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ORIGINAL ARTICLE

Perceptual Responses and Health Parameters of 12 Weeks of Moderate- and High-Intensity Interval Exercise Intervention in Physically Inactive College Students

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ABSTRACT

Background. Both affective and enjoyment responses to continuous-type exercise are regulated by the exercise intensity, but the changes in these responses during interval-type exercise with different intensity is unclear. **Objectives.** The present study examined the effect of different work intensities on the perceptual and health parameters during interval exercise. **Methods.** Twenty-four inactive college students (aged 20.8±1.2 years; PA levels=448±80 MET-min/week) were randomized to 12 weeks of HIIE (n=12; 6-10×1-min work-intervals at 90% of MAS) or MIIE (n=12; 6-10×1-min work-intervals at 60% of MAS), both for three days in a week (36 sessions). Perceptual responses (affective, enjoyment, and perceived exertion) observed in sessions 1, 18, and 36 were analyzed. Whereas health parameters (cardiorespiratory fitness and body composition) were measured before and after 12-week exercise intervention. **Results.** HIIE generated lower affective responses at work interval 4 and end work interval in session 1 and session 18 (all P<0.04, all ES>1.70). However, HIIE elicited greater FS at the end of the work interval during sessions 18 and 36 compared to session 1 (P<0.04, ES>1.55). Both groups generated greater post-enjoyment in session 36 compared to session 1 (all P<0.02, all ES>0.60). HIIE produced greater improvement in cardiorespiratory responses and body composition than MIIE following a 12-week intervention (P<0.04, all ES>60). **Conclusion.** HIIE appears to be a time-efficient and viable strategy to facilitate future exercise adherence while producing health benefits among physically inactive college students when considering the impact of perceptual responses and health parameters.

KEYWORDS: ***Interval Exercise, Affective Responses, Inactive Adults, Body Composition, Cardiorespiratory Responses.***

INTRODUCTION

Evidence has indicated that college students are frequently exposed to unhealthy behavior changes such as increasing sedentary behavior while decreasing levels of physical activity (PA) (1). Regular PA is recommended as an effective lifestyle strategy for health promotion (2), but evidence has indicated that almost half of the college students (40% to 50%) are physically inactive with "lack of time" being one of the most commonly cited barriers to regular participation (1). Consequently, researcher and health provider have shifted their attention to high-intensity interval exercise (HIIE) as a health strategy to promote PA (3). HIIE has been shown as a time-efficient strategy to enhance multiple health benefits including cardiorespiratory fitness and cardiometabolic diseases during 2-12 weeks of exercise interventions in adults (4, 5).

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Despite the well-known health benefits of HIIE, the application of HIIE as a public health strategy is controversial due to the high-intensity workload required in this exercise regime (e.g., above 90% of maximal effort or heart rate). According to Ekkekakis (6), high-intensity exercise typically leads to more negative affective responses (i.e., unpleasant feelings) than exercise performed at a low to moderate intensity, thus leading to poor exercise adherence towards HIIE in future sessions. Data are available indicating that some permutations of HIIE protocols (e.g., low volume HIIE vs. Sprint interval) may not entirely evoke negative affective responses (7). However, this evidence is limited to the comparisons of affective responses (pleasure and displeasure feelings) to the different work intensities within the HIIE protocols, which may not adequately consider the impact of interval exercise on affective responses to exercise.

Given the significant contribution of exercise intensity to the changes of affective responses during exercise, Jiménez-Pavón et al. have suggested examining the potential role of moderate intensity interval exercise (MIIE) in promoting better exercise implementation, maintenance, and adoption as opposed to HIIE (8). A previous study in adolescents has reported that MIIE (8 x 1 min work interval performed at 90% of ventilatory threshold) elicited more pleasurable feelings compared to low volume HIIE (8 x 1 min work interval performed at 90% of peak power) in 13 to 15 years, boys and girls (9). However, this valuable study is limited to the acute bout of exercise and did not consider the impact of health benefits (e.g., cardiorespiratory responses and body compositions) within an extended period (e.g., more than two weeks of intervention) for both conditions. Moreover, a study by Malik and colleagues (9) has been conducted in a laboratory setting, whereby the ecological validity of the affective experience of interval exercise will be compromised. Documenting this information during the interval type of exercise is therefore important as affective responses during exercise could influence the implementation and adherence of PA while facilitating health benefits, particularly in physically inactive college students (10).

