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Original Article

Perceptual responses and running performance during treadmill and overground self-paced interval running in moderately active adults

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Abstract
Background: Perceptual responses (affect, enjoyment and perceived exertion) and exercise performance (running speed) during self-paced continuous running are dependent on environmental setting (treadmill vs overground), but these observations remain unclear during interval exercise. We examined the running speed, affect, enjoyment, and perceived exertion to self-paced interval running (IR) with different environmental settings in adults. *Methods*: Twelve moderately active men and women (6 women, 21.3 ± 1.7 years) unfamiliar with interval exercise performed two counterbalanced self-paced IR (8 x 1-min work intervals separated by 75 s recovery) under two different conditions: Treadmill IR and Overground IR. Affect was recorded before, during, and after exercise. Heart rate (HR) and perceived exertion were recorded throughout the exercise trials and enjoyment responses were collected following the exercise trials. *Results*: Overground IR elicited greater running speed and perceived exertion compared to Treadmill IR during work intervals 1 to 4 ($P<0.01$, ES=2.49-0.39) and 1 to 8 ($P<0.001$, ES=0.55-0.91), respectively. HR was also significantly greater in Overground IR than Treadmill IR during work intervals 1 to 5 ($P<0.001$, ES=2.91-1.73). Affect was lower in Overground IR compared to Treadmill IR during work intervals 5 to 8 ($P<0.01$; ES=0.83-1.16). Similar post-enjoyment was evident in both conditions ($P=0.24$; ES=0.35). *Conclusions*: Perceptual responses during interval running are not solely influenced by the environmental setting but predominantly by exercise performance (running speed) derived from the distinct exercise conditions. Treadmill IR offers greater affect and lower perceived exertion which may serve as an initial strategy for facilitating participation in interval running exercise particularly for those unfamiliar with this form of exercise.
Key Words: **affect, self-selected, interval running, environmental setting, exercise performance**

Introduction

Interest in optimising the magnitude of health adaptations while reducing the time commitment during exercise has led to the adoption of high-intensity interval exercise (HIIE) as a strategy to encourage exercise participation in adults (Batacan et al., 2017; Viana et al., 2019). HIIE is a promising method by which to attenuate the frequently cited barrier to exercise which is time constraints (Hoare et al., 2017). The effectiveness of HIIE to improve various aspects of cardiovascular and metabolic health has been well documented (Batacan et al., 2017), but the implementation of this protocol to the general population is contentious due to its high-intensity nature (Biddle & Batterham, 2015). Sceptics argue that high-intensity exercise prescribed during HIIE may generate negative affective responses (i.e. feelings of displeasure) and lead to poor exercise adherence (Biddle & Batterham, 2015; Hardcastle et., 2014; Oliveira et., 2013). Therefore, it is vital to understand the pattern of affective responses (pleasure/displeasure feelings) during HIIE, as previous research has indicated that the affect experienced during exercise can influence future exercise adherence in adults (Williams et al., 2016).

Despite available evidence on the affective responses (i.e. feelings pleasure and displeasure) to HIIE in adults (Oliveira et., 2018; Stork et., 2017), data are contradictory between studies. Several studies (Decker & Ekkekakis, 2016; Oliveira et al., 2013) have reported that individuals may adhere to HIIE because they will find it pleasurable (positive affective response), while others (Jung, Bourne, & Little, 2014; Martinez et al., 2015) find it unpleasant (negative affect response) and therefore be unlikely to repeat the exercise experience. The divergent findings observed across studies may be attributed to the different work intensity employed within each study (e.g. 70% to 100% of maximal exercise capacities), indicating that the prescription of inappropriate work intensity may hamper the preservation of pleasurable feelings during HIIE. Furthermore, these previous HIIE based studies on affect responses typically involved prescribed work intensities rather than allowing participants to self-regulate their own exercise intensity. This approach is unusual however, given that individuals typically self-select their own exercise intensity while exercising in the real-world setting (e.g. walking, running, and cycling). Previous evidence has indicated that incorporating a self-paced intensity will result in more pleasurable feelings compared to imposed intensity (Ekkekakis, 2009), but data are limited to

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continuous types of exercise. It is not possible to extrapolate these findings to interval exercise due to potential differences in perceptual and physiological responses (Oliveira et al., 2018; Stork et al., 2017). Consequently, the ecological validity of this form of exercise in adults is unclear.

