Influence of personality and self-efficacy on perceptual responses during high-intensity interval exercise in adolescents

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Abstract

Inter-individual cognitive factors have been shown to be related to the changes in affect evaluations during continuous high-intensity exercise in adolescents, but the role of cognitive factors on affect during high-intensity interval exercise (HIIE) is currently unknown. This study evaluated the influence of personality traits (behavioural activation system; BAS and behavioural inhibition system; BIS) and self-efficacy on affect, enjoyment and perceived exertion during HIIE in adolescents. Participants (N=30; 15 boys; mean age= 12.2 ± 0.4 years; moderate to vigorous physical activity levels per day = 33 ± 12 min) were median split into low vs. high BAS/BIS and self-efficacy groups. All participants performed HIIE consisting of 8 x 1-min work-intervals at 85% of peak power separated by 75 seconds recovery. Affect, enjoyment, and rating of perceived exertion (RPE) were recorded 5 min before HIIE, near the end of the HIIE work intervals, and 20 min after HIIE. The high BAS/low BIS group elicited greater affect and enjoyment compared to low BAS/high BIS group during work-intervals 5 to 8 (all $P<0.039$, all ES>0.59) and after HIIE for post-enjoyment (all $P<0.038$, all ES>0.95). Affect and enjoyment were greater in high compared to low self-efficacy group during work-intervals 5 to 8 (all $P<0.048$, all ES>0.62). The BAS/BIS groups elicited similar RPE (all $P>0.10$), but RPE was lower in high than low self-efficacy group at work-intervals 5 to 8 (all $P<0.037$, ES>0.98). Individual differences in personality and self-efficacy may influence the affective, enjoyment and RPE responses during HIIE in adolescents.

Key Words: feeling states, personality characteristic, perceived capability, interval exercise, youth.

Lay summary

This study aimed to evaluate the role of personality characteristics and self-efficacy on perceptual responses (pleasure/displeasure and enjoyment) during HIIE in youth. Individual differences in personality characteristics and self-efficacy may decrease or increase the likelihood that a person will experience pleasurable feelings and enjoyment to HIIE in youth.

Introduction

High-intensity interval exercise (HIIE, exercise performed above the ventilatory threshold (VT)) has been shown to be a viable exercise protocol for enhancing cardiorespiratory fitness and cardiometabolic health in adolescents (Bond et al., 2017; Costigan et al., 2015). Recent studies in youth have shown that a commonly used HIIE protocol (i.e. 8 x 1-min work interval separated by 75 s recovery) performed at intensity below 100% of peak power or maximal aerobic speed elicited positive affect responses (Malik et al., 2018a; 2019), suggesting that the recovery interval incorporated into HIIE may be preserving the further decline in affect responses. This finding contrasts with the expected pattern of negative affect responses (unpleasant feelings) during high-intensity exercise in youth as predicted by the dual mode theory (DMT), which is based on continuous high-intensity exercise and an incremental test to exhaustion (Benjamin et al., 2012; Stych & Parfitt, 2011). Therefore, the adoption and implementation of HIIE protocol as a health strategy is promising in youth.

Despite the aforementioned HIIE protocol generating pleasurable feelings in youth, Malik and colleagues (2018a; 2019) indicated that the decline in affect (i.e. less pleasurable feelings) during HIIE is related to physiological factors such as heart rate (HR) and brain oxygenation responses). According to the DMT (Ekkekakis et al., 2005), the predominance of interoceptive/physiological cues (e.g. increased HR) or cognitive/psychological cues (e.g. self-efficacy) during high-intensity exercise is related to unpleasant and pleasant feelings, respectively. Furthermore, the interaction of an individual’s cognitive and physiological factors could also influence perceptions that either maintain or enhance the positive affective response during exercise at a given intensity (Rose & Parfitt, 2007). While previous research has evaluated the relationship between affect responses and physiological responses during HIIE in youth (Malik et al., 2018a; 2018b; 2019), data on cognitive factors during HIIE have yet to be explored.