Therefore, the purpose of the present study is to examine the perceptual responses (affective, enjoyment, and perceived exertion responses) and health indices (cardiorespiratory responses and body compositions) to outdoor-based HIIE and MIIE setting across 12 weeks of exercise intervention in physically inactive college students. We hypothesized that 1) affective and enjoyment responses would be different in both HIIE and MIIE conditions across a 12-week exercise intervention, and 2) cardiorespiratory responses and body compositions would be improved in both conditions following a 12-week exercise intervention.

MATERIALS AND METHODS

Participants. Four physically inactive students (male=12 and female=12) attending Shanxi Technology and Business College, Taiyuan City, China, aged 18- to 25 years old gave their written consent form to participate in the present study. The size of the sample was based on the ability to detect a medium to large effect on the affective and enjoyment responses using previously published data (3) for a repeated measures ANOVA (with in-between interaction) with an alpha of 0.05 and a power of 0.8. This resulted in an indicative sample size of 8 to 12 participants for each group to detect a moderate and large effect respectively. The study protocol was approved by the Human Research Ethics Committee of Universiti Sains Malaysia (USM/JEPeM/22080551) and the protocol was conducted according to the Declaration of Helsinki. Participants were not included in the present if they had previously been involved in any type of exercise program within the past two months or had contraindications to exercise according to the Physical Activity Readiness Questionnaire. Participants were recruited through E-mail announcements and flyers.

Experimental overview. The present study involved a repeated measure, within-subjects, parallel-group design, whereby each participant was assigned into two different exercise groups: high-intensity interval exercise (HIIE group) and moderate-intensity interval exercise (MIIE group). The randomization between these two groups was stratified by gender. The first experimental visit was to determine cardiorespiratory fitness, measure anthropometric variables as well and familiarization of experimental protocols and scales. Subsequently, participants completed a 12-week exercise intervention consisting of HIIE and MIIE, with three exercise sessions per week (total of 36 sessions) in the outdoor-based setting (i.e.,

football field). Each exercise session was separated by a minimum two-day rest period (48 hours) in both conditions. Perceptual responses (i.e., affective responses, enjoyment, and perceived exertion) were measured during each 36 sessions of HIIE and MIIE. All exercise sessions were performed at the same time (14:00 to 17:00) of the day to minimize any confounding effects related to the effects of diurnal biological variation. All the measurements tested in the first experimental visit were repeated ultimately no less than a four-day after the final exercise training session.

Anthropometric and physical activity measurements. Height and body mass were observed to the nearest 0.1 cm and 0.1 kg, respectively. Subsequently, both variables were used to calculate body mass index (BMI; body mass (kg) /stature (m) 2). Participants' daily habitual physical activity was measured by using a Chinese language version of the International Physical Activity Questionnaire (IPAQ-C) (11).

Cardiorespiratory fitness. Participants completed the multi-stage 20-m shuttle run fitness test (20mMSFT) to establish the participant's maximal aerobic speed (MAS) of the outdoor running and cardiorespiratory fitness as indicated by the predicted maximal oxygen consumption (VO2 max). This protocol was also intended to familiarize the participants with the field-based protocol of interval running. The 20mMSFT involved running between two lines set 20 m apart at a pace dictated by a recording emitting tones at appropriate intervals. The test started with a running pace of 8.5 km·h−1 for the first minute, which increased by 0.5 km·h−1 every minute thereafter. The test score attained by the participants was the number of 20 m shuttles completed before the participant either withdrew voluntarily from the test or failed to be within 3 m of the end lines on two consecutive tones. MAS was calculated based on the formula provided by Gerbeaux and colleagues (12) for 20mMSFT. Heart rate responses were continuously recorded throughout the test (Polar H12, Finland). Whereas, V ̇O2max was estimated from the equation established by Strickland and colleagues (13).