One available laboratory-based study has evaluated the perceptual responses (affect and enjoyment) between an imposed and self-selected 8 x 1 min HIIE cycling protocol in adults (Kellogg et al., 2018). The authors reported that the self-selected HIIE protocol led to the selection of higher power output during HIIE (~17% higher) and greater physiological stress (heart rate responses, perceived exertion), which was accompanied by lower affect and enjoyment when compared to imposed HIIE. This finding may indicate that the selection of work intensity during interval exercise may not be driven by individual tendency to maximise their pleasurable feelings, which is not in line with previous studies in adults involving continuous type of exercise (Ekkekakis, 2009). Differences in mode of exercise (interval vs continuous) may be attributed to these inconsistent results. The available evidence by Kellogg and colleagues (2018) are limited however, as the self-paced HIIE protocol comprised of laboratory-based cycling protocol. Thus, this area of research is in its infancy and more work needs to be conducted to evaluate psychophysiological responses in research exploring self-paced interval running as an effective health strategy in adults.

The majority of HIIE based studies on affect responses have been laboratory-based interventions (Oliveira et al., 2018; Stork et al., 2017), which limits the applicability of such study findings to real-world exercise experiences. One previous study has shown that 20 minutes of self-paced overground (outdoor based) walking elicited greater affect responses (more pleasurable) and lower perceived exertion than treadmill walking in adults (Dasilva et al., 2011). This previous evidence indicates that natural setting could enhance pleasurable feeling and lower exertional stress in adults due to the multiple external cues or higher attentional distraction in naturalistic environments (outdoor). Furthermore, a recent systematic review of crossover studies reported that runners prefer running overground compared to treadmill during high-intensity exercise as they will have a greater control over their speed and reduce risk of falling (Miller et al., 2019). Consequently, overground running elicited greater exercise performance (running/walking speed) than treadmill running during continuous high intensity exercise (Miller et al., 2019), but no evidence on affect and enjoyment across studies were reported. To date, it is unclear whether self-paced interval running exercise in a more naturalistic environment (i.e. overground) would elicit different perceptual responses and exercise performance compared to a laboratory setting in adults.

The purpose of the present study was to evaluate the acute perceptual responses (affective response, perceived exertion, and enjoyment) and exercise performance (running speed and distance covered and heart rate response) to self-paced interval running with different environmental setting (treadmill vs overground) in moderately active adults. It was hypothesised that self-paced treadmill interval running will generate lower affective response (less pleasurable) and enjoyment response accompanied by greater perceived exertion and exercise performance when compared to self-paced overground interval running.

Methods

Participants

Twelve men and women adults (6 women) were recruited into the study using a convenience sampling approach. They were included on the basis that they were aged between 18 and 25 years, and were moderately active (Category 2, <3000 MET-min/week) determined based on Malay language version of the International Physical Activity Questionnaire IPAQ-M (Shamsuddin et al., 2015). All participants were also non-regular runners (jogging/running no more than once a week) and unfamiliar with HIIE regimes and informed consent was obtained from all participants prior to study commencement. The study protocol was approved by the Human Research Ethics Committee of Universiti Sains Malaysia.

Experimental overview

Participants completed three experimental visits, separated by at least two-day recovery period. The first visit was to measure anthropometric variables, determine maximal aerobic speed (MAS), establish maximal heart rate responses (HR_{max}) and familiarise participants with the measurement scales. This was followed by two experimental visits; each involving a self-paced interval running protocol with a different environmental condition (i.e. treadmill vs. outdoor running), the order of which was randomised and counterbalanced to control for carryover effects. Participants performed the exercise test at the same time of the day between the hours of 08:00 to 10:00. The running protocol settings were an outdoor 400 m field track and a motor-driven treadmill in a sport science laboratory (TMX428CP Trackmaster treadmill, USA). The laboratory temperatures and humidity were set similar to the outdoor temperature (temperatures = 25-27 °C and humidity 55-60%).

Anthropometric and physical activity measures

Body mass and stature were measured to the nearest 0.1 kg and 0.1 cm, respectively. Body mass index (BMI) was calculated as body mass (kg) divided by stature (m) squared. Participants' daily habitual physical activity was measured by using validated IPAQ-M prior to the experimental visits (Shamsuddin et al., 2015). IPAQ-M is divided into three levels of categorical score that consists of Category 1 (Inactive; <600 MET-min/week), Category 2 (moderately active; <3000 MET-minutes/week) and Category 3 (health-enhancing physical activity (HEPA); >3000 MET-minutes/week).

Determination of maximal aerobic speed and maximal heart rate

Participants were habituated to the motorised treadmill before completing an incremental speed-based protocol to establish MAS and HR_{max}. Participants began a warm-up against a speed of 4.0 km/h for 3 min, followed by running at the speed of 6.0 km/h with 0.5 km/h increments every 30 s until volitional exhaustion, before a 5 min cool down at 4.0 km/h. Throughout the incremental test, the treadmill gradient was set at 1%. HR was measured continuously using a telemetry system (Polar Electro, Kempele, Finland) and the highest HR achieved during the incremental speed test was taken as HR_{max}. This protocol has been used previously for determining MAS in adults (Laurent et al., 2014).

