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ORIGINAL ARTICLE

Effects of 10 Weeks of Outdoor-Based High-Intensity Interval Exercise on Perceptual Responses, Health Parameters, and Cortisol Levels in Overweight-to-Obese Adults

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ABSTRACT

Background. Previous high-intensity interval exercise (HIIE) studies on perceptual responses and health parameters in overweight and obese adults have mainly focused on laboratory-based settings, which could limit the effectiveness of HIIE protocol in a real-world setting. **Objectives.** We examined the changes in affective, enjoyment, cardiorespiratory fitness, body composition, and cortisol levels during outdoor-based HIIE over a 10-week intervention in overweight and obese adults. **Methods.** Thirty-two physically inactive overweight or obese adults (men =12 and women =20; age 28.3±4.9 years) performed an outdoor-based HIIE protocol across a 10-week intervention (3x/week, 30 sessions). Perceptual responses and changes in cortisol levels observed in sessions 1 (S1), 15 (S15), and 30 (S30) were analyzed using two-way repeated-measures analysis of variance. Health parameters were measured before and after the 10-week HIIE intervention. **Results.** HIIE elicited lower affect responses across all selected work intervals (all P<0.02, all ES>1.19) in S1 compared to S15 and S30. HIIE participation also generated greater post-enjoyment from S1 to S30 (all P<0.04, all ES>43). HIIE also improved cardiorespiratory fitness and decreased body fat percentage following the 10-week intervention (all P<0.001, all ES>0.78). Finally, changes in affect responses induced by HIIE were negatively correlated with the changes in cortisol levels (all P<0.03, all r>-0.71). **Conclusion.** The 10-week outdoor-based HIIE protocol improved perceptual responses, cardiorespiratory fitness, and body fat percentage in overweight and obese adults. Additionally, changes in cortisol levels may influence HIIE-induced affective responses across the 10-week intervention in overweight and obese adults.

INTRODUCTION

An escalating epidemic of overweight/obese is taking over in many regions across the world despite growing concerns regarding health problems (e.g., diabetes, heart disease, and stroke) associated with the crisis of overweight and obese (1, 2). In Malaysia, the overweight rate of adults ≥18 years of age was 31.3% in 2023, and the obesity rate was 22.2%, increasing by 1.0% and 2.5% from 2019, respectively (3). A substantial body of research has indicated that changes in lifestyle behaviors, such as regular exercise participation and a healthy diet, are critical strategies for controlling and preventing excess body weight among adults (4). However, traditional exercise interventions (e.g., continuous moderate exercise) designed to support long-term health impacts have failed mainly because of more significant exercise program attrition among individuals with overweight and obesity (5, 6). Previous studies have shown that the perceived lack of time and enjoyment may be the most significant deterrent to regular exercise participation in overweight/obese adults (5). Therefore, there is a solid rationale to study alternative forms of exercise in overweight and obese adults, with one strategy focussing on smaller volumes of high-intensity exercise.

High-intensity interval exercise (HIIE) has been promoted as an effective, time-efficient form of exercise training that yields multiple health benefits, including enhanced cardiorespiratory fitness, cardiometabolic health, and body composition, following 2-to-12-week exercise interventions in overweight and obese adults (7, 8). Despite the effectiveness of HIIE in promoting health benefits, implementing this exercise as a public health strategy is criticized because of the high-intensity workload (e.g., greater than 85% of maximal effort or heart rate) required for this exercise protocol. According to Ekkekakis (9), high-intensity exercise typically leads to more negative affective responses (i.e., unpleasant feelings) than exercise performed at low to moderate intensity, thus leading to poor exercise engagement and a lower likelihood of forming a future exercise habit. However, several systematic reviews and meta-analyses have concluded that HIIE protocols with greater work intensity (e.g., 100% - 120% of maximal effort) may be less pleasurable than those with lower work intensity (85% to 90% of maximal effort) (10, 11), indicating that some permutations of HIIE protocols (e.g., low-volume HIIE) may not evoke entirely negative affective responses (less pleasurable) in adults. Moreover, most studies have reported that HIIE generates similar post-exercise enjoyment responses regardless of the prescribed work intensity (10, 11). However, these observations on perceptual responses have focused on the acute affective response and enjoyment level after a single session of HIIE in a laboratory-based setting (10, 11), which could limit the applicability of such study findings to real-world exercise experiences.

Consequently, the overall interpretation of affective and enjoyment responses to HIIE in a real-world setting over long-term interventions is currently unclear, especially for overweight and obese adults.

