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PHYSICAL ACTIVITY AND HEALTH

Affective Responses to High Intensity Interval Training Relative to Moderate Intensity Continuous Training

RESEARCH

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TYLER M. DREGNEY
CHELSEY M. THUL
JENNIFER A. LINDE
BETH A. LEWIS

*Author affiliations can be found in the back matter of this article

ABSTRACT

Background: Although physical activity (PA) among adults is associated with health benefits, only one-third of young adults meet PA recommendations. Examining if the type of PA has an impact on individuals' psychological responses may impact future interventions and PA rates among young adults.

Aims: This study examined affective and other psychological responses to a class of high intensity interval training (HIIT) or moderate intensity continuous training (MICT).

Methods: Participants (n = 41) were active 18–25-year-old college students randomized to participate in HIIT or MICT. HIIT was higher intensity and included more breaks from PA relative to MICT. Both classes were 30-minutes that included a warm-up and cool down. Psychological factors included affect, enjoyment, and exercise-feeling.

Results and Conclusions: Participants in the HIIT condition reported lower positive affect and higher physical exhaustion during PA than the MICT condition. However, there was no effect of group assignment on enjoyment, tranquility, positive engagement, and revitalization. This study provides some evidence that HIIT may result in lower levels of positive affect and more exhaustion during PA; however, HIIT does not appear to impact enjoyment. Future studies should examine affect in HIIT relative to MICT through the lens of dual-mode theory over a multi-week intervention. Additionally, HIIT is often discussed as requiring less time relative to traditional workouts while experiencing similar positive health benefits, so future studies should examine affect during HIIT vs. MICT in shorter classes.

CORRESPONDING AUTHOR:
Tyler M. Dregney
University of Minnesota, Minneapolis, MN, USA
dregn011@umn.edu

KEYWORDS:
HIIT; MICT; affect; enjoyment

TO CITE THIS ARTICLE:
Dregney, T. M., Thul, C. M., Linde, J. A., & Lewis, B. A. (2023). Affective Responses to High Intensity Interval Training Relative to Moderate Intensity Continuous Training. *Physical Activity and Health*, 7(1), pp. 229–238. DOI: https://doi.org/10.5334/paah.271

DOI: 10.5334/paah.271

INTRODUCTION

Physical and mental health benefits are experienced from sufficient physical activity (PA). Specifically, meeting PA guidelines is associated with the prevention of type II diabetes, cardiovascular disease, cancer, hypertension, obesity, and osteoporosis (United States Department of Health and Human Services, 2018; Warburton & Bredin, 2017; Warburton, Nicol, & Bredin, 2006). Mental health benefits include improved cognitive function, improved sleep quality, reduced anxiety, reduced depression, and improved quality of life (United States Department of Health and Human Services, 2018).

To experience these benefits, the United States Department of Health and Human Services (2018) recommends that adults engage in 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity PA per week. However, based on self-report measures, only 19% of women and 26% of men meet these PA guidelines (United States Department of Health and Human Services, 2018). As few as 5% of adults meet the guidelines when PA is assessed objectively via an accelerometer (Tucker et al., 2016). Among college-aged individuals, only 34% of individuals report meeting the PA guidelines (National Center for Health Statistics, 2018).

PA typically decreases as individuals enter early adulthood, and, on average, this trend continues throughout one's life (Cocca et al., 2014; Hallal et al., 2012; Lox, Ginis, & Petruzzello, 2016). Therefore, establishing recommended PA behaviors during young adulthood could have a lifelong impact on PA levels (Telama et al., 2005). Brinthaupt, Kang, and Anshel (2010) observed common barriers to PA including not having enough time, lacking confidence, insufficient knowledge, and being intimidated to be active.

High intensity interval training (HIIT) has been a popular strategy to help adults meet PA recommendations. HIIT consists of small bouts of intense PA interspersed with rest intervals. Research indicates that HIIT is related to positive health benefits (Martinez et al., 2015; Poon et al., 2018; Ramos et al., 2015). HIIT is often compared to moderate intensity continuous training (MICT), which is continuous PA with no or few breaks, as MICT is the more traditional structure for cardiovascular activity (Martinez et al., 2015; Poon et al., 2018; Ramos et al., 2015). For example, Ramos et al. (2015) conducted a meta-analysis examining the physiological benefits and health-related impact of HIIT relative to MICT among adults. The review indicated that HIIT produced significantly greater improvements in cardiorespiratory fitness, cardiovascular disease risk factors, and vascular function compared to MICT. HIIT interventions have also produced positive outcomes (e.g., greater positive affect, enjoyment) when implemented with college students (Martinez et al., 2015; Poon et al., 2018).