Self-paced interval running

The comparison interval running protocol consisted in performing one self-paced run on the treadmill (laboratory-based, Treadmill IR) and one self-paced run on a 400 m field track (outdoor based, Overground IR). Both settings required the participants to complete a 3 min warm-up followed by 8 x 1 min work intervals, interspersed with 75 s active recovery. The selected interval running protocol is based on commonly utilised low-volume protocol in HIIE-based studies in adults (Sultana et al., 2019). A 2 min cool down was provided at the end of the protocols. Participants were required to self-select their own intensity at either walking or jogging pace during warm-up, recovery intervals and cool down for the given exercise duration. For both conditions (Treadmill IR vs Overground IR), participants were encouraged to try to run as fast as they would like for 1 min across eight repetitions of work interval. They were informed there is no right or wrong speed rather just select the speed they felt was their highest effort given the exercise situation. During Treadmill IR, participants were allowed to adjust their running speed every 10 s before the end of each work interval. The treadmill grade for Treadmill IR was set to 1% to make the effort equivalent to running outdoors (Jones & Doust, 1996). The overground IR was performed from a standing start (position similar to that on the treadmill), and performance (i.e. speed and distanced covered) was measured by ASICS Runkeeper^{TM} Running Tracker App version 10.7.2 (FitnessKeeper, Inc.; http://Runkeeper.com/), which was previously validated to measure distance travelled and speed during walking and running in healthy and physically active adult (Adamakis, 2017). Running speed for both conditions was recorded based on Kilometre per hour ($km \cdot h^{-1}$). A threshold of ≥85 % HR_{max} was used as our criterion for satisfactory compliance to the HIIE protocol (Ito, 2019).

Experimental Measures

Affective valence (pleasure/displeasure) was measured using the feeling scale (FS; Hardy & Rejeski, 1989). Participants responded to how they felt on an 11-point bipolar scale ranging from "Very Good" (+5) to "Very Bad" (-5). Perceived activation levels were measured using the single-item felt arousal scale (FAS; Svebak & Murgatroyd, 1985). Participants responded on a 6-point scale ranging from 1 'low arousal' to 6 'high arousal'. Both scales exhibited correlations ranging from 0.41 to 0.59 (FS) and 0.47 to 0.65 (FAS), respectively, with the Affect Grid (Russell, Weiss, & Mendelsohn, 1989), indicative of convergent validity with similar established measures (Van Landyut et al., 2000). Participants responded to the FS and FAS 5 min before exercise and at 20 s before the end of each work interval

The physical activity enjoyment scale (PACES), which was validated for use with adults (Kendzierski & DeCarlo, 1991), was used to assesses enjoyment 10 minutes after exercise . The PACES consists of 7 positively worded and 11 negatively worded items, each rated from 1 to 7 on a 7-point bipolar scale. Negative items were reverse scored, and all 18 items were summed to produce a total enjoyment score out of 126. The internal consistency was acceptable at each administration (Cronbach's αs > 0.85) in the present study.

The rating of perceived exertion (RPE) was assessed using the 10-point category-Ratio 10 Scale (Borg, 1998). Participants were instructed to report perceptions of their exertion via a 0-10-point Likert item ranging from 0 (nothing at all) to 10 (absolute maximum). This scale has been established as a reliable and valid measure of physical exertion during exercise (Borg, 1998). Participants responded to the RPE at 20 s before the end of each work interval.

Statistical analyses

All statistical analyses were conducted using SPSS (SPSS 24.0; IBM Corporation, Armonk, NY, USA). Descriptive characteristics are presented as mean ± standard deviation (SD). Normal distribution of the data was checked by the Shapiro–Wilk normality test. A series of 2 (condition, treadmill vs overground) by 8 (work intervals) two-way repeated measures ANOVA were conducted to examine differences in perceptual responses (affect and RPE responses) and running performance (speed, distance covered and HR responses). In addition, post-enjoyment scores between conditions were analysed using paired samples t-tests. Bonferroni post hoc test was carried out on significant interactions to examine the location of differences. The magnitude of mean differences was interpreted using effect size (ES) calculated using Cohen's *d* (Cohen, 1988). Pearson's product–moment correlation coefficient was used to examine the relationships of outcome variables during the work intervals.