The DMT postulates that cognitive factors are unique to the individual and are likely to be influenced by self-efficacy, personality traits and goal achievement (Ekkekakis, 2003). Research has investigated personality traits and self-efficacy as the cognitive factors that underlie affective responses to exercise in adolescents and adults (McAuley & Courneya, 1992; Schneider & Graham, 2009). Regarding personality traits, Carver and White (1994) proposed that behavioural activation system (BAS, approach motivation) individuals are sensitive to the stimuli that are typically associated with a sense of reward and positive feelings (e.g. pleasurable and happiness), whereas behavioural inhibition system (BIS, avoidance motivation) individuals are sensitive to the stimuli that are typically associated with a sense of punishment and negative feelings (e.g. frustration and sadness). A previous study in adolescent boys and girls (aged 14.8 ± 0.46 years) revealed that the BAS group experienced greater enjoyment and pleasurable feelings compared to the BIS group during continuous moderate- and high-intensity exercise (Schneider and Graham, 2009). This finding indicates the role of an individual's personality on affect responses, but this observation was made during continuous exercise where high-intensity exercise was perceived as unpleasant. It is currently unknown whether affect and enjoyment responses during HIIE is related to individual's BIS and BAS in youth.

With regard to self-efficacy (i.e. confidence to perform the exercise task), a review of research in adolescents has indicated self-efficacy as a prominent personal determinant to engage with PA behaviour (Van der Horst et al., 2007). Bandura (1986) argued that there is a link between affective responses and the subsequent formation of individual self-efficacy (i.e. pleasurable feelings may reflect high confidence level and unpleasant feelings may reflect low confidence level). Previous studies in adults have consistently reported that individuals with high self-efficacy exhibit more positive affect and a lower rating of perceived exertion (RPE) compared to low self-efficacy individuals during exercise (Focht, 2013; McAuley & Courneya, 1992; Tate et al., 1995). These authors revealed that the differences between low vs. high self-efficacy individuals were increasingly evident at more demanding work intensities (e.g. above 70% of predicted maximal heart rate). However, these observations were limited to incremental exercise to exhaustion and continuous exercise in adults, which is untypical of youth patterns of activity and exercise (Barkley, Epstein, & Roemmich, 2009).

Given the above, the extent to which affect responses differ according to personality and self-efficacy factors during HIIE has not yet been examined in youth. Therefore, the purpose of the present study was to evaluate the influence of personality (BIS/BAS) and self-efficacy on the affect, enjoyment and RPE responses to a commonly used HIIE protocol in adolescent boys and girls. We hypothesised that individuals with high BAS, low BIS, and high self-efficacy would perceive HIIE to be more pleasurable and enjoyable, and less exertional compared to individuals with low BAS, high BIS and low-efficacy.

Methods

Participants

The data in the current study were obtained by combining data across two published studies that have examined the perceptual responses to HIIE in adolescents (Malik et al., 2018b; 2019). Information related to the inclusion and exclusion criteria and recruitment of the participants is explained in the original studies. Data on individual personality and self-efficacy in response to affect, enjoyment and RPE during HIIE were not reported in these previous studies. The present study resulted in the sample size of 30 participants (11 to 13-years-old, 15 boys). Using a repeated measure analysis of variance (ANOVA) statistical test in G*Power (3.0.10), a sample size of 26 participants to detect a moderate effect using a power of 0.8, an alpha of 0.05 and an effect size (F) of 0.25 was indicated. The sample size reflects related research in youth (Malik et al., 2019). All the participants were unfamiliar with HIIE. Written assent from the participants and written informed consent from the parent/guardian were obtained. Information about participants' health status was obtained before the commencement of exercise using a standard health screening form for children. All participants free of any musculoskeletal injury and health problems. The study procedures were approved by the

Experimental overview

The present study was a combination of two studies which involved four experimental visits. However, the current study only reports data from the HIIE protocol performed at 85% peak power. Consequently, only data from two visits were taken into consideration for the present study. The first visit was to measure anthropometric variables, determine cardiorespiratory health status and familiarise participants with the measurement scales. Participants also were asked to complete a BIS) and BAS scales which consist of 20 items (Carver & White, 1994) in the first visit. This was followed by another visit involving a cycling HIIE protocol. All exercise tests were performed using an electronically braked cycle ergometer (Lode Corival Pediatric, Groningen, The Netherlands).