Perceptual responses. Affective responses (i.e., pleasure and displeasure) were assessed using the 11-point bipolar rating single-item scale (5 to -5) known as Feeling Scale (14). The FS has been used extensively for the assessment of affective responses during exercise in adults. Perceived exertion was observed via a 6-20-point Likert item ranging from 6 (nothing at all) to 20 (absolute maximum) (15). Both scales (FS and RPE) were presented by the visual preference technique and verbal responses were recorded 5 minutes before the start of exercise and during the last 15 seconds of work intervals of each session. Whereas, the Chinese version of the Physical Activity Enjoyment Scale (PACES) (16) was used to evaluate enjoyment responses by completing 18 questions scored on a 1–7 Likert scale, 10 min after each exercise session.

Training protocol. Participants completed a 12-week exercise intervention consisting of a 3-minute warm-up at 4.0 km.h-1 followed by either HIIE or MIIE as presented in Table 1. During the 1-min running, participants continuously ran between two cones set apart to allow the speed to match participants' 90% MAS and 60% MAS for HIIE and MIIE groups, respectively (i.e., the distance between the cones varied between participants, Figure 1) as in previous HIIE-based study (9). To pace 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.

Statistical analysis. All statistical analyses were conducted using SPSS (SPSS 26.0; IBM Corporation, Armonk, NY, USA). Descriptive characteristics are presented as mean ± standard deviation (SD). The normal distribution of the data was checked by the Shapiro–Wilk normality test. A mixed model ANOVA design with the between factor 'group' (HIIE vs MIIE), repeated factor 'interval' (work interval 1, 4, and end work interval), and repeated 'session' (session 1, session 18, and session 36) was used to analyze training session variables (i.e., affective, enjoyment, RPE responses, cardiorespiratory responses). Each of the exercise sessions for both groups consisted of a different end work interval (Session 1=7 reps; Session 18=7 reps; Session 36=10 reps). A Bonferroni post hoc test was carried out on significant interactions to examine the location of differences. Where the assumption of sphericity was violated, degrees of freedom were corrected with Greenhouse–Geisser epsilon. The magnitude of mean differences was interpreted using effect size (ES) calculated using Cohen's d (Cohen, 1988).

Table 1. A 12-week exercise training program for HIIE and MIIE

Groups	Variables	Weeks (1-2)	Weeks (3-4)	Weeks (5-6)	Weeks (7-8)	Weeks (9-10)	Weeks (11-12)
HIIE	Repetition	5	6	7	8	9	10
	Duration (Work/Recovery)	60/75 s					
	Work intensity	90% of MAS					
	Recovery intensity	Self-paced					
MIIE	Repetition	5	6	7	8	9	10
	Duration (Work/Recovery)	60/75s					
	Work intensity	60% of MAS					
	Recovery intensity	Self-paced					

HIIE: high-intensity interval exercise; MIIE: moderate-intensity interval exercise.