Results

Descriptive characteristics of participants are depicted in Table 1. Data showed the participants had the BMI values range between 17.7–26.3 $kg.m^{-2}$ and the body fat percentage range between range 12.8–39.4%. All participants were moderately active (CATEGORY 2) based on their habitual PA levels measured by IPAQ-M

(<3000 MET-min/week). Also, all participants completed both exercise protocols (treadmill vs overground) with no adverse events recorded and ~80% of participants indicated that they preferred the Treadmill IR.

Table 1 Descriptive characteristics of the participants (N = 12)

	Mean ± SD	Range
Age (y)	21.3 ± 1.7	19 - 25
Body mass (kg)	55.8 ± 9.2	42.2 - 69.4
Stature (m)	1.63 ± 0.07	1.49 - 1.76
BMI (kg·m^{-2})	20.9 ± 2.7	17.7 - 26.3
Body fat (%)	22.6 ± 7.1	12.8 - 39.4
HR_{max} (bpm)	194 ± 8	177 - 209
RPE_{max}	7.5 ± 1.8	5 - 10
MAS (km·h^{-1})	13.4 ± 2.3	10.0 - 16.5
IPAQ-M (MET-min/week)	2446 ± 1238	838 - 4053

BMI, body mass index; HR_{max}, maximal heart rate; RPE_{max}, maximal rating of perceived exertion; MAS, maximal aerobic speed; IPAQ-M, Malay version of international physical activity questionnaire; km·h^{-1}, Kilometre per hour.

Heart rate responses

The mean interval by interval HR responses during Treadmill IR and Overground IR are illustrated in Figure 1A. HR showed a significant condition by interval number interaction effect (P<0.001). HR was significantly greater during Overground IR than Treadmill IR at work intervals 1 to 5 (P<0.001, ES = 2.91 to 1.73). HR increased during the work intervals (P<0.01) in both conditions. During Treadmill IR, FS significantly increased from 5-min pre at work interval 1 to 8 (P<0.001; ES = 3.89 to 9.23,). Similarly, during Overground IR the increase from 5-min pre was significant at work interval 1 to 8 (work, P<0.01; ES = 8.73 to 14.85). The highest peak HR achieved during Treadmill IR and Overground IR were 176 ± 11 bpm (90% HR_{max}) and 188 ± 6 bpm (97% HR_{max}), respectively.

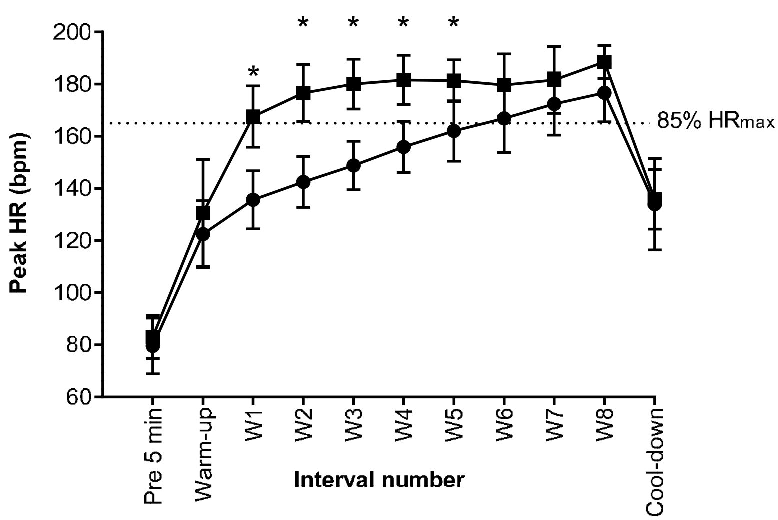

Figure 1. The mean peak HR (in beats per minute) during the work interval (W) of the Treadmill IR (●) and Overground IR (■).*Significant difference between conditions (P<0.05). Error bars are presented as SD values.

Running speed

Figure 2A presents the running speed during both conditions. There was a significant condition by interval number interaction effect in running speed (P=0.03). Running speed (km·h^{-1}) was significantly greater during Overground IR compared to Treadmill IR at work intervals 1 to 4 (P<0.01, ES = 2.49 to 0.39). Also, running speed significantly increased from work interval 1 to 8 (6.9 – 13.6 km·h^{-1}; 52 – 100% of MAS) during Treadmill IR (P<0.01; ES = 0.83 to 1.16). In contrast, running speed significantly lower at work intervals 5 to 7 compared to work interval 8 with no significant difference in other work intervals during Overground IR (P<0.02, all ES > 2.09, range of speed across work interval = 82 – 96% of MAS). Both conditions elicited the highest MAS at work interval 8 [Treadmill IR=13.6 ± 3.5 (100% of MAS); Overground IR= 12.9 ± 2.2 (96% of MAS)]. There was a strong positive correlation between running speed and HR responses for Treadmill IR and Overground IR across work interval (Treadmill IR = all r>0.81, all P<0.03; Overground IR = all r>0.58, all P<0.05).

