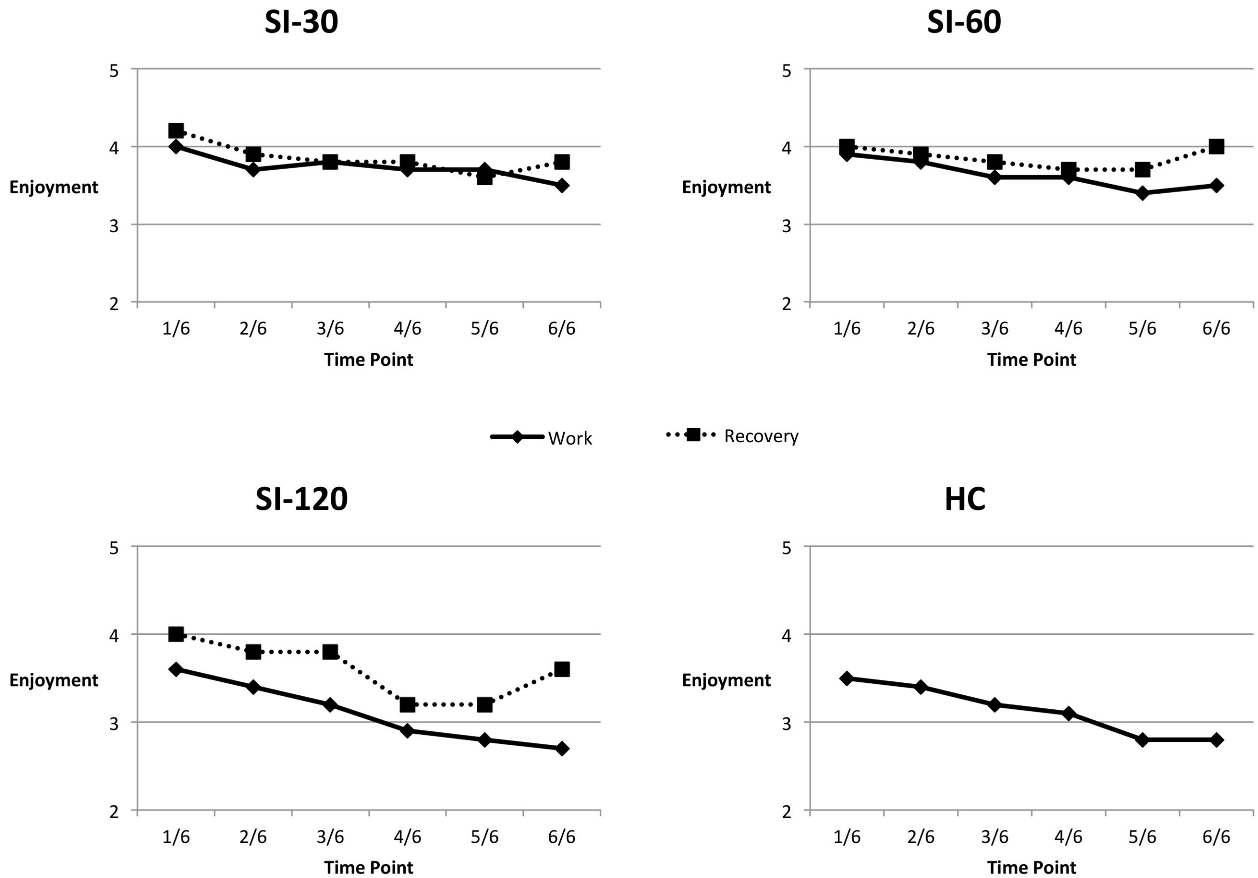

Figure 2 — Enjoyment responses during exercise: Trials being compared are hard continuous (HC) and severe intervals (SIs) varied on duration from 30 to 120 s (SI-30, SI-60, SI-120). Time points represent fractional completion of prescribed, equal work exercise trials.