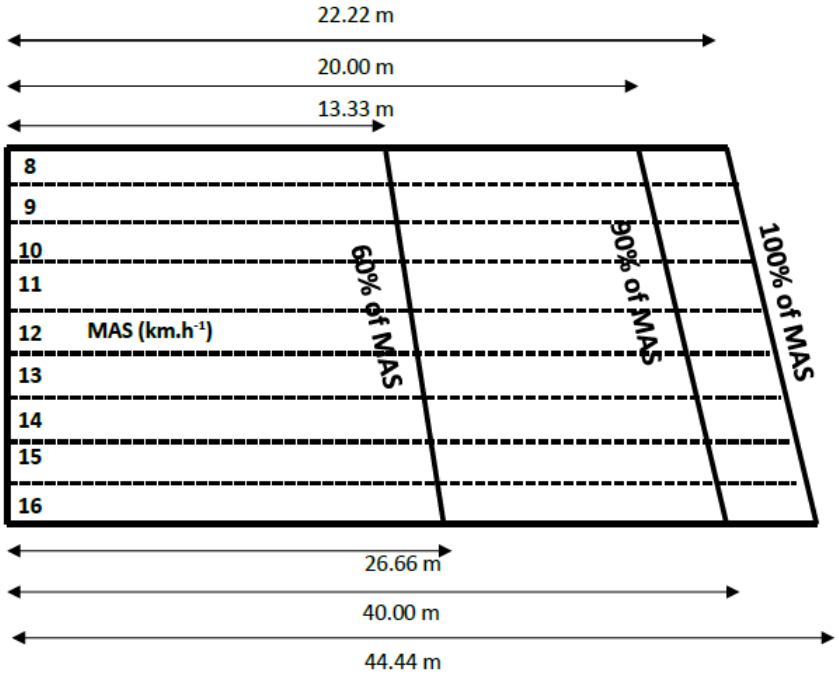

Figure 1. Short track for interval exercise.

RESULTS

Participants' characteristics are presented in Table 2. There was no significant group-by-time interaction, but the findings showed a significant main-time effect across all variables (P<0.01), excluding height, IPAQ, and MAS. Specifically, the HIIE group elicited greater improvement before and after the intervention in weight (kg), BMI, and body fat percentage compared to the MIIE group (all P<0.05, all ES>0.60). Also, the HIIE group elicited greater estimated $\dot{V}O_2max$ after the exercise intervention compared to the MIIE group (P=0.01, ES=0.84). Whereas the MIIE group showed enhancement only in estimated $\dot{V}O_2max$ from pre and post-exercise intervention (P=0.02, ES=0.45) and not for other health parameter variables (all P>0.05, all ES<0.24). Training compliance was 100% for both groups and no adverse effects were reported.

Heart Rate responses. Changes in HR responses across three sessions (sessions 1, 18, and 36) in both MIIE and HIIE groups are illustrated in Figure 2. There was a significant group of session-by-interval interaction for HR responses (P=0.03). Specifically, the HIIE group elicited greater HR responses compared to the MIIE group across all exercise sessions at work interval 1 (P<0.05, all ES>3.57), 4 (P<0.05, all ES=4.44) and end work interval (P<0.05, all ES>4.07).

Affective responses. Changes in affective responses measured by FS across three sessions

(sessions 1, 18, and 36) in both MIIE and HIIE groups are illustrated in Figure 3 (a, b, and c). There was a significant group by an interval of session interaction for FS responses (P=0.01). Specifically, the HIIE group generated lower affective responses at work interval 4 and the end of work interval in session 1 (P=0.03; ES= 1.75) and at the end of work interval in session 18 (P=0.04, ES=1.70). Also, the HIIE group elicited lower FS at the end of the work interval during session 1 compared to sessions 18 and 36 (all P<0.04, ES>1.55).

Rating of perceived exertion. Changes in RPE across three exercise sessions (sessions 1, 18, and 36) in both MIIE and HIIE groups are illustrated in Figure 3 (d, e, and f). There was a main effect of group by interval by session interaction for RPE (P=0.03). Specifically, RPE response was significantly greater during the HIIE group compared to the MIIE group at work-interval 4 and end work intervals in session 1 (all P<0.04; all ES >0.48) and session 18 (all P<0.04; ES >0.59). Whereas the HIIE group generated greater RPE than the MIIE group at the end of the work interval of session 36 (all P<0.05; all ES >0.51). Also, the HIIE group showed a significantly greater RPE at work intervals 1 and 4 in session 1 compared to sessions 18 and 36 (all P<0.01, all ES>1.09). Similarly, the MIIE group elicited greater RPE at work intervals 1 and 4 during session 1 compared to sessions 18 and 36 (P<0.01, ES>1.18).

Enjoyment responses. Post-enjoyment responses for both exercise groups are depicted in Figure 4. There was a main effect of the session for post-enjoyment (P=0.01). Specifically, the HIIE group elicited lower post-enjoyment in session 1 than in session 36 (all P<0.01, ES=0.74). Whereas the MIIE group elicited lower post-enjoyment in session 1 than in session 18 and session 36 (all P<0.02, all ES>0.60).