Previous HIIE-based studies have evaluated physiological stress responses to establish factors that could contribute to the changes in affective responses during the HIIE protocol (12, 13). These valuable studies have reported that physiological variables associated with cardiorespiratory stress responses (e.g., HR responses, oxygen uptake, and ventilation rates) generated during HIIE have a strong negative influence on affective responses (12, 13). Nevertheless, this approach may not adequately characterize the relative bodily stress responses induced during high-intensity exercise. Martínez-Díaz and Carrasco (14) called for the evaluation of the impact of stress biomarkers (e.g., cortisol hormones) on affective responses during HIIE. Indeed, evidence has shown that cortisol levels rise during physical stress (e.g., intense exercise training) could induce multiple psychological stress states such as tension, anxiety, and negative affect (15), indicating an association between elevated circulating cortisol and dysfunctional psychological during intense exercise. However, this valuable observation is limited to athlete groups during specific training periods. Despite the emerging body of evidence supporting the increase in cortisol levels following a single HIIE session in healthy adults (16), there is a lack of information about HIIE-induced cortisol responses in overweight and obese adults and their relationships with transient changes in affective responses to HIIE.

Therefore, the primary aim of the present study is to evaluate the changes in affective responses, enjoyment responses, cortisol levels, cardiorespiratory responses, and body composition throughout a 10-week outdoor HIIE intervention in overweight and obese adults. Moreover, we also examined the potential relationship between changes in affective responses and circulating cortisol levels induced by HIIE.

MATERIALS AND METHODS

Participants. Thirty-two physically inactive overweight or obese adults (12 men and 20 women) aged 18-30 years were included in this study. As reported in previous studies (14), the sample size was calculated based on the ability to detect a medium to large effect on the relevant outcomes (i.e., affect, enjoyment, and cortisol levels), with an alpha of 0.05 and a power of 0.8. We opted to use a medium effect size (f=0.30) in the a priori power analysis via G*Power (Version 3.1, University of Düsseldorf, Germany) for all the parameters examined in the present study. This resulted in a minimum sample size of 28 participants. An additional four participants were recruited to account for any potential loss to attrition (15%). Participants were excluded if they had 1) a body mass index (BMI) <24.9 kg·m^{-2}, 2) any cardiometabolic disease (e.g., diabetes or heart disease), 3) contraindications to performing high-intensity running exercise, or 4) any musculoskeletal injuries. Participants were recruited via posters and word-of-mouth. The study procedures were approved by the Human Research Ethics Board (USM/JEPeM/22080549) of Universiti Sains Malaysia and the study protocol was conducted according to the Declaration of Helsinki. Written informed consent was obtained from the participants.

Experimental Protocol. In this study, we incorporated a quasi-experimental within-subject design, whereby participants completed a 10-week HIIE intervention with pre-and post-test measurements. The first visit (pretest) was to measure participants' anthropometric characteristics, determine cardiorespiratory fitness, and familiarize participants with the measurement scales. The participants subsequently completed a 10-week exercise intervention consisting of an HIIE protocol, with three exercise sessions per week (total of 30 sessions) in an outdoor-based setting (Sports complex field). Each exercise session was separated by a minimum two-day rest period (48 hours). Affective responses (feelings of pleasure and displeasure), enjoyment, and perceived exertion were measured during each selected HIIE session [sessions 1 (S1, initial), 15 (S15, mid-intervention), and 30 (S30, end-intervention)]. Serum cortisol levels were measured before and immediately after each selected HIIE session (S1, S15, and S30). HIIE sessions were performed simultaneously (from 08:00 am to 12:00 pm) across the entire 10-week intervention to minimize any confounding effects (e.g., diurnal biological variation and hormonal sensitivity). All the pretest measurements (i.e., anthropometric and cardiorespiratory fitness) were repeated no less than four days (96 hours) after the S30. The participants were encouraged to avoid deviation from their regular dietary practices for the study and to maintain a normal lifestyle.

Anthropometric and Physical Activity Measures. Height (nearest 0.01 m) was measured with a stadiometer (SECA, 700, Hamburg, Germany), whereas body composition, consisting of body weight (nearest 0.1 kg), body fat percentage (%BF), and BMI (kg·m^{-2}), was measured via bioelectrical impedance (TBF-410 Body Composition Analyzer, Tanita). The participants' daily habitual physical activity prior to the experimental visits was measured with the validated Malay version of the International Physical Activity Questionnaire (17).