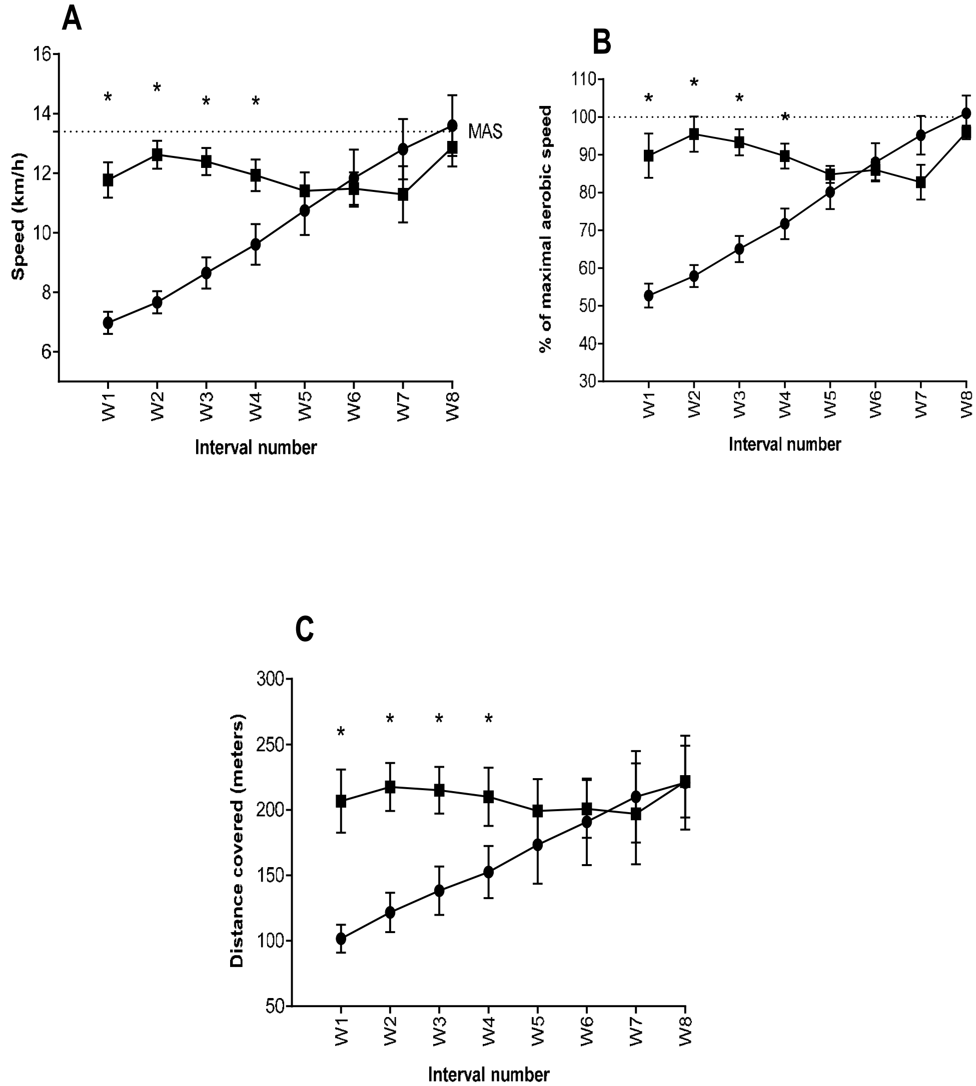

Figure 2. Running speed in kilometres per hour (A), percentage of maximal aerobic speed (B), and distance covered (meters) (C) during the work interval (W) of the Treadmill IR (●) and Overground IR (■). *Significant difference between conditions (*P*<0.05). Error bars are presented as SD values.

Running distance

Distance covered during the Treadmill IR and Overground IR are illustrated in Figure 2C. There was a significant condition by interval number interaction effect in running distance (*P*=0.04). Distance covered (m) was significantly higher during Overground IR compared to Treadmill IR at work intervals 1 to 4 (*P*<0.01, ES = 3.60 to 1.78). Also, distance covered significantly increased from work interval 1 to 8 (101 to 220 m) during Treadmill IR (*P*<0.01; all ES>1.00). However, distance covered during Overground IR was significantly lower at work intervals 5 to 7 compared to work interval 8 (*P*<0.03, all ES>0.54; work intervals 5-7 = 199 to 197 m vs. work interval 8 = 221 m). Overground IR (1309 ± 280 m) accumulated the largest distance covered than Treadmill IR (1667 ± 257 m) across work interval (*P*=0.012, ES = 1.33).