Table 2. Descriptive characteristics of the participants (N=24)

VARIABLES	MIIE (n=12)		P-Value	HIIE (n=12)		P-Value
	pre	post		pre	post	
Age (years)	20.92±1.08	-	-	20.75±1.29	-	-
Body mass (kg)	60.6±8.2	60.3±8.9	0.15	63.3±9.1	61.5±8.7	0.02
Stature (m)	168.9±8.5	-	-	166.3±6.2	-	-
BMI ($kg \cdot m^2$)	21.6±1.9	21.3±1.8	0.24	22.1±1.6	21.1±1.5	0.04
Body fat (%)	19.9±5.1	19.6±5.1	0.18	20.5±5.8	19.1±4.7	0.02
$\dot{V}O_{2max}$ ($mL \cdot min^{-1} \cdot kg^{-1}$)	36.7±2.9	39.2±3.2	0.02	36.6±2.7	42.8±2.7	0.01
MAS ($km \cdot h^{-1}$)	5.1±0.1	-	-	9.1±1.0	-	-
IPAQ-C (MET-min/week)	451±77	-	-	446±87	-	-

Values are reported as mean±standard deviation; BMI: body mass index; IPAQ-C: Chinese version of international physical activity questionnaire; $\dot{V}O_{2max}$: maximal oxygen uptake; $\dot{V}O_{2max}$: maximal oxygen uptake.

DISCUSSION

This study presents data on responses effective, enjoyment responses, cardiorespiratory responses, and body composition to two exercise training interventions, namely HIIE and MIIE among physically inactive college students. The major findings of this study were: 1) The HIIE group elicited lower affective responses (less pleasurable) compared to the MIIE group towards the end of the work interval of sessions 1 and 18. However, both groups generated similar affective responses in session 36; 2) HIIE and MIIE groups produced comparable post-enjoyment responses across all sessions; 3) HIIE group showed greater RPE responses compared to MIIE group towards the end of work interval across all sessions; And 4) HIIE group produced a significant improvement across all body compositions outcomes and cardiorespiratory responses following 12-week exercise interventions. In contrast, the MIIE group showed a significant improvement only in cardiorespiratory responses.

Consistent with the study hypothesis, we found that the MIIE group generated more pleasurable feelings than the HIIE group during the initial few weeks of exercise intervention (i.e., sessions 1 and 18). According to the dual mode theory (DMT) of affective responses to exercise (6), the continuous type of high-intensity exercise commonly leads to more feelings of displeasure than the continuous type of low-to-moderate-intensity exercise (17–19). The DMT predicts that negative affective

responses during high-intensity exercise are influenced by physiological factors (e.g., increased exertional stress and HR) produced during exercise. We, therefore, reason that greater bodily stress response produced during HIIE compared to MIIE, as reflected in greater HR and exceptional stress (measured via RPE) responses during the HIIE group than MIIE group, may generate less pleasurable feelings in HIIE compared to MIIE as predicted by the DMT. Indeed, both HR and RPE responses are key factors in determining in-task affective responses to exercise (20).