Cardiorespiratory Fitness. The participants performed the multi-stage 20-m shuttle run fitness test (20mSRT) to determine their maximal aerobic speed (MAS) and cardiorespiratory fitness. The details related to the 20mMSFT can be found in our previous published work (18). Throughout the 20mSRT, heart rate responses were continuously monitored with a heart rate monitor (Polar H10). MAS was calculated based on the 20mSRT performance with the formula provided by Berthoin and colleagues (19, 20). Heart rate responses were continuously recorded throughout the test (Polar H10, Finland). VO_2max was estimated from the equation established by Strickland and colleagues (21).

HIIE Training Protocol. Participants completed a 10-week exercise intervention consisting of a 3-minute warm-up at 4.0 km.h^{-1} followed by HIIE, as presented in Table 1. During the 1-minute running, participants continuously ran between two cones set apart to allow the speed to match participants' 90% MAS (i.e., the distance between the cones varied between participants, Figure 1). To place individual speeds, every ten seconds (i.e., 6 times per minute), a sound cue (i.e., whistle blow) was emitted to which participants should be at their cone. No audio or visual entertainment was provided during the exercise session. A≥85% HRmax cutoff point was used as our criterion for satisfactory compliance with the HIIE protocol (22).

Measures.

Perceptual Responses. The Feeling Scale (FS) developed by Hardy and Rejeski (23) was used to measure affective valence before and during the three exercise conditions. Specifically, the FS is an 11-point bipolar, single-item scale that varies between "very bad" (-5) and "very good" (+5) along a pleasure–displeasure continuum. The RPE was measured via the Borg CR-10 scale, which ranges from 0–10 (24). The participants were asked to provide their FS and RPE scores 5 min before the exercise protocol, 15 s before the warm-up session, and 15 s before the end of the first, fourth, and final work intervals. The Physical Activity Enjoyment Scale (25) was used to evaluate exercise enjoyment following 10 minutes of selected HIIE sessions (S1, S15 and S30). The PACES is an 18-point Likert-type questionnaire in which participants rated their exercise enjoyment on a 7-point bipolar scale. After the appropriate questions are reverse scored, the average score is calculated to assess how much participants enjoyed the exercise session, with higher scores reflecting greater levels of enjoyment (maximal possible score =126). The internal consistency was acceptable at each administration (Cronbach's αs >0.85) in the present study.

Table 1. A 10-week exercise training program for HIIE.

Groups	Variables	Weeks (1-2)	Weeks (3-4)	Weeks (5-6)	Weeks (7-8)	Weeks (9-10)
HIIE	Repetition	6	7	8	9	10
	Duration (Work/Recovery)	60/75 s				
	Work intensity	90% of maximal aerobic speed				
	Recovery intensity	Self-paced				

HIIE: High-intensity interval exercise.

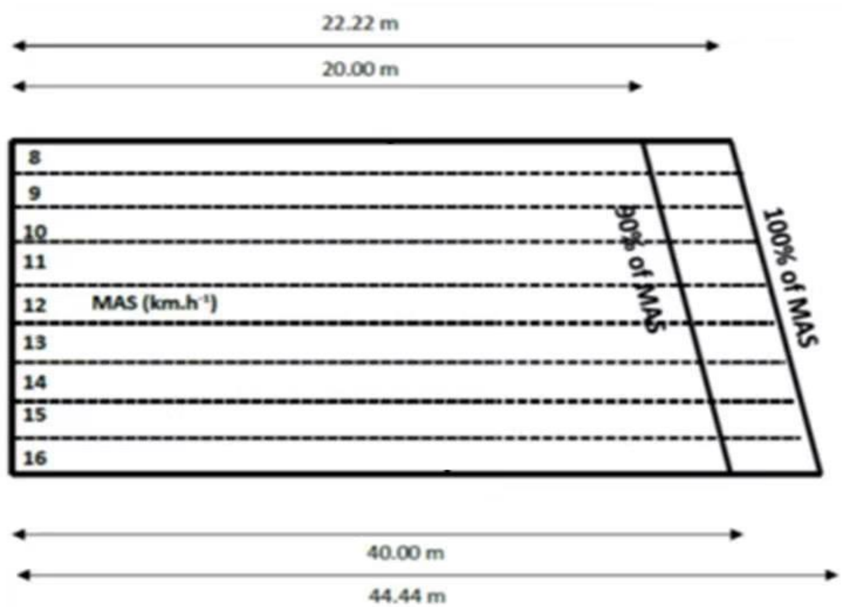

Figure 1. Short outdoor-based track for interval exercise.