Affective responses

FS depicted a significant condition by interval number interaction effect (*P*=0.021) as illustrated in Figure 3A. Specifically, FS was significantly greater during Treadmill IR than Overground IR at work intervals 4 to 8 (*P*<0.01, ES = 0.88 to 0.29). Also, FS declined during Treadmill IR from 5-min pre at work intervals 5 to 8 (*P*<0.01; ES = 0.83 to 1.08). In contrast, the decrease in FS during overground IR was significant at work intervals 2 to 8 (*P*<0.01; ES = 1.07 to 1.11). FS remained positive at work-interval 8 during treadmill IR (1.3 ± 2.4, FS range between 5 to -1) in 9 participants (75%). In contrast, Overground IR elicited a negative FS score at work-interval 8 (-0.6 ± 3.1, FS range between 3 to -5) in 7 participants (58%). There was a strong negative correlation between affect and HR responses for Treadmill IR and Overground IR across work intervals (Treadmill IR = all r>0.85, all *P*<0.04; Overground IR = all r>0.48, all *P*<0.05).

There was no condition by time interaction (*P*=0.71) but there was a main effect of time (*P*=0.01) for FAS. Specifically, the increase from the 5-min pre was significant at work interval 5 to 8 for both conditions (*P*<0.05; Treadmill, ES = 0.60 to 1.06 and Overground IR, ES = 0.57 to 1.08) as illustrated in Figure 3B..

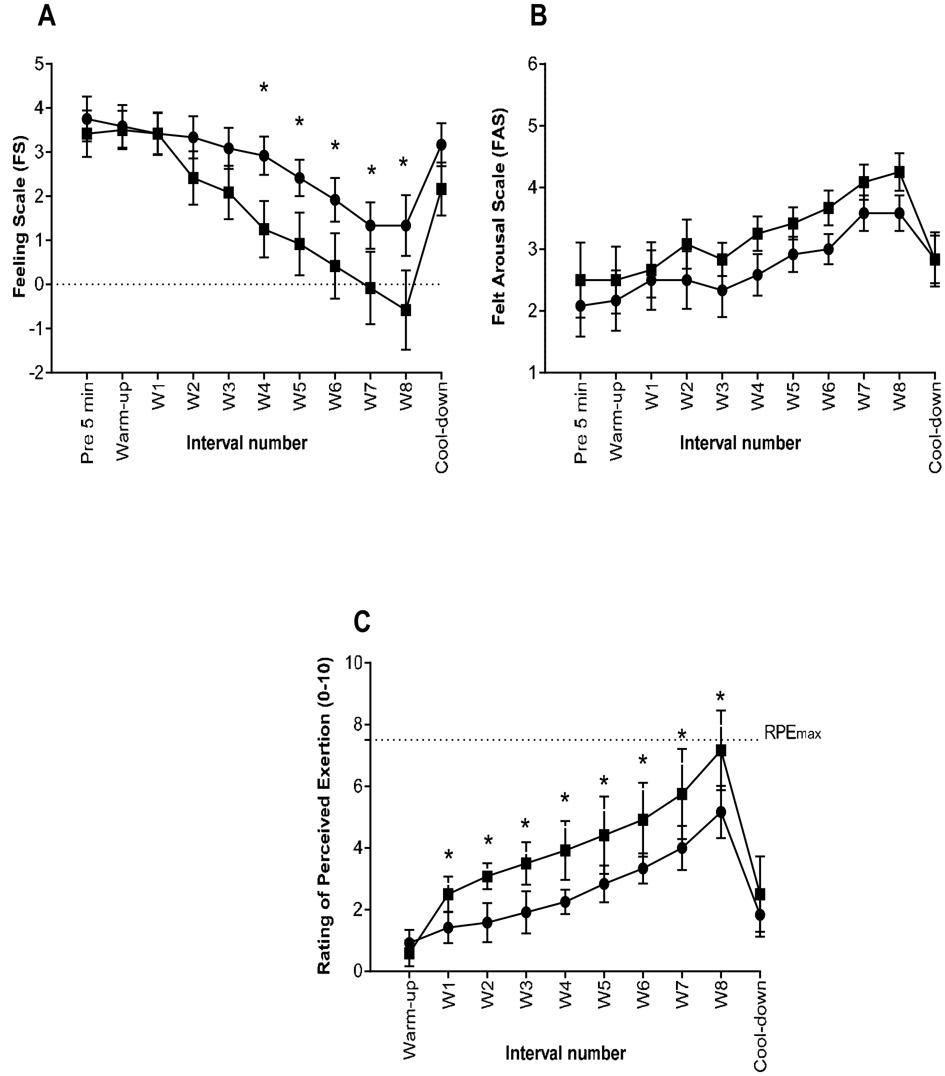

Figure 3. FS (A), FAS (B), and RPE (C) during the work interval 9 (W) of the Treadmill IR (●), and Overground IR (■). *Significant difference between conditions (*P*<0.05). Error bars are presented as SD values.