Anthropometric and physical activity measures. Stature and body mass were quantified to the nearest 0.01 m and 0.1 kg using standard procedures. Body mass index (BMI) was calculated as body mass (kg) divided by stature (m) squared. Age and sex specific BMI cut-points for overweight and obesity status were determined (Cole et al., 2000). Percentage body fat was estimated using triceps and subscapular skinfolds to the nearest 0.2 mm (Harpenden callipers, Holtain Ltd, Crymych, UK) according to sex and maturation specific equations (Slaughter et al., 1988). Cardiometabolic health status was determined based on age and sex specific aerobic fitness cut-offs (Adegboye et al., 2011). Following completion of the HIIE protocol, participants wore an accelerometer (GENEActiv, GENEA, UK) on their non-dominant wrist for seven days. The accelerometer was set to record at 100 Hz. Participants' data were used if they had recorded ≥10 hours/day of wear time for at least three week days and one weekend day (Riddoch et al., 2007). Data were analysed at 1 s epoch intervals to establish time spent in moderate and vigorous intensity physical activity using validated cut-points (Phillips et al., 2013).

Cardiorespiratory fitness. Participants were familiarised to exercise on the cycle ergometer before completing a ramp test to establish maximal oxygen uptake ($\dot{V}O_{2max}$) and the VT (Barker et al., 2011; Sansum et al., 2019). The highest value from a ramp test represents a true $\dot{V}O_{2max}$ in ~ 90% of cases as reported by Sansum et al., (2019). Participants began a warm-up of unloaded cycling for 3 min, followed by 15 W increments every 1 min until volitional exhaustion, before a 5 min cool down at 25 W. Participants cycling at a constant cadence between 75-85 rpm with exhaustion was defined as a drop in cadence below 60 rpm for 5 consecutive seconds despite strong verbal encouragement. Peak power was taken as the highest power output achieved at the end of the ramp test.

HIIE protocol. Participants completed the HIIE protocol consisting of a 3 min warm-up at 20 W followed by 8 x 1 min work intervals performed at 85% of the peak power determined from the ramp test, interspersed with 75 s active recovery at 20 W. A 2 min cool down at 20 W was provided at the end of the protocol. Participants were instructed to maintain a cadence between 75-85 rpm throughout the exercise condition.

Experimental measures

Gas exchange and heart rate. Expired gas exchange and ventilation variables during the cardiorespiratory fitness test and HIIE protocol were measured using a calibrated metabolic cart (Cortex Metalyzer III B, Leipzig, Germany). HR responses were recorded continuously using a telemetry system (Polar Electro, Kempele, Finland). Both gas exchange and HR data were subsequently averaged over 10 s intervals. The VT was determined from the incremental test data using the ventilatory equivalents for carbon dioxide production ($\dot{V}CO_2$) and $\dot{V}O_2$ (Beaver, Lamarra, & Wasserman, 1981). $\dot{V}O_{2max}$ was determined as the highest 10 s average in

$\dot{V}O_2$ elicited either during the incremental or supramaximal test. Maximal HR (HR_{max}) was taken as the highest HR achieved during the ramp test. A cut-off point of ≥90 % HR_{max} was used as the criterion for compliance to the HIIE protocol (Malik et al., 2017; Taylor at al., 2015).