Cortisol Levels. Blood (5 ml) was drawn from the antecubital vein before and immediately after HIIE sessions. Blood samples were collected into ethylenediaminetetraacetic acid (EDTA)-containing tubes and centrifuged at 1,000 rpm for 20 min at 4°C. The obtained plasma was aliquoted and stored at −20°C until subsequent analyses. Commercially available human ELISA kits (morning sensitivity: 20–800 ng/dl; RE52061, IBL International, Germany) were used to measure plasma cortisol concentrations in duplicate, according to the procedures provided by the Manufacturer (AbnovaTM KA3382; Tapei City, Taiwan).

Statistical Analyses. All the statistical analyses were conducted via SPSS (SPSS 28.0; IBM Corporation, Armonk, NY, USA). Descriptive characteristics (means ± standard deviations) between the pretest and post-test were analyzed via paired samples t-tests. The Shapiro–Wilks test was used to test the normality of distribution for the dependent variables. Two-way repeated-measures analysis of variance (ANOVA) was used to examine differences in affective responses, the RPE, and cortisol levels across three HIIE sessions (S1, S15, and S30) over different work intervals and times.

In contrast, one-way repeated-measures ANOVA was used to analyze post-exercise enjoyment responses across three selected HIIE sessions. In the event of significant effects, follow-up pairwise comparisons were conducted to examine the location of the mean differences. The magnitude of the mean differences was interpreted via the effect size (ES) calculated via Cohen's d, where an ES of 0.20 was considered a slight change between means, and 0.50 and 0.80 were interpreted as moderate and significant changes, respectively. Pearson's product-moment correlation coefficients were calculated to examine the relationships between the change (Δ) in cortisol levels (the cortisol level immediately post-exercise minus the cortisol level at baseline) and the change in affective responses (ΔFS; FS score at end interval minus FS score at work interval 1) during HIIE. All the data are reported as the means ± standard deviations, and P values <0.05 were considered to indicate statistical significance.

RESULTS

The participants' descriptive characteristics are shown in Table 2. There was a statistically significant difference between the pretest and post-test results in terms of the participant's body fat percentage (%BF, P=0.002), estimated VO_2max (P=0.002), and MAS (P=0.001). Specifically, HIIE elicited a lower %BF after a 10-week training intervention. Additionally, increases in VO_2max and MAS were observed after 10 weeks of training intervention. Moreover, our participants were characterized as physically inactive individuals based on the IPAQ (518±334 MET-minutes/week).

Table 2. Descriptive characteristics of the participants (N=32).

	Mean ± SD		Effect size
	Pretest	**Post-test**	
Age (y)	28.3±4.9	-	-
Body mass (kg)	74.2±11.2	73.9±10.2	0.03
Stature (m)	1.62±8.5	-	-
BMI (kg·m^{-2})	28.2±2.9	28.1±2.8	0.04
%BF	22.8±5.4	18.9±4.6*	0.78
HR_{max} (bpm)	184±10	185±9	0.11
MAS (km·h^{-1})	9.5±0.6	10.0±0.7*	0.77
Estimated $\dot{V}O_2$max (ml·min^{-1}·kg^{-1})	38.2±2.3	41.6±2.4*	1.45

The values are reported as the means ± standard deviations. BMI: Body mass index; %BF: Body fat percentage; $\dot{V}O_2$max: Maximal oxygen uptake; HR_{max}: Maximal heart rate; MAS: maximal aerobic speed; *: Significant pre-post difference.

Heart Rate Responses. Changes in HR responses across three different HIIE sessions (S1, S15, and S30) are presented (Figure 2). There was a significant interval-by-session interaction effect for HR responses (P=0.001). Specifically, the HR response was significantly greater in S1 than in S15 and S30 at baseline measurement [P<0.001, all ES>0.63; 97±10 bpm (53% HRmax) vs. 91±9 bpm (50% HRmax) vs. 88±8 bpm (48% HRmax), respectively]; work interval 1 [P<0.001, all ES>0.61; 165±14 bpm (90% HRmax) vs. 157±12 bpm (86% HRmax) vs. 154±8 bpm (84% HRmax), respectively]; work interval 4 [P<0.001, all ES>0.70; 178±9 bpm (97% HRmax) vs. 171±11 bpm (93% HRmax) vs. 165±10 bpm (90% HRmax), respectively]; and end work interval [P<0.001, all ES>0.48; 180±10 bpm (98% HRmax) vs. 176±11 bpm (96% HRmax) vs. 173±11 bpm (95% HRmax), respectively].