RPE and enjoyment responses

RPE showed a significant condition by interval number interaction (*P*<0.001). RPE was significantly greater during Overground IR compared to Treadmill IR across all work intervals (all *P*<0.001, ES = 0.55 to 0.91) as illustrated in Figure 3C. A strong positive correlation between affect and RPE responses for Treadmill IR and Overground IR across work interval (Treadmill IR = all r>0.75, all *P*<0.02; Overground IR = all r>0.83, all *P*<0.01). There was no significant difference was observed for post enjoyment between two conditions (*P*=0.24, Treadmill IR = 83 ± 4 vs. Overground IR = 85 ± 7, ES = 0.35) as measured via PACES.

Discussion

This study presents data on running performance and perceptual responses (affect, enjoyment and RPE) during self-paced interval running performed with two different environmental settings (treadmill vs. overground) in moderately active adults. The key findings from this study are: 1) Overground IR elicited greater running speed and distance covered during the earlier work intervals (1 to 4) compared to Treadmill IR; 2) Overground running generated lower positive affect near the completion of exercise compared to Treadmill IR; 3) Similar enjoyment was observed for both exercise conditions and; 4) Overground running elicited greater RPE across all work intervals compared to Treadmill IR. The exercise protocol utilised in this study design was well tolerated by all participants and therefore may have practical implications for health strategies in similar populations.

In the present study, our participants selected a lower running speed initially (during work interval 1 to 4) but gradually increase across work intervals during Treadmill IR compared to Overground IR. In contrast, participants tend to regulate almost similar running speed across work intervals with slight adjustment in the middle of work intervals during Overground IR. The pattern of running speed for Overground IR (consistent pattern) and Treadmill IR (increasing pattern) in this study is consistent with the work of Dasilva et al. (2011), but utilised self-paced continuous walking in adults. In a recent meta-analytic study, Miller et al. (2019) argues that participants tend to select slower pacing strategies during high intensity running on a treadmill as they feel less comfortable (potential risks of falling) compared to more naturalistic environment of overground running. Indeed, overground running provides a real-world biped locomotion, whereby individuals' centre of mass moves relatively to the supporting ground, as compared to treadmill conditions. Furthermore, previous evidence has revealed that the degree of familiarity with treadmill cited as one of the most often reasons for the differences in running performance (e.g. cadence and stride length) between overground running and treadmill (Lavcanska, Taylor, & Schache, 2005). We therefore reason that unfamiliarity experience (non-regular runners) of our participants to performed high-intensity interval running on treadmill is likely to account for the difference pacing strategy or speed in earlier work intervals for both conditions.

Despite a greater running speed generated at earlier work intervals (work interval 1 to 4) during Overground IR, participants selected the highest running speed at work interval 8 in both conditions (Treadmill IR = 100% MAS; Overground IR = 96% MAS). Moreover, the selection of running speed was similar towards the end of work interval in both conditions. Our observation seems to corroborate to the teleoanticipation model (Ulmer, 1996). Specifically, this model predicts that effort regulation during self-paced running over a given duration will be governed by the subconscious brain to allow an individual to execute exercise in the fastest possible time without overly stressing the physiological responses (e.g. HR responses, blood lactate). In the present study, we found a significant positive correlation between running speed and HR responses in both conditions, suggesting that physiological factors (HR responses) could have influence over the individual selection of running speed. Moreover, adjustment of running speed in the earlier and middle of work intervals during Treadmill IR and Overground IR (see Figure 2A), respectively, led to similar HR responses (81 - 97% of HR_{max}) at work intervals 5 to 8 in both exercise settings (See Figure 1). Consequently, this observation may indicate that pacing strategies adopted by our participants during Treadmill IR and Overground IR are influenced by the body's physiological stress as reflected in the HR data. It is also noteworthy to highlight that this pacing strategy (adjustment of running performance) did guide the participants to achieve their optimal performance (i.e. running speed, see Figure 2A) towards the completion of exercise regardless of environmental setting.