Affective responses. Affective valence (pleasure/displeasure) was measured using the feeling scale (FS; Hardy & Rejeski, 1989) according to previous work in adolescents (Benjamin et al., 2012; Malik et al., 2018a). Participants were asked to rate how they currently feel on an 11-point bipolar scale ranging from "Very Good" (+5) to "Very Bad" (-5). Van Landuyt et al. (2000) report that FS exhibited convergent validity with the Affect Grid (Russell et al., 1989).

Activation levels were measured using the felt arousal scale (FAS; Svebak & Murgatroyd, 1985). The FAS is a single-item measure of perceived activation, with participants asked to rate themselves on a 6-point scale ranging from 1 ‘low arousal’ to 6 ‘high arousal’. Van Landyut et al. (2000) report that FS and FAS exhibited correlations ranging from 0.41 to 0.59 and 0.47 to 0.65, respectively, with the Affect Grid (Russell, Weiss, & Mendelsohn, 1989), indicative of convergent validity with similar established measures. Affective responses were also assessed from the perspective of the circumplex model (Russell et al., 1989), using a combination of FS and FAS.

Perceived enjoyment. Participants rated their enjoyment during the exercise conditions on a 7-point exercise enjoyment scale (EES; Stanley & Cumming, 2010). Participants respond to the statement: “Use the following scale to indicate how much you are enjoying this exercise session” via a 7-point Likert item from 1 (not at all) to 7 (extremely). EES exhibited correlations ranging from 0.41 to 0.49 with FS, indicative of convergent validity with similar established measures (Stanley et al., 2009). Post-exercise enjoyment was measured using the modified physical activity enjoyment scale (PACES), which is validated for use in adolescents (Motl et al., 2001). The PACES includes 16 items that are rated on a 5-point bipolar scale (score 1 = "strongly disagree" to score 5 = "strongly agree"). The score for each item was summed to calculate a total enjoyment score for each exercise protocol, resulting a possible range of scores from 16 through to 80 with a higher score representing greater enjoyment.

Rating of perceived exertion. RPE was assessed using the validated 0–10 Pictorial Children's OMNI scale (Robertson et al., 2000). Participants responded to the statement "How tired does your body feel during exercise" via a 0-10 point Likert item ranging from 0 (not tired at all) to 10 (very, very tired).

Measurement time points. The measurements scales (i.e. FS, EES, RPE and PACES) were administered before (i.e. 5-min before and warm-up), 20 s before the end of the HIIE work and recovery intervals, and after (i.e. immediately after and 20-min after) HIIE. The FS and RPE were also obtained at the end of every stage during the incremental test to exhaustion to familiarize the participants with the scale. The same verbal instructions for using all the scales were given to all participants before undertaking the exercise protocols by the same researcher. No verbal encouragement was given to the participants during the HIIE protocol.

Exercise Task Self-Efficacy. Participants' confidence in their ability to repeat the HIIE protocol they had just completed was assessed at 20-min post-exercise using a 5-item measure. Each question anchored the stem ''How confident are you that you can'' following the item ''perform one/two/three/four/five bout(s) of exercise a week for the next 4 weeks that is just like the one you completed today?'' Participants responded to each item on a 100-point percentage scale with 10 percent increments that ranged from 0% (not at all confident) to 100% (completely confident). The five item scores were averaged and used as the self-efficacy score. The format for this scale was consistent with Bandura, (1997) and a previous study that examined the influence of affective responses to HIIE in adults (Jung et al., 2014). Based on the Cronbach's alpha test, the internal consistencies for the self-efficacy scale in this study were excellent (α= 0.93). Self-efficacy questionnaire was administered by the same researcher.