Martinez et al. (2015) conducted an intervention comparing the impact of varying interval length during HIIT relative to MICT in college students. Findings revealed that engaging in interval training, particularly intervals of 30 and 60 seconds, resulted in participants reporting greater pleasure and enjoyment relative to those in MICT. These findings are supported by research from Poon et al. (2018), who compared the impact HIIT, MICT, and vigorous-intensity continuous training had on college students affect, self-efficacy, and PA preference. Participants reported greater affect in the HIIT condition relative to the MICT.

Martinez et al. (2015) and Poon et al. (2018) findings are significant as PA adherence has been linked to three states, including mood, emotion, and affective responses (Crocker et al., 2004; Ekkekakis, 2003; Williams et al., 2008). An affective response is hedonic, meaning an event leads to a subjective feeling of either pleasure or displeasure (Ekkekakis, 2003; Weiner, 1986. Hedonic theory proposes human behavior is motivated by the pursuit of pleasure and avoidance of pain (Kahneman, 1999). In support of the findings from Martinez et al. (2015) and Poon et al. (2018), hedonic theory suggests that the affect one experiences during PA may dictate their future desire to engage in PA (Ekkekakis, 2009).

Dual-mode theory is also important to consider, which suggests an individual can experience a pleasurable affective response even after completing PA that is perceived as an aversive stress or stimulus (Ekkekakis, 2005), which can lead individuals to maintain their PA behavior (Oliveira et al., 2013). This theory is supported by findings from Stork et al. (2019), who observed that young adults experienced negative affect during a class of HIIT, then reported a preference for HIIT relative to MICT post-activity. Given the connection of affect to PA behavior, applying these theories to PA interventions warrants further consideration.

PA interventions are typically completed in lab-based settings (Ramos et al., 2015), which do not generalize to real world settings. There have been very few high quality, home-based PA studies. Blackwell et al. (2017) found that delivering a home-based PA program can be an effective strategy to overcome many of the barriers to PA faced by adults. However, previous home-based studies (Blackwell et al., 2017; Reljic, Wittmann, & Fischer, 2018) have yielded mixed results. Further, previous studies have not assessed the impact of a home-based PA study on college students.

In summary, there are conflicting findings regarding the effect of HIIT on affect and enjoyment (Ekkekakis, Hall, & Petruzzello, 2004; Martinez et al., 2015; Poon et al., 2018; Stork et al., 2019) and limited findings on home-based PA (Blackwell et al., 2017; Ramos et al., 2015; Reljic, Wittmann, & Fischer, 2018). Therefore, the purpose of this study was to examine affective and other psychological responses to HIIT relative to MICT delivered via home-based, online video. The first hypothesis was that, consistent with hedonic theory, participants randomly assigned to HIIT would report more positive affective responses during and after the class relative to participants in MICT. Consistent with dual-mode theory, the second hypothesis proposed that participants randomly assigned to the HIIT class would report higher levels of enjoyment and exercise feeling after the class relative to participants in the MICT.

METHOD

PARTICIPANTS

A convenience sample of 77 individuals completed the pre-screening questionnaire. All individuals who completed the pre-screening questionnaire were eligible for the study and contacted to schedule their class. Fifty of the 77 replied with availability for classes and were randomly assigned to a condition (HIIT, n = 26; MICT, n = 24). Nine of the participants did not attend their assigned class. Therefore, 41 individuals participated in either the HIIT (n = 22) or MICT (n = 19) condition.

Participants were enrolled at a large, public, Midwestern university and were recruited from undergraduate kinesiology classes via email and in-class announcements. Extra credit towards their course was offered for their participation. The participants were college students who met the inclusion criteria of being capable of completing a 25-minute PA class. The exclusion criteria included being pregnant, unable to read and write in English, and instruction from a health professional to not engage in PA. The final sample was primarily female, and a majority were white (see Table 1). Most participants reported being active at least three times per week for 30 minutes each session. The study (STUDY00010935) was approved by the University's Institutional Review Board.