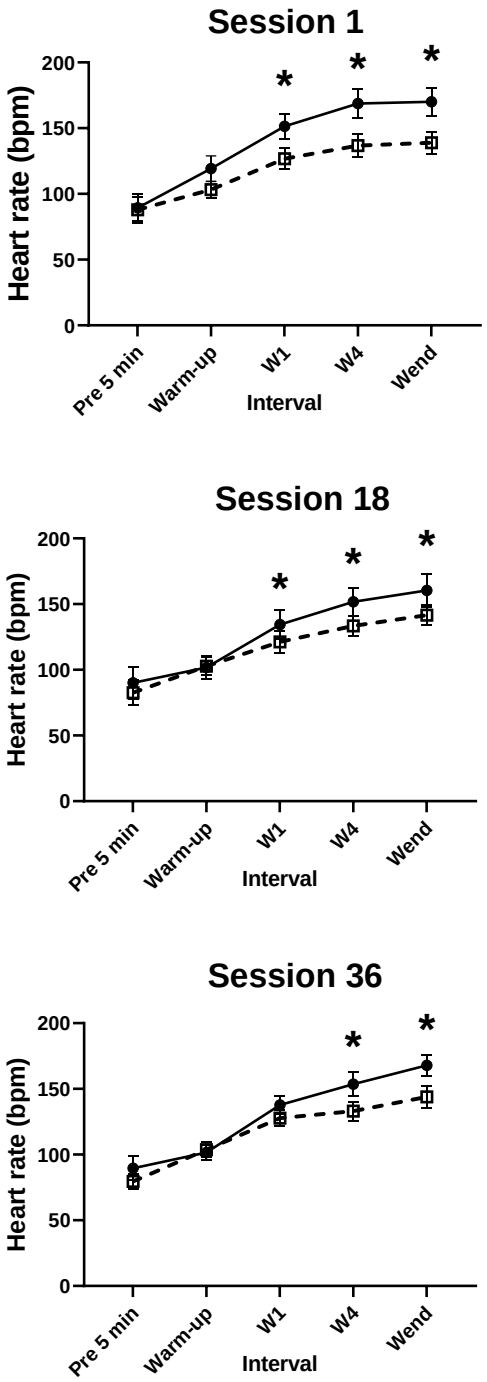

Figure 2. Heart rate responses to HIIE group (●) and MIIE group (□). Where, W=work interval and Wend=end work interval. *: Significant difference between HIIE and MIIE (P<0.01). #: Significant difference across sessions for HIIE (P<0.01). Error bars are presented as standard deviation.