The goals of exercise programs are often twofold, with emphasis both on physiological benefit and tolerability. The possibility that recreational exercisers and athletes might enjoy HIIT exercise could be deemed as having limited value from a broad public health perspective because these individuals are already engaging in regular exercise. In contrast, the current findings that shorter-duration HIIT was more enjoyable and functioned to better preserve affect in overweight and insufficiently active adults than longer-duration HIIT and heavy continuous exercise is promising. The many benefits from HIIT are only truly helpful on a health promotion scale when such forms of exercise are well tolerated and adhered to by the individuals who are the targets of public health recommendations and interventions. As such, the current findings suggest that HIIT can be a pleasurable experience provided that the duration of the intervals are carefully considered. Maintenance of pleasure within the exercise session is important given findings that affective valence has the potential to predict future physical activity participation in sedentary individuals (Williams, Dunsiger, Jennings, & Marcus, 2012). However, research outside of the exercise domain has shown that the effect of core affect on behavior is mediated by specific cognitive appraisals (Seo, Bartunek, & Barrett, 2010). Although affect was not as well preserved in the shorter interval trials as in-task enjoyment, it was still better preserved than the longer interval and continuous trials. Thus, given the same amount of overall workload, individuals may be more likely to adhere to shorter interval HIIT than longer interval HITT and continuous heavy exercise, a proposal ripe for future research.

Strengths of the current study are noteworthy. The tightly controlled design related to workloads and exercise environment increase the likelihood that findings can be attributed rather exclusively to the experimental manipulation. Specifically, the design feature allowing all trials to be of the same estimated energy expenditure removes potential confounds that would interfere with interpretation of study findings. Another important strength relates to the study sample. These participants were both insufficiently active and overweight-to-obese, which suggests that the current findings have direct application to large segments of the general population for whom PA interventions are most needed. A final innovation for this study relates to the manner in which exercise intensity was quantified. While many studies have prescribed exercise based on maximal aerobic capacity or anaerobic threshold, the current study is the first to precisely prescribe exercise relative to multiple metabolic thresholds that impact exercise tolerance. This design feature allows an approach to assessing affective responses that provides for a useful test of the dual-mode theory within the context of interval-based exercise.

Limitations for the current study are also important to consider. While the sample was overweight-to-obese and insufficiently active, most participants were college-aged, which limits generalizability to the broader population. Generalizability is further limited by the tightly controlled research design, which yielded a rather sterile laboratory environment lacking the visual, auditory, and social stimuli noted within more typical exercise settings. A related limitation linked to ecological validity exists because the exercise sessions were fully prescribed and did not provide flexibility or autonomy for the exerciser. Although these factors may limit generalizability of the findings, they were required to ensure accurate comparisons of affect and enjoyment across the four experimental trials. It remains possible that similar sessions that provide more varied work and recovery segments could be perceived differently than that which was observed in the current study. Also possible is that the difference in exercise duration in the interval sessions (24 min) compared with the continuous trial (20 min) may have influenced the findings, but this did not appear to be the case as there were differences among the interval trials and between the interval and continuous trials. A final limitation also relates to the absence of a moderately intense continuous exercise session, which would be useful as a comparison given the well-established findings that intense continuous exercise is not very pleasurable, especially for unfit and overweight individuals. However, the primary goal of matching continuous and interval exercise sessions for total external work was achieved and thus helps ease the challenges presented by these limitations.

Given the innovations and limitations within the current study, there are many opportunities to both improve and expand this line of research with future studies. While the current data indicate that shorter intervals of 30 and 60 s are more pleasurable and enjoyable than longer intervals, it would be important to determine whether this trend would continue with intervals of shorter duration. Future research should also consider a similar design employed using a weight-bearing modality such as walking or running, especially within an overweight or obese sample. It is possible that some of the features of intervals that are perceived as pleasurable may not be present when using an exercise modality that requires the excess weight to be more readily felt by the exerciser. And finally, researchers should consider what type of continuous exercise session is best suited to serve as the comparison group in these types of studies. The current design selected a relatively intense continuous exercise session to compare with high-intensity intervals, but future research might consider the utility of a more moderate session of exercise that would have a considerably longer duration, which may be more reflective of the type of continuous exercise that unfit and insufficiently active individuals might select.

In conclusion, the experimental design provided an important test of the dual-mode theory and opens up the possibility that the model may require elaboration to more adequately consider the impacts of interval exercise on affective responses to exercise. This study provides a foundation for future investigations interested in examining interval training and traditional continuous exercise in overweight and insufficiently active populations with the larger goal of improving exercise tolerability, enjoyment, and ultimately adherence in this important target for health promotion efforts.

Acknowledgments

Funding for this project was provided by USF World.

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Manuscript submitted: August 16, 2014

Revision accepted: January 17, 2015