CHARACTERISTIC	TOTAL (n = 41)	HIIT (n = 22)	MICT (n = 19)	P-VALUE
Age	20.51 (1.94)	20.00 (.98)	21.11 (2.56)	0.07
Gender (%)				0.49
Female	28	17	11	
Male	23	5	8	
Race (%)				0.06
White	31	14	17	
Non-white	10	8	2	
Ethnicity (%)				0.28
Hispanic	1	0	1	
30 minutes of exercise %	0.71	0.73	0.68	0.76

Table 1 Participant Characteristics.

Note: Figures are reported as totals and means with standard deviations in parentheses.

PROCEDURE

Once participants were deemed eligible for the study, they were randomized to one of the two conditions. The classes were home-based, held on Zoom, with participants completing the class in their own space. Once online, participants provided written consent and completed the pre-class questionnaire at the beginning of their class on the Zoom call. The written consent and all questionnaires were provided to and completed by participants by sending the Qualtrics URL

DOI: 10.5334/paah.271

through Zoom's chat feature. Participants were then presented either a HIIT or MICT video through Zoom, which were created by an American College of Sport Medicine Exercise Physiologist®.

The classes consisted of a five-minute warm up, 20-minute body weight HIIT or MICT class, and five-minute cool down. Participants were asked to leave their cameras on to ensure they were engaging in the class. The HIIT class contained higher intensity exercises (e.g., jump squats, running in place) and more breaks (20 seconds of exercise followed by 10 seconds of rest repeated for four minutes, then a one-minute break) relative to the MICT class (e.g., walking in place, side stepping) with fewer breaks (one minute break every five minutes). Additionally, participants were tasked with maintaining an assigned target heart rate zone (THZ) measured through either their radial (wrist) or carotid (neck) artery based on their condition, with HIIT participants aiming for 70–85% of their maximum heart rate and MICT participants aiming for 55–70% of their maximum heart rate. Participants' maximum heart rate was calculated by subtracting their age from 220 (CDC, 2011). The differences between the conditions are summarized in Table 2. During similar stages of the HIIT and MICT class, the video was paused on Zoom twice to administer the mid-class questionnaires and to allow participants to measure their heart rate. The participants remained on the Zoom call while completing questionnaires. The first pause coincided with the conclusion of a break halfway through the class, while the second pause coincided with the beginning of a break two-thirds of the way through the class. After the class, participants completed the post-class questionnaire.

Table 2 Condition Characteristics.

Note: THZ = Target Heart Rate Zone.

	HIIT	MICT
Class Structure	5-minute warm-up, 20-minute workout, 5-minute cool down	5-minute warm-up, 20-minute workout, 5-minute cool down
Exercises	Jump squats, high knees, plank variations, burpees, jumping lunges	Walking in place, side stepping, front kicks, mini side lunge, grapevine
Breaks	20 seconds of exercise followed by 10 seconds of rest repeated for four minutes, then a one-minute break	One minute break every five minutes
THZ	70–85%	55–70%

MEASURES

Participants were asked to complete a series of questionnaires before, during, and after their participation in their assigned condition. The measures included demographic information, affective response, exercise feeling, PA enjoyment, and rate of perceived exertion.

DEMOGRAPHICS

Participants completed demographic questionnaires regarding their age, gender identity, race, ethnicity, and average PA minutes per week.

AFFECTIVE RESPONSE

Participants' affective responses to PA were measured using the Feeling Scale (FS; Hardy & Rejeski, 1989). The FS asks participants how they are feeling and enjoying exercise. The FS is only two items and therefore, it can be administered before, during, and after exercise quickly. The participants rated their current feeling as part of the FS using a scale of -5 to +5, with a higher score indicating higher levels of positive affect. They also rated their enjoyment as part of the FS on a scale of 1–7, with higher scores reflecting higher enjoyment. The FS is reliable for assessing in-exercise affect (Hardy & Rejeski, 1989).

EXERCISE FEELING

Participants completed the exercise-induced feeling inventory (EFI), which assessed participants' exercise feeling before and after a class (Gauvin & Rejeski, 1993). The 12-item questionnaire instructs participants to rate how they felt on a scale of 0–4. The EFI is scored by summing the four subscales, which include revitalization, physical exhaustion, positive engagement, and tranquility. The four subscales each consist of three items. The EFI has demonstrated good internal consistency and reliability (Gauvin & Rejeski, 1993).