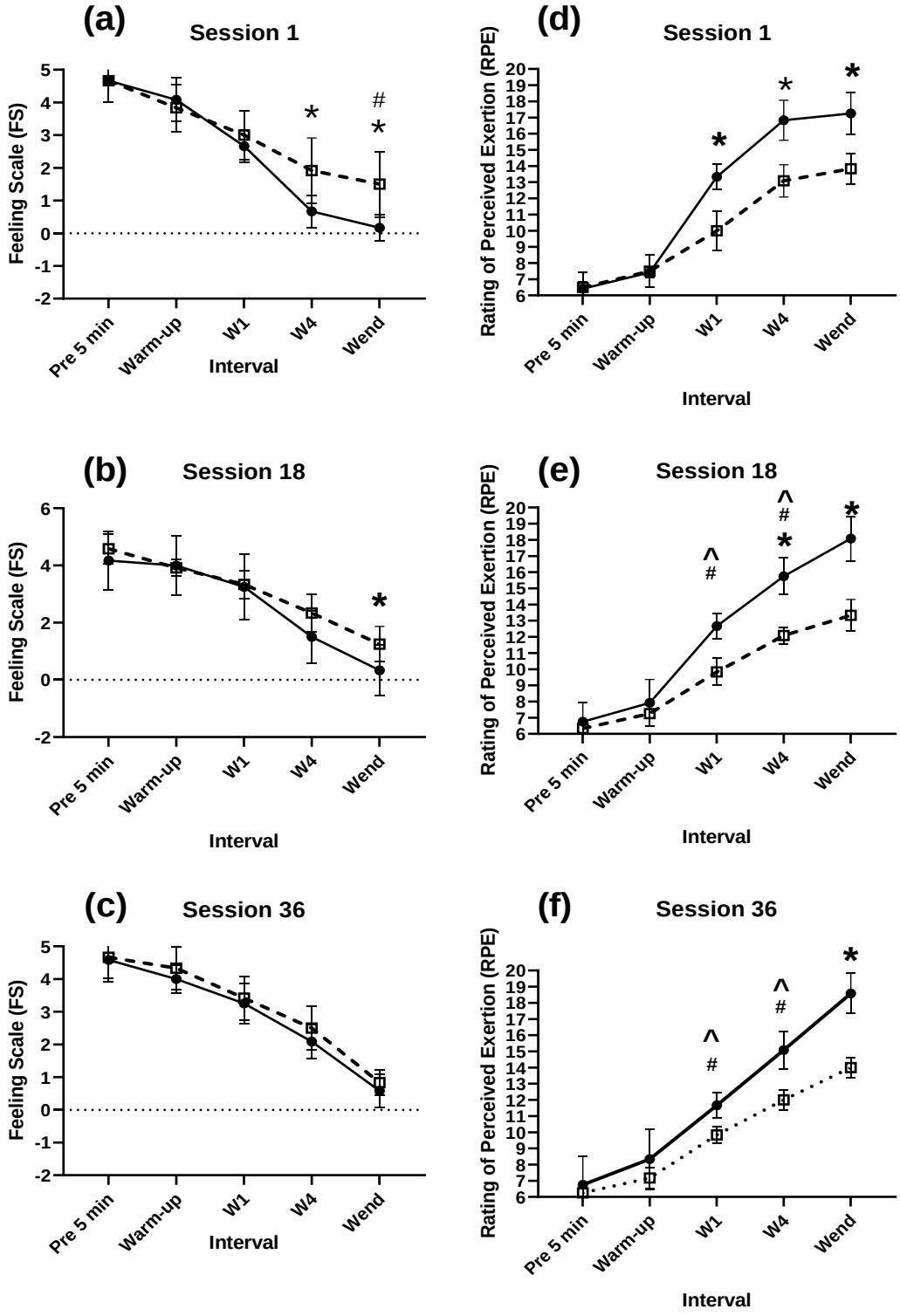

Figure 3. Feeling scale (a, b, c) and rating of perceived exertion (d, e, f) responses to HIIE group (●) and MIIE group (□). Where, W=work interval and Wend=end work interval. *: Significant difference between HIIE and MIIE (P<0.01). #: Significant difference across sessions for HIIE (P<0.01). ^: Significant difference across sessions for MIIE (P<0.01). Error bars are presented as standard deviation.

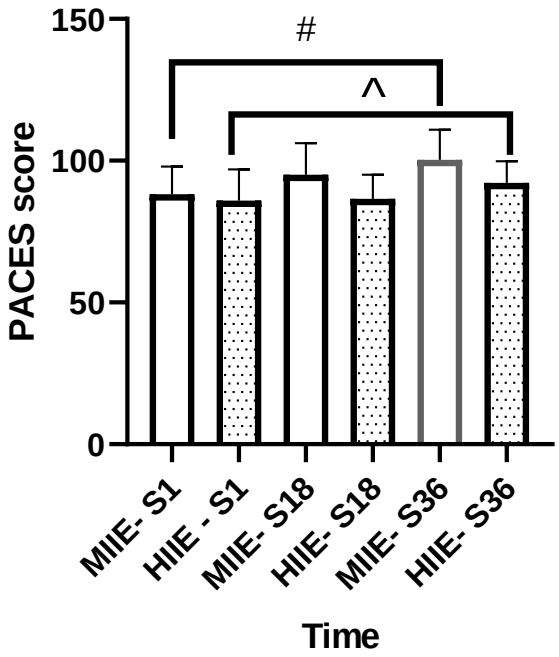

Figure 4. Post-enjoyment responses to moderate-intensity interval exercise (MIIE) and high-intensity interval exercise (HIIE) measured by PACES across all sessions. Where S=session. #: Significant main effect of time for MIIE group (P<0.01). ^: Significant main effect of time for HIIE group (P<0.01). Error bars are presented as standard deviation.