Affective Responses. Changes in FS scores (valence) across the three selected HIIE sessions are illustrated (Figure 3). The FS scores had a significant interval-by-session interaction effect (P<0.001). Specifically, the FS scores at the first, fourth, and final work intervals were significantly lower during S1 than S15 (all P<0.02, all ES>1.19) and S30 (all P<0.01, all ES>1.30). The FS score remained positive at the final work interval during S15 and S30 (0.4±2.4 and 1.2±2.6, respectively). The ΔFS score during S30 was significantly lower than that during S1 (P=0.03; -3.0±2.6 vs. -4.5±2.4; ES=0.60, respectively).

Postexercise Enjoyment. The session had a significant main effect on the PACES (P<0.001). Specifically, the PACES was significantly lower in S1 than in S15 (P=0.002; 97±16 vs. 105±14; ES=0.53, respectively) and session 30 (P<0.001, 97±16 vs. 111±14; ES=0.93, respectively). Additionally, the PACES was significantly lower in S15 than in S30 (P=0.035, 105±14 vs. 111±14; ES=0.43, respectively).

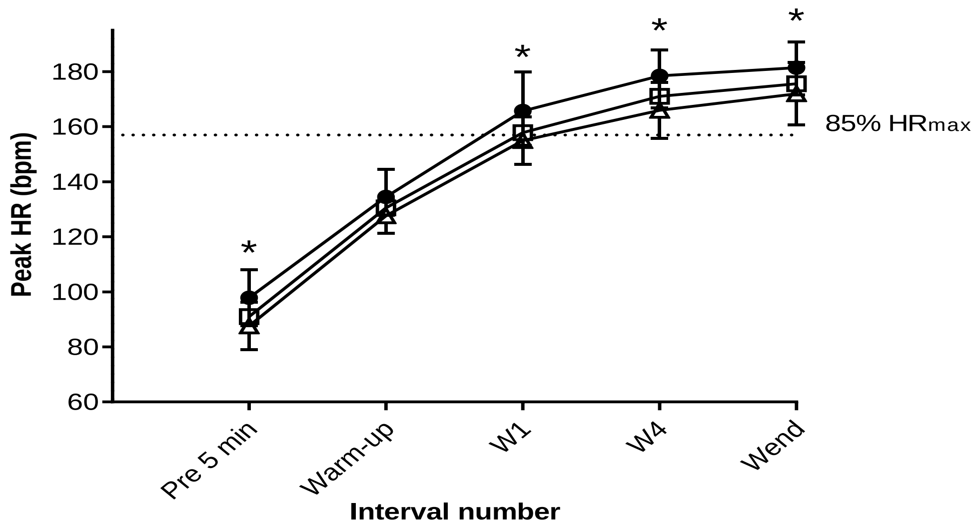

Figure 2. The mean peak HR (in beats per minute) during the work interval phase of HIIE in S1 (●), S15 (□), and S30 (Δ). W = work interval, Wend = end work interval for every session, and HR_{max} = maximal heart rate. *: Significant difference between sessions (P<0.05). The error bars represent the SD values.

RPE Responses. Changes in the RPE response during the three selected HIIE sessions are illustrated (Figure 3). RPE had a significant interval-by-session interaction effect (P<0.001). Specifically, the RPE was significantly greater during the first, fourth, and final work intervals of S1 than during those of S15 (all P<0.01, all ES>0.88) and S30 (all P<0.001, all ES>0.85). Additionally, the RPE was significantly greater during the fourth and final work intervals of S15 than during those of S30 (all P<0.03, all ES>0.38).