PA ENJOYMENT

To measure participants' PA enjoyment, the PA enjoyment scale (PACES; Kendzierski & DeCarlo, 1991) was used. The PACES is an 18-item measure directing participants to rate how they feel about various items relating to PA on a 1–7 scale, with one and seven reflecting opposite ends of the spectrum. For example, the two anchors for the first item are, "I enjoy it" and "I hate it," where the one aligns with "I enjoy it" and a seven aligns with "I hate it." Eleven of the items are reverse scored. Higher scores indicate higher enjoyment of PA (Kendzierski & DeCarlo, 1991).

RATE OF PERCEIVED EXERTION

To measure participants' perceived exertion, the rating of perceived exertion (RPE) scale (Borg & Ottoson, 1986) was used. RPE has been linked to affect in previous studies (Acevedo, Rinehardt, & Kraemer, 1994). Participants report their perceived exertion level using a 6–20 scale, with lower numbers representing less exertion and a higher number representing greater exertion. The scale includes descriptors of the levels to improve participants' understanding of the levels. For example, level six represents "no exertion at all" and level 17 would be considered "very hard." The RPE scale has been shown to be a valid measure of perceived exertion in PA among healthy individuals (Chen, Fan, & Moe, 2002).

DATA ANALYSIS

After the completion of data collection, data were entered into SPSS® 27 and screened for missing data. Since the questionnaires were collected via Qualtrics, no questions were left unanswered as responses to all questions were required before the questionnaires could be submitted. Descriptive analysis of the demographic questionnaires was conducted. All scales were found to be reliable via Cronbach's alpha.

To examine the first aim, a between groups univariate analysis was conducted to examine the effect of condition assignment on affect during and after HIIT relative to MICT controlling for baseline levels. The second aim was assessed using a between groups univariate analysis to examine the effect of condition assignments on exercise feeling and enjoyment controlling for baseline levels. Significance was determined using p £ 0.05.

RESULTS

Participant characteristics are listed in Table 1. Participants' reported heart rate data (see Table 3) indicates that participants were in the intended heart rate range for their condition. The majority of participants in the HIIT condition reported heart rates within the THZ, with 77.27% and 68.18% being within 70–85% of their maximum heart rate respectively during the two measurements. The majority of participants in the MICT condition reported heart rates within the THZ, with 68.42% and 84.21% being within 55–70% respectively during the two heart rate measurements. Additionally, participants' previous physical activity experience had no impact on their reported RPE.

VARIABLE	CONDITION	MID #1		% IN THZ	MID #2		% IN THZ
		M	(SD)		M	(SD)	
Heart Rate							
	HIIT	150.91	18.05	77.27	148.95	21.64	68.18
	MICT	123.58	23.57	68.42	128.53	16.12	84.21

Table 3 Descriptive statistics for heart rate mean between conditions.

Note: THZ = Target Heart Rate Zone.

AFFECT

When controlling for baseline, there were no differences between HIIT and MICT on positive affect during the first mid-class or post-class ratings. However, participants in the HIIT condition did report significantly less positive affect relative to the MICT condition during the mid-class second rating, $F(1, 38) = 7.503$, $p < .01$ (see Table 4). The results for the enjoyment scale of the FS revealed no significant differences between the two conditions at any of the timepoints.

VARIABLE	CONDITION	PRE		MID #1		MID #2		POST	
		M	(SD)	M	(SD)	M	(SD)	M	(SD)
FS-Current (Range: -5–5)									
	HIIT	2.32	2.03	2.14	1.75	**1.95**	2.19	2.68	1.84
	MICT	2.37	1.86	3.42	1.68	**3.53**	1.71	3.11	1.73
FS-Enjoyment (Range: 1–7)									
	HIIT	4.23	1.27	2.32	1.64	2.14	1.83	4.86	1.17
	MICT	4.16	1.12	2.63	1.71	2.79	1.51	4.63	1.30

Table 4 Descriptive statistics for FS-current and FS-enjoyment over time by condition.

Notes: FS = Feeling Scale. HIIT = High Intensity Interval Training. MICT = Moderate Intensity Continuous Training. Bold indicates a significant ($p < .05$) difference between the conditions.

ENJOYMENT/EXERCISE FEELING

There were no significant differences of condition assignment on positive engagement, revitalization, and tranquility subscales on the EFI or PACES when controlling for pre-class scores (see Table 5). There was a significant difference for the EFI physical exhaustion subscale, $F(1, 38) = 27.596$, $p < .001$, indicating that participants in the HIIT class reported higher levels of exhaustion relative to participants in the MICT class after controlling for baseline. Consistent with this finding, participants in the HIIT condition also reported significantly higher RPE, $F(8, 41)$, $p < .001$, relative to the MICT during both mid-class ratings (see Table 6).