Behavioural activation and behavioural inhibition. Participants' personality characteristics were measured during the first visit using the BIS and BAS scales which consist of 20 items (Carver & White, 1994). This scale has been successfully used and validated for use in adolescents (Cooper et al., 2007; Schneider & Graham, 2009). Items are scored on a four-point Likert-type scale. The BIS consists of a single subscale measuring the anticipation of punishment, whereas the BAS consists of three subscales measuring drive, fun seeking, and reward responsiveness. In order to focus on different aspects of incentive sensitivity of BAS as proposed by Carver and White (1994), the reward responsiveness subscale was used to represent the BAS group. This is because previous work in youth has shown that feelings of reward facilitated elevated enjoyment levels after HIIE (Malik et al., 2017). The total score for BAS and BIS were averaged for each item and used as the BAS and BIS score. The internal consistencies for the BIS and BAS scale in this study were excellent (α= 0.80 and α= 0.86, respectively). The BIS/BAS questionnaire was administered by the same researcher.

Statistical analyses

All statistical analyses were conducted using SPSS (24.0; IBM Corporation, Armonk, NY, USA). Descriptive characteristics (mean ± standard deviation) and cardiorespiratory data between boys and girls were analysed using independent samples t-tests. The BAS/BIS and self-efficacy variables were transformed into dichotomous variables using a median split to form high and low groups for the total of 30 participants: low (n = 14) and high (n = 16) BAS; low (n = 17) and high (n = 13) BIS; and low (n = 15) and high (n = 15) self-efficacy). This median split was conducted after all the participants completed the HIIE protocol. The mean difference between each grouping was analysed using independent samples t-test for self-efficacy and BIS/BAS. Data were analysed using a mixed model analysis of variance

(ANOVA) to examine group differences (low BAS vs. high BAS; low BIS vs. high BIS; low self-efficacy vs. high self-efficacy) in affect, enjoyment, and RPE over time during HIIE (the work and recovery intervals) and the incremental test (min 1, VT, VT+1 min, end). The exclusion of sex into the ANOVA model was due to the insufficient numbers between boys and girls across the group following the median split. In the event of significant effects (P< 0.05), follow-up Bonferroni post hoc tests were conducted to examine the location of mean differences. The magnitude of mean differences was interpreted using effect size (ES) calculated using Cohen's *d* (Cohen, 1988), where an ES of 0.20 was considered to be a small change between means, and 0.50 and 0.80 interpreted as a moderate and large change, respectively.

Results

The participants' descriptive characteristics are presented in Table 1. A total of 26 participants (12 boys) were deemed to have a low level of aerobic fitness indicative of increased cardiometabolic risk. Also, three out of 30 participants were categorised as overweight and the remainder were normal weight. Three boys and one girl achieved the recommended guideline of 60 min of daily MVPA.

HIIE cardiorespiratory data for boys and girls are presented in Table 2. Based on the VT representing ~ 50% VO_{2max} in our sample the prescribed HIIE protocol was performed at an intensity that exceeded the VT for work-intervals 1 to 8 (i.e. 71% to 78% $\dot{V}O_{2max}$). There were significant increases in HR across consecutive work intervals in all BIS/BAS and self-efficacy groups (P<0.01), but there was no condition by interval number interaction (all P>0.28) or main effect of condition (P>0.31). A total of 27 participants (14 girls) reached the cut-off point of ≥90 % HR_{max}, which occurred during work intervals 4 to 8. Also, there was no significant difference in VO_{2max} and MVPA levels between the BIS/BAS and high/low self-efficacy groups (all *P*>0.51 and *P*>0.37, respectively). All participants completed the HIIE protocol and no adverse events were observed.

BIS/BAS with affective responses. The BAS and BIS exhibited an average of 2.7 ± 1.1 (minimum to maximum=1.86 to 3.71) and 2.8 ± 0.5 (1.9 to 3.7) of FS score, respectively. For the incremental test, FS showed a significant group by time interaction effect for BIS (*P*=0.025) and BAS (*P*=0.031). FS was significantly higher in the high BAS compared to low BAS group at VT+1 min and end of incremental test (all *P*<0.021, ES=0.49 and 0.46, respectively). FS was also significantly higher during low the BIS than high BIS group at VT+1 min and end (all *P*<0.029, ES=0.49 and 0.45, respectively). FS remained negative at the end of incremental test in low BAS in 14 participants (100%; FS= -1.5 ± 0.8), high BAS in 12 participants (75%; FS= -1.0 ± 1.3), low BIS in 13 participants (76%; FS= -1.1±1.3) and high BIS in 13 participants (100%; FS= -1.6 ± 0.9).