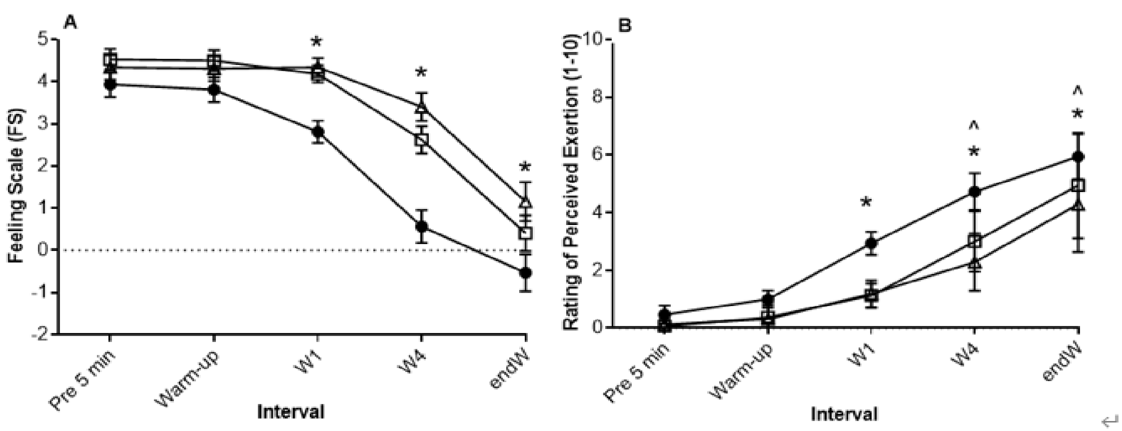

Figure 3. Perceptual responses to high-intensity interval exercise. Feeling Scale score (A) and rating of perceived exertion (B) during the work interval phase of HIIE in S1 (●), S15 (□), and S30 (Δ). W = work interval. *: Significant difference between S1 compared to S15 and S30 (P<0.05). ^: Significant difference between S15 compared to S30 (P<0.05). The error bars represent the SD values.

Cortisol Changes. The changes in cortisol levels in response to baseline and immediately after three HIIE sessions are presented in Table 3. There was no significant time-by-session interaction effect on circulating cortisol levels (P=0.93). However, a significant main effect of session was evident in the Δ cortisol levels from pre- to post-HIIE sessions (P=0.04). Specifically, the Δ cortisol levels in S30 were lower than those in S1 (P=0.03, ES=0.92). Additionally, a significant main effect for time was detected for cortisol (P<0.001). Specifically, the cortisol levels of the participants increased significantly from baseline to immediately after all HIIE sessions (all P<0.001, all ES>0.67). Finally, there was a significant negative correlation between ΔFS score and Δ cortisol levels in sessions 15 and 30 (all P<0.03, all r>-0.71) (Figure 4).

Table 3. Plasma cortisol concentrations measured before and after HIIE.

HIIE sessions	Pre (ng/ml)	Immediately post (ng/ml)	Δ plasma cortisol (ng/ml)
S1	385.75±59.27	503.15±57.45*	117.89±54.41^
S15	382.27±69.64	479.66±83.24*	97.22±100.60
S30	390.21±98.07	466.44±62.39*	75.47±35.34

The values are reported as the means ± standard deviations. *: Significant pre-post difference. ^: Significant difference between S1 and S30.

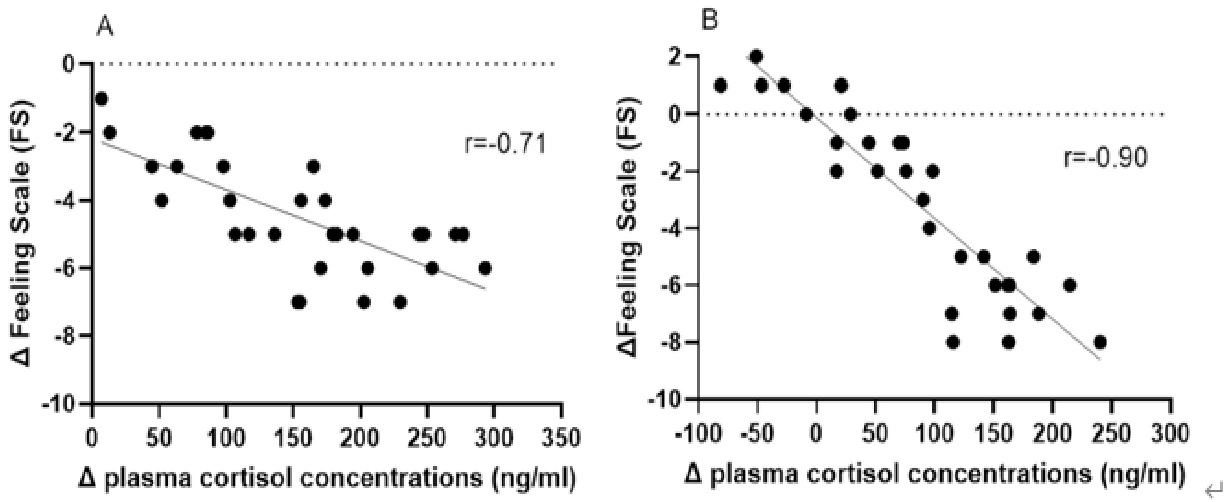

Figure 4. Correlation between the Feeling Scale score changes and plasma cortisol concentration in high-intensity interval exercise S15 (A) and S30 (B).