VARIABLE	CONDITION	POSSIBLE RANGE	PRE		POST	
			M	(SD)	M	(SD)
EFI-Positive Engagement		0–12				
	HIIT		7.27	–2.10	7.82	–1.59
	MICT		6.47	–2.29	7.90	–2.08
EFI-Revitalization		0–12				
	HIIT		6.00	–2.33	7.14	–2.49
	MICT		5.21	–2.37	7.05	–2.09
EFI-Physical Exhaustion		0–12				
	HIIT		3.86	–2.46	**6.00**	–2.76
	MICT		3.11	–2.33	**1.90**	–1.88
EFI-Tranquility		0–12				
	HIIT		8.00	–3.21	6.18	–2.46
	MICT		6.00	–2.36	6.95	–2.70
PACES		18–126				
	HIIT		103.27	–16.31	101.32	–16.79
	MICT		101.26	–14.97	104.53	–17.66

Table 5 Descriptive statistics for the EFI subscales, PACES, FAS, and ESES over time by condition.

Notes: EFI = Exercise-Induced Feeling Inventory. PACES = Physical Activity Enjoyment Scale. Standard deviations are listed in parentheses. Bold indicates a significant ($p < .05$) difference between the conditions.

VARIABLE	CONDITION	POSSIBLE RANGE	MID #1		MID #2	
			M	(SD)	M	(SD)
RPE		6–20				
	HIIT		**13.41**	2.11	**14.18**	2.48
	MICT		**11.00**	1.76	**11.74**	1.59

Table 6 Descriptive statistics for RPE mean between conditions.

Notes: RPE = Rate of perceived exertion. Bold indicates a significant ($p < .05$) difference between the conditions.

DISCUSSION

Previous research examining the impact of HIIT on affect, enjoyment, and exercise-feeling relative to MICT in college students and young adults has yielded inconsistent results (Ekkekakis, Hall, & Petruzzello, 2004; Martinez et al., 2015; Poon et al., 2018; Stork et al., 2019). No previous

research has examined the impact of a home-based PA program for college students. This study sought to address these inconsistencies and gaps by examining affective and other psychological responses to HIIT relative to MICT delivered via home-based, online video.

In contrast to the first hypothesis, affect was not higher in the HIIT condition relative to the MICT condition. During the second mid-class rating, HIIT was reported as significantly less pleasurable than MICT, while there were no differences between conditions during the remaining time points. Additionally, the post-class rating revealed no significant differences. Our findings contrast with the Martinez et al. (2015) and Poon et al. (2018) studies which found that young adults experience greater levels of positive affect during a class of HIIT relative to MICT. A potential explanation for this contrast could be the inclusion of two one-minute breaks during the MICT class since neither Martinez et al. (2015) nor Poon et al. (2018) had breaks in their MICT conditions. However, the post-class ratings having no significant differences between conditions does support dual-mode theory.

Dual-mode theory proposes individuals can experience an aversive state (i.e., negative affect) during an activity, which is then followed by a positive response at the end of the activity. Consistent with dual-mode theory and this study, Stork et al. (2018) observed positive affect levels decrease during a HIIT class followed by an increase in positive affect post-class. A potential explanation for the decrease in affect is that activity near or above the ventilatory threshold has been found to decrease positive affect during activity (Ekkekakis, Hall, & Petruzzello, 2004). Despite the decrease in positive affect during activity, the increase post-class suggests HIIT can lead to positive affect after activity. Research in this area continues to be inconclusive given findings from Martinez et al. (2015), Poon et al. (2018), Stork et al. (2018), and this study. Examining hedonic theory and dual-mode theory in HIIT moving forward will be an important topic.

As expected, participants in the HIIT condition reported higher levels of physical exhaustion than participants in the MICT condition. Contrary to the hypothesis, there was no effect of condition assignment on the other types of exercise feeling (i.e., positive engagement, revitalization, and tranquility). These findings are inconsistent with dual-mode theory. Dual-mode theory suggests an individual can experience a positive response even after completing PA perceived as an aversive stress or stimulus (Ekkekakis, 2005). However, our findings are consistent with Tuuri's (2014) study, which found that although participants may interpret HIIT as significantly more intense, they experience similar levels of positive engagement, revitalization, and tranquility relative to MICT. Participants in the HIIT condition reported higher RPE ratings relative to the MICT condition, indicating that despite higher intensity ratings, there was no lasting negative effect on positive engagement, revitalization, and tranquility.