Interestingly, the present study found comparable affective responses in both HIIE and MIIE groups towards the end of exercise intervention (i.e., session 36), indicating an improvement in pleasurable feelings across a 12-week exercise intervention in the HIIE group. This observation is consistent with recent work by Malik et al. who found that affective responses were greater (more pleasurable) towards the end of the work interval during HIIE (9 x 1 min work interval performed at 90% of maximal aerobic speed) at final week compared to the first week of a 5-week exercise intervention among overweight-to-obese adults (21). A previous systematic review by Rhodes & Kates concluded that experienced exercisers may be able to improve their overall positive affective response evaluation towards specific exercise protocols to facilitate their capability and motivation to adhere to or maintain future PA behavior (22). Moreover, Frazao and colleagues reported that the accumulated exercise experience and familiarity with HIIE protocols led to the improvement of positive affective responses during such protocols (23). Therefore, it seems plausible to indicate that the link between exercise intensity to affective responses could be negated following a few HIIE sessions in physically inactive college students.

In the present study, a similar post-enjoyment was observed in both HIIE and MIIE groups across the first and last session of the exercise intervention which is consistent with previous systematic review and meta-analysis by Oliveira et al., showing comparable enjoyment responses following HIIE and continuous moderate-intensity exercise (24). This finding indicates similar beneficial effects of enjoyment responses to exercise regardless of exercise intensity. Moreover, in our study, both HIIE and MIIE groups, produced greater post-exercise enjoyment in session 36 compared to session 1, indicating an improvement in enjoyment responses following a few exercise sessions in both interval conditions. An explanation for this observation may be attributed to a ‘rebound effect’ from the previous feeling stimulated during and challenging or intense exercise as explained by the opponent-process theory. In the present study, the exercise challenge was increased in session 36 compared to session 1 due to the increasing number of work interval repetitions following every two weeks across a 12-week exercise intervention in both

groups. We, therefore, reason that an escalation in the challenge posed during both MIIE and HIIE groups across 12 weeks of exercise intervention is likely to contribute to the greater post-exercise enjoyment responses in session 36 than in session 1 for both HIIE groups.

Following a 12-week HIIE intervention, the HIIE group elicited greater enhancement across all health indices including cardiorespiratory fitness and body compositions (ES>0.60), parameters compared to the MIIE group (ES<0.20). This observation indicates that the HIIE protocol is a time-efficient means for enhancing cardiorespiratory fitness across 12 weeks of exercise intervention in physically inactive college students. Our observation is consistent with previous HIIE-based studies in adults (25), showing that HIIE interventions are effective for improving cardiorespiratory fitness despite using lower energy expenditure within a short period of exercise intervention (e.g., 2-8 weeks). An explanation for the dissimilar improvement pattern of aerobic capacity between both exercise groups may be attributed to the greater exercise stimulus (i.e., running speed and HR responses) exerted in the HIIE group compared to the MIIE group across all exercise sessions.

Several strengths and limitations should be acknowledged in this study. One strength is that the participants involved in this present study were insufficiently active based on their IPAQ. This characterization of our participants could augment the generalizability of data for exercise interventions that are substantially required in physically inactive college students. The present study is limited to the interval running exercise and it is not possible to extrapolate to other exercise modalities (e.g. Cycling) due to potential differences in cardiorespiratory responses (26) and preference of exercise mode (27).

CONCLUSION

Although MIIE produced a significantly more pleasurable feeling compared to HIIE during the initial weeks of training intervention, HIIE shows improvement in affective and enjoyment responses following a few sessions (i.e., sessions 18 and 36) of exercise intervention. Moreover, the HIIE protocol has shown to be a more effective and time-efficient strategy in improving health indices compared to the MIIE protocol across a 12-week exercise intervention as indicated in the cardiorespiratory responses and body composition data. Therefore, considering the impact of feeling responses and health indices, HIIE appears to be a viable strategy to facilitate future exercise and adherence, while producing health benefits among physically inactive college students.

APPLICABLE REMARKS

- HIIE elicited lower affective responses during the initial week but both groups produced comparable affective responses after a few weeks of interventions.
- Similar enjoyment responses were evident following HIIE and MIIE.
- HIIE generated greater improvement in cardiorespiratory fitness and body composition compared to MIIE.

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AUTHORS' CONTRIBUTIONS

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

CONFLICT OF INTEREST

No conflict of interest to declare.

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