The affective responses during HIIE when separated for BIS/BAS groups are illustrated in Figure 1A. FS showed a significant group by interval number interaction effect for BIS (*P*=0.028) and BAS (*P*=0.039). FS was significantly higher in high compared to low BAS at work intervals 4 to 8 (all *P*<0.039, ES=0.59 to 1.73) and recovery intervals 4 to 7 (all *P*<0.031, ES=0.50 to 1.56, respectively). FS was also significantly higher during low BIS than high BIS during work intervals 4 to 8 (all *P*<0.012, ES=0.99 to 1.68) and recovery intervals 4 to 7 (all *P*<0.032, ES=1.11 to 1.48). FS remained positive at work-interval 8 in low BAS in 11 participants (78%; FS= 0.8 ± 0.7), high BAS in 16 participants (100%; FS= 2.1 ± 1.3), low BIS in 16 participants (94%; FS= 2.0 ± 1.3) and high BIS in 11 participants (84%; FS=0.12 ± 0.9).

FAS did not reveal any significant group by interval number interaction for BAS (*P*=0.41) and BIS (*P*=0.26) or a main group effect for BAS *(P*=0.21) and BIS *(P*=0.28). Affective responses (valence and activation) during the work intervals for HIIE protocols when separated for BIS/BAS were plotted onto a circumplex model (Figure 3 A, B, C and D). There was a shift from the unactivated/pleasant to the activated/pleasant quadrant for all BIS/BAS groups.

BIS/BAS with enjoyment responses. The enjoyment responses during HIIE when separated for BIS/BAS groups are illustrated in Figure 1B. EES showed a significant group by interval number interaction effect for BAS (*P*=0.01) and BIS (*P*=0.039). EES was significantly higher in high compared to low BAS at work-intervals 5 to 8 and recovery-intervals 5 to 7 (all *P*<0.015; ES=1.21 to 1.66 and ES=1.15 to 1.16, respectively). EES was also significantly higher in low compared to high BIS at work-intervals 6 to 8 and recovery-intervals 6 to 7 (all *P*<0.035; ES=1.31 to 1.86 and ES=1.18 to 1.20, respectively).

PACES showed a significant main group effect in BAS (*P*=0.02) and BIS (*P*=0.038). PACES was significantly higher in high than low BAS immediately after (75±3 vs. 72±2, ES=1.19) and 20 min after HIIE (77 ± 2 vs. 74 ± 2, ES=1.50). PACES was also significantly higher in low than high BIS immediately after (74 ± 4 vs. 71 ± 2, ES=0.95) and 20-min after HIIE (75 ± 2 vs. 73 ± 2, ES=1.00).

BAS/BIS with RPE The RPE responses during HIIE when separated for BIS/BAS groups are represented in Figure 1A. RPE did not reveal any significant group by interval number interaction for BAS (*P*=0.31) and BIS (*P*=0.36) or a main group effect for BAS *(P*=0.14) and BIS *(P*=0.10).

Self-efficacy with affective responses. For the incremental test, FS showed a significant group by time interaction effect for self-efficacy (*P*=0.03). FS was significantly higher in the high than low self-efficacy group at VT+1 min and end (all *P*<0.043, ES= 0.45 and 0.50, respectively). FS remained negative at the end of the incremental test in the low self-efficacy group in 15 participants (100%; FS= -1.6 ± 1.1) and high self-efficacy in 11 participants (73%; FS=-1.1 ± 0.9).