This study had several strengths. First, the study included random assignment to conditions and validated measures. Second, the HIIT and MICT classes were designed and instructed by an American College of Sport Medicine Exercise Physiologist®. Additionally, factors were controlled between the two conditions by having the same instructor instruct both classes via the same delivery model (i.e., online video). Third, this study is one of the first to deliver home-based PA via video with live, online participants when observing the impact of HIIT relative to MICT. Finally, affect was assessed during PA in addition to before and after the PA classes.

There were also several limitations to this study. First, the study population lacked ethnic, gender, and racial diversity, therefore, limiting the generalizability of the findings. Second, the study population was a highly active sample. Therefore, the findings do not generalize to inactive individuals. Third, given the small sample size, it is possible the lack of differences between conditions was due to low power. Fourth, there was no control group to allow for comparison between the intervention and comparison conditions. Finally, this is the first study that has used these specific HIIT and MICT classes, so it is possible that the structure or intensity of the classes were not consistent with previous studies. Specifically, the MICT class in this study had two one-minute breaks during the class, which is not consistent with other research in this area (Martinez et al., 2015; Poon et al., 2018).

The limitations of this study indicate a need for more research in this area with a more representative group of individuals including more diversity in gender, race, ethnicity, and PA level. Additionally, the current sample all had adequate space, electronic equipment, and bandwidth to engage in this program at home via Zoom, which may not be the case in samples

with greater economic diversity. A larger sample could provide insight on how findings might differ between demographic groups and clarification on the inconsistencies that exist in the literature when observing the effect of HIIT and MICT on affective responses. Additionally, HIIT is often touted as providing positive health benefits with less required time, so future studies should examine affect during HIIT vs. MICT in shorter classes. Finally, future studies could observe affect, exercise feeling, enjoyment, arousal, and self-efficacy through the lens of dual-mode theory over multiple classes of HIIT relative to MICT.

Future studies could also compare the efficacy of live, online delivery of home-based PA relative to in-person classes. Home-based PA can be a useful strategy to improve accessibility to PA for college students. Bevan et al. (2021) found undergraduate college students cited weight stigma and concerns about physical appearance as reasons for avoiding physical activity and sport. Home-based PA can be implemented to overcome many barriers to PA (Zheng et al., 2022) while providing similar benefits relative to face-to-face interventions (Blackwell et al., 2017).

CONCLUSION

In summary, participants in the HIIT condition reported significantly lower positive affect and higher physical exhaustion relative to those in the MICT condition. However, consistent with dual-mode theory, participants in the HIIT condition experienced an increase in positive affect post activity. Despite these findings, there were no differences in post-class affect, enjoyment, engagement, tranquility, and revitalization. Young adulthood is a common point in life when a large decrease in PA is observed making PA interventions particularly relevant for this age group. Since participants in this study were homogenous and highly active, future research is necessary with young adults who are more representative of the population. Additionally, future studies should examine how a multi-week intervention would impact affect using the framework of dual-mode theory in HIIT relative to MICT.

DATA ACCESSIBILITY STATEMENT

The dataset supporting the results of the study is available upon request.

ETHICAL AND CONSENT

This study was approved by the university's Institutional Review Board. Participants provided written consent to participate. All methods were carried out in accordance with Social Protocol (HRP-580). Informed consent was obtained from all participants.

COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

TD conducted the study and TD, CT, JL, and BL contributed to development of study. TD and BL analyzed the data. All authors read and approved the final manuscript.

AUTHOR AFFILIATIONS

Tyler M. Dregney orcid.org/0000-0003-2062-2133
University of Minnesota, Minneapolis, MN, USA

Chelsey M. Thul
University of Minnesota, Minneapolis, MN, USA

Jennifer A. Linde orcid.org/0000-0002-9033-2097
University of Minnesota, Minneapolis, MN, USA

Beth A. Lewis orcid.org/0000-0002-6034-568X
University of Minnesota, Minneapolis, MN, USA

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TO CITE THIS ARTICLE:
Dregney, T. M., Thul, C. M., Linde, J. A., & Lewis, B. A. (2023). Affective Responses to High Intensity Interval Training Relative to Moderate Intensity Continuous Training. *Physical Activity and Health*, 7(1), pp. 229–238. DOI: https://doi.org/10.5334/paah.271

Submitted: 04 April 2023
Accepted: 20 June 2023
Published: 10 July 2023