DISCUSSION

The present study depicts data on affective enjoyment, cardiorespiratory fitness, body composition, and cortisol levels throughout a 10-week outdoor HIIE intervention in overweight and obese adults. The key findings of this study were as follows: 1) the HIIE protocol elicited improvements in affective responses (i.e., more pleasurable) across all work intervals toward the end of the HIIE intervention period; 2) enjoyment responses progressively increased following the HIIE protocol from S1 to S30; 3) HIIE resulted in increased cortisol levels following all HIIE sessions, but the changes in cortisol levels were smaller in S30 than S1; 4) changes in affective responses during HIIE were negatively correlated with changes in cortisol levels; and 5) HIIE resulted in significant improvements in %BF and cardiorespiratory fitness following the 10-week intervention. The HIIE protocol utilized in this study design complied with the HIIE protocol criterion (i.e., >85% of HRmax) across all exercise sessions, and the protocol was well tolerated by all participants with 100% total attendance.

In the present study, we observed greater positive affective responses (more pleasurable) from the initial session to the final session of the HIIE intervention (ES>1.19), indicating an improvement in pleasurable feelings across a 10-week HIIE intervention in overweight and obese adults.

Our observation is consistent with a recent study by Ming et al. (18), who reported an increase in affective responses following a few HIIE sessions across 12 weeks of interventions in physically inactive college students. A previous study reported that accumulated exercise experience and familiarity with HIIE protocols may significantly influence affective responses to a single HIIE session in active and inactive adults (26). Indeed, in a previous meta-analytical review, Nasuti and Rhodes (27) reported that experienced exercisers may be able to draw upon their overall exercise experiences as indicators of their capability and motivation while optimizing affective responses, resulting in future exercise adherence. Therefore, it seems plausible to suggest that the link between exercise intensity and affective responses could be mitigated following a few HIIE sessions because of the establishment of prior exercise experience and familiarity with the HIIE protocol in overweight and obese adults. Our study also supports previous evidence of trajectory changes in affective responses during outdoor HIIE over multiple sessions rather than a single HIIE session per se in overweight and obese adults.

A growing body of literature indicates that cortisol levels continuously increase from baseline to immediately after a single HIIE protocol and can remain elevated for up to 2 hours in adults (16). This observation may suggest an essential indication of the bodily stress response exhibited by the HIIE protocol. Despite the significant role of cortisol as catabolic hormones that promote energy substrate mobilization (i.e., carbohydrates, fat, and protein), an increase in cortisol levels could be a neurophysiological cause of exercise-induced stress symptoms. These exercise-induced stress symptoms may include negative affective responses, dysfunctional mood states, and muscle fatigue (28). The pattern of cortisol responses observed in our study from baseline to immediately after HIIE was consistent with the previous study by Dote-Montero and colleagues (16), who reported increases in plasma cortisol levels.

Nevertheless, we also found that the changes in cortisol levels were smaller at S30 than at the first session (ES=0.92). An explanation for the current observation in cortisol response is not readily apparent but may be attributed to the body adaptations induced by a 10-week HIIE training in overweight and obese adults. Specifically, HIIE has a potent stimulatory role in triggering the central and peripheral adaptations, which could influence the hormonal production triggered by metabolic stress caused by HIIE (29). However, the role of the change in cortisol as an indicator of body adaptations induced by HIIE training is not entirely understood and should be further investigated.

Importantly, our findings suggest that multiple exposures to HIIE across the 10-week intervention could have mitigated the stress experienced in overweight and obese adults, as reflected in the reduction of HR and RPE responses accompanied by increased affective responses towards the end of HIIE intervention. This notion is supported by a strong negative correlation between Δ cortisol levels and ΔFS scores during S15 and S30 (all $r > -0.71$). Similarly, Martínez-Díaz and Carrasco (14) reported a significant negative correlation between cortisol levels and mood states (i.e., fatigue and confusion) induced by a single HIIE session among active male adults. To our knowledge, the present study provides the first data concerning stress biomarkers, namely cortisol levels and affect changes elicited by multiple HIIE sessions across a 10-week intervention in overweight and obese adults.

Regarding enjoyment responses, we found a more remarkable improvement in post-exercise enjoyment from the initial session to the final session of the HIIE intervention (ES>0.43). This finding is consistent with most HIIE-based studies across various populations, including overweight and obese adults (10, 11). Raedeke (30) reported that an increase in positive affective response experienced during exercise may lead to greater enjoyment following an exercise session. Our findings strengthen this evidence based on the more excellent enhancement in both affective responses and enjoyment from the initial session toward the end of the HIIE session, suggesting a parallel pattern of these two responses to HIIE in overweight and obese adults. Another explanation for the postexercise enjoyment observed in this study may be attributed to a 'rebound effect' as proposed by Bixby et al. (31), whereby greater positive feelings can occur during the postexercise period after an unpleasant stimulus or stress generated during an intense work stimulus. In our study, the exercise challenge was greater in S30 than in S1 because of the greater number of HIIE work intervals (6 vs. 10 repetitions) every two weeks across the 10-week exercise intervention. Given that enjoyment of exercise has been linked to perceived success once the participants have successful experiences and find it challenging (32), it could be suggested that the progressive challenge posed by HIIE toward the end of the intervention period may be a crucial factor in increasing enjoyment levels in overweight and obese adults.