The affective responses during the HIIE when separated for low vs. high self-efficacy groups are illustrated in Figure 1A. FS exhibited a significant group by interval number interaction effect in self-efficacy (P=0.024). FS was significantly higher in high than low self-efficacy group during work-intervals 5 to 8 (all P<0.26, ES= 0.88 to 1.06) and recovery-intervals 5 and 7 (all P<0.042, ES= 0.79 to 0.73). FS remained positive at work-interval 8 in the high-efficacy group in 15 participants (100%; 1.7 ± 1.3) and low-efficacy group in 12 participants (80%; 0.8 ± 0.7).

FAS did not reveal any significant group by interval number interaction effect in self-efficacy (P=0.39) Affective responses (valence and activation) during the work intervals for HIIE protocols, when separated for self-efficacy groups, were plotted onto a circumplex model (Figure 3 E and F). There was a shift from the unactivated/pleasant to the activated/pleasant quadrant for all self-efficacy groups.

Self-efficacy with enjoyment responses. The enjoyment responses during the HIIE when separated for self-efficacy groups are illustrated in Figure 1B. EES exhibited a significant group by interval number interaction effect in self-efficacy (P=0.031). EES was significantly higher in the high than low self-efficacy group at work-intervals 5 to 8 (all P<0.044, ES=0.62 to 0.99) and at recovery-intervals 5 to 7 (all P<0.048, ES=0.53 to 0.89). There was no condition by time interaction (P=0.58) or effect of group (P=0.62), but there was a main effect of time (P<0.01) for PACES. PACES was significantly higher 20-min after compared to immediately after HIIE (high-efficacy, 76 ± 2 vs. 74 ± 3, P=0.02, ES=0.67; low-efficacy, 76 ± 3 vs. 73 ± 2, P=0.002, ES=1.18).

Self-efficacy with RPE. The affective responses during HIIE when separated for low vs. high self-efficacy are illustrated in Figure 1A. RPE exhibited a significant group by interval number interaction effect in self-efficacy (P=0.018). RPE was significantly higher in high compared to low self-efficacy groups during work-intervals 5 to 8 (all $P<0.037$, ES=0.98 to 1.43).

Discussion

The aim of this investigation was to examine the role of personality characteristics (BIS/BAS) and self efficacy on affect, enjoyment and RPE responses during a commonly used HIIE protocol in adolescents. The key findings are: 1) the high BAS/low BIS groups experienced greater positive affect and enjoyment responses at the mid-point to the end of HIIE compared to the low BAS/high BIS groups; 2) the high BAS/low BIS groups also experienced greater post-enjoyment (immediately after and 20-min after) compared to low BAS/high BIS groups; and 3) the high self-efficacy group elicited greater positive affect and enjoyment accompanied by lower RPE at the mid-point to the end of HIIE compared to low self-efficacy group.

In the present study, we observed greater positive affect and enjoyment levels in high BAS/low BIS groups than the low BAS/high BIS groups during the last five HIIE work intervals. These findings suggest that personality traits (i.e. BAS/BIS) may have dependent effects near the end of HIIE bout. We reason that the increase in HR responses during HIIE in the current study is likely to account for the difference in BAS/BIS groups. According to the DMT (Ekkekakis, 2003), an individual's interpretation of physiological cues (e.g. pain due to the intensified physiological strain such as increased in HR) to manifest in an expression of pleasant and unpleasant feelings could be influenced by individual's personality characteristics in the zone of response variability (i.e. exercise above the VT, termed as high-intensity). Indeed, Ekkekakis et al. (2005a) argued that the presence of stable inter-individuals traits (e.g. personality traits) can influence the intensity of exercise a person is predisposed to tolerate or select. We therefore suggest that variation in personality traits (i.e. BAS/BIS) and stimulated challenge by the physiological strain (i.e. increased in HR) during HIIE may improve or reduce the likelihood that an individual will experience positive affect and enjoyment in youth.