In contrast to our hypotheses, we found a significantly lower and greater decline in affective responses from baseline (5 min) during Overground IR work intervals compared to Treadmill IR, which initially occurred at work interval 2 and 5, respectively. Although both conditions elicited similar affect responses during the earlier work intervals, greater selection of running speed during Overground IR (~20%, ~ 4 $km \cdot h^{-1}$) may have led to a significantly lower and negative affect at the end of Overground IR work interval (FS = -0.6) compared to Treadmill IR (FS = 1.3). This notion is in line with findings from Parfitt and Eston (1995), which reveals that the exposure of intense work intensity at the early phase of high-intensity exercise may not be sufficient enough to generate negative feelings, but the reduction in the affect response continues until completion of the exercise. Furthermore, the selection of higher work intensity (i.e. running speed) over almost all work intervals accompanied by an increase in RPE during Overground IR may also contribute to the greater reduction of affect response compared to Treadmill IR in the present study. According to the parallel processing model (Leventhal & Everhart, 1979), an increase in an individual's exertional stress (unpleasant feeling, fatigue) is reflected by an increase in physiological cues (e.g., HR). Therefore, we speculate that during Overground IR, when physiological cues (an increase in HR) become predominant during exercise due to a greater selection of running speed, exertional stress will occupy the limited capacity of focal awareness (the sensory data to which one chooses to attend) to the brain area (i.e. prefrontal cortex area). This notion is strengthened by a positive and negative strong correlation between affect with RPE and HR, respectively, regardless of exercise conditions.

In the present study, we observed similar enjoyment responses, as measured by PACES, following Overground IR and Treadmill IR. This is consistent with previous HIIE studies on adults that found similar enjoyment responses following HIIE regardless of work intensity prescribed within study(Stork et al., 2017). Similar enjoyment responses following both conditions in the present study is not surprising as post-exercise feelings may reflect a 'rebound effect' from the previous feeling stimulated during high-intensity exercise as suggested by Ekkekakis, Hall, & Petruzzello, 2005. Furthermore, according to the self-determination theory (Deci & Ryan, 1985), self-selected intensity during exercise (autonomous conditions) could enhances individual's level of enjoyment and intrinsic motivation. Therefore, in the present study, it is plausible to suggest that the perceived control over a running intensity in both conditions may have led to similar post enjoyment.

The findings presented in the current study should be viewed in the light of a number of methodological considerations. First, no expired gases were collected across the experimental trials in the present study.

Therefore, in-depth classification of individuals fitness levels and identification of exercise intensity (moderate vs. high intensity) in relation to the ventilatory threshold (to ensure physiological equivalence between individuals) are not available in the present study. However, the HR responses and running speed collected in our study have sufficiently indicated the identification of self-paced interval protocol as high intensity based on the HR cut-off point reported from the previous HIIE-based studies. Furthermore, this methodological approach (no facemask during experimental trials) also could enhance the representations of a participant's real-world affective response to exercise. Also, the present study is limited as the exercise protocol comprised 8 x 1 min running intervals is which considered as a low-volume type of HIIE. Therefore, the findings may not apply to other exercise modalities (e.g. cycling) and protocol (e.g. sprint interval protocol). Future studies may consider expanding the scope of the present investigation to other exercise modalities or long-term exercise interventions (e.g. 12 weeks) of self-paced interval running.

Our data on HR responses have shown that both experimental protocols achieved the threshold of ≥85% HR_{max} that occur at work interval 5 to 8 and work interval 1 to 8 during Treadmill IR and Overground IR, respectively. Previous studies have proposed using a threshold of ≥85% HR_{max} to serve as the criterion for compliance with the HIIE protocol to improve multiple health benefits in adults. Therefore, based on the knowledge that the current participants selected running paces that corresponded to true HIIE, it is likely that health benefits may ensue irrespective of environmental setting. Implications of using Overground IR must be taken with caution, however, as this protocol elicited greater feelings of displeasure (due to negative end affect score) and perceived exertion compared to Treadmill IR.

Conclusions

The present study shows that the differences in perceptual responses between Treadmill IR and Overground IR running are not solely influenced by the environmental setting but predominantly by exercise performance that derived from both conditions. Specifically, greater selection of running speed initially has led to greater perceived exertion and less pleasurable feelings towards the end of Overground IR when compared with Treadmill IR. Furthermore, our study suggest that individuals seem to choose a running pace to the highest speed possible towards the end of interval running exercise without compromising their perceptual responses (affect responses and perceived exertion) regardless of environmental setting. This observation is contradicted with the previous self-paced exercise study that utilised a continuous mode of exercise which indicated that a more naturalistic setting may facilitate greater positive affect and lower influences than a treadmill exercise setting. Finally, self-paced interval running performed on treadmill could serve as an initial strategy to promote interval exercise participation for those unfamiliar with interval exercise in adults.

Competing interest
There were no conflicts of interest to disclose in the present study.

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