In the present study, we observed a significant improvement in cardiorespiratory fitness and %BF following a 10-week HIIE intervention, suggesting that interventions lasting for 10 weeks can promote sufficient increases in health parameters in overweight and obese adults. Indeed, recent systematic reviews and meta-analyses have shown that HIIE interventions provide a time-efficient strategy for improving cardiorespiratory fitness despite lower energy expenditure within a brief exercise intervention period (e.g., 3-10 weeks) in overweight and obese adults (33). The authors also reported that intervention components such as the number of repetitions, work intensity, recovery duration, and number of exercise sessions are paramount for achieving optimal adaptations to promote the effects of HIIE on cardiorespiratory responses and body composition. Therefore, we suggest that the outdoor-based HIIE protocol implemented in the present study can yield optimal health benefits in overweight and obese adults, indicating the feasibility and practicality of this HIIE protocol.

Several strengths and limitations should be acknowledged in the present study. One of the strengths of this study relates to the sample population. The participants involved in our study were not only overweight and obese but also categorized as physically inactive based on their IPAQ scores. This characterization of our participants could increase the generalizability of the data regarding HIIE interventions for overweight and obese individuals. Another strength of the present study is that the HIIE protocol involved outdoor running. This approach can enhance the ecological validity of this study. However, given that various HIIE protocols have emerged in adult studies, the protocol used in this study should be considered as only one of many possibilities. HIIE protocols with different training variables, such as work interval durations and intensities, or different modalities (cycling vs. running) may generate different perceptual and physiological responses. Finally, the quasi-experimental design utilized in the present study has methodological limitations that do not adequately address causality. Therefore, more research needs to be conducted in various populations with different research designs (e.g., randomized controlled trials) to establish any potential relationship between changes in cortisol levels and HIIE-induced affect responses.

CONCLUSION

In conclusion, a 10-week outdoor-based HIIE intervention improved perceptual responses (affect and enjoyment), cardiorespiratory responses, and % body fat in overweight and obese adults. Moreover, HR and cortisol adaptations were observed during the intervention, which led to a more significant improvement in affective responses toward the end of the intervention. Significantly, our data extends those of previous HIIE-based studies indicating that changes in affective responses are related to changes in stress biomarkers, namely, cortisol levels, during HIIE in overweight and obese individuals. Therefore, based on all the observed responses combined, our findings show that outdoor HIIE is a suitable and feasible strategy to promote exercise adherence and health benefits in overweight and obese adults.

APPLICABLE REMARKS

- Affective and enjoyment responses were improved after a few sessions of outdoor-based HIIE in overweight and obese adults.
- Outdoor-based HIIE promotes excellent cardiorespiratory fitness and body fat percentage improvement over a 10-week intervention in overweight and obese adults.
- Changes in cortisol levels induced by HIIE may decrease or increase the likelihood that a person will experience pleasurable feelings in response to HIIE in individuals with overweight and obesity.

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AUTHORS’ CONTRIBUTIONS

Study concept and design: Ruohan Zhang, Adam A. Malik, Hairul A. Hashim. Acquisition

of data: Ruohan Zhang. Analysis and interpretation of data: Ruohan Zhang, Adam A. Malik, Hairul A. Hashim. Drafting the manuscript: Ruohan Zhang, Adam A. Malik. Critical revision of the manuscript for important intellectual content: Ruohan Zhang, Adam A. Malik. Statistical analysis: Ruohan Zhang, Adam A. Malik. Administrative, technical, and material support: Ruohan Zhang, Adam A. Malik. Study supervision: Adam A. Malik, Hairul A. Hashim.

CONFLICT OF INTEREST

The authors have no competing interests to disclose.

FINANCIAL DISCLOSURE

We have no financial interests related to the material in the manuscript.

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ETHICAL CONSIDERATION

The study protocol has been approved by Jawatankuasa Etika Penyelidikan Manusia USM (JEPeM Code: USM/JEPeM/2208054).

ROLE OF THE SPONSOR

The funding organizations are public institutions and have no role in the design and conduct of the study, collection, management, and analysis of the data or preparation, review, and approval of the manuscript.

ARTIFICIAL INTELLIGENCE (AI) USE

No specific AI and AI-assisted technologies were used in the manuscript to disclose.

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