In the present study, the greater positive affect and enjoyment responses in the high BAS compared to low BAS groups may be due to the greater sensitivity to reward, which led participants to perceive the challenge of HIIE as positive reinforcement, as proposed by Gray's personality theory (1993). By contrast, a greater sensitivity to punishment and threat cues may have caused high BIS individuals to perceive the challenge of HIIE as a negative reinforcement, resulting in less pleasurable and enjoyment responses compared to low BIS individuals. In contrast to our data, Schneider and Graham (2009) stated that only BIS and not BAS influences affect during continuous high-intensity exercise in youth. Differences in type of exercise (continuous vs interval) may be an important contributing factor to these inconsistent results. Furthermore, the high BAS group in the Schneider and Graham (2009) study experienced negative affect during continuous high-intensity exercise, whereas the majority of our participants (above 78%), regardless of personality characteristics, evoked positive affect at the end of the HIIE bout. This observation highlights that the recovery interval built into HIIE may have reduced the challenge posed by the HIIE protocol compared to continuous exercise, thus making HIIE a less threatening condition. This is in line with the previous studies (Jung et al., 2014; Malik et al., 2018a), which predicts that a pleasurable feeling can occur during rest periods due to the withdrawal of the stress generated stimulus during the work intervals.

The present study also found greater pleasurable and enjoyment feelings in the high self-efficacy group compared to the low-efficacy group during HIIE. Our result is in accordance with a previously reported study in adults, which suggested that high self-efficacy individuals tend to report greater positive affect compared to low-efficacy individuals when exercise is performed at high-intensity exercise (i.e. above 70% of predicted maximal HR) during a graded exercise test (McAuley & Courneya, 1992). According to Bandura (1997), high self-efficacy individuals are more likely to engage in challenging tasks and are more resistant to stressful or aversive stimuli compared to individuals with low-efficacy. This may explain the differences in affect and enjoyment responses between the low and high self-efficacy groups during HIIE in our study. These observations, however, were only evident after work interval 5, suggesting that the challenging or stressful stimuli during HIIE is only perceived after about half of the total work performed. We reason that low intensity exercise performed during recovery periods could potentially improve confidence levels even with the low-efficacy group by reducing the aversive and stressful stimuli (i.e. intensified sensory body cues) found after about half of the total work is performed. It should also be noted that similar enjoyment was observed following HIIE in both the low and high efficacy groups. In light of enjoyment findings from the study by Malik et al. (2017), it is possible that the participants interpreted the HIIE as a mastery experience (e.g. it gives me a strong feeling of success) regardless of levels of confidence. Indeed, Bandura's (Bandura, 1997) theoretical framework support that mastery experiences as one of the primary sources to develop individual's beliefs about their efficacy apart from vicarious experience and social persuasion.

In this study, we found similar RPE regardless of personality characteristics, but high self-efficacy groups elicited lower RPE compared to low self-efficacy groups. This indicates that self-efficacy and personality traits have an independent effect on RPE during HIIE in adolescents. We speculate that this is because self-efficacy is more associated with judgment of one's capabilities or confidence to execute a demanding task, while BIS/BAS is associated with the judgment of one's feelings regarding the exercise task. Indeed, RPE reflects the conscious sensation of how hard, heavy, and strenuous the physical task is (Pageaux, 2016). Furthermore, previous studies in adults and youths have consistently shown that personality traits do not influence RPE during continuous exercise regardless of intensity (Coquart et al., 2012; Schneider & Graham, 2009). With regards to self-efficacy, previous studies have shown that lower RPE during exercise is linked with higher self-efficacy after exercise in youth (Pender et al., 2002; Robbins et al., 2004), which supports our observations. However, these studies (Pender et al., 2002; Robbins et al., 2004) were limited to continuous moderate-intensity exercise (e.g. 60% VO_{2max}) and no observations were made regarding affect and enjoyment. In this study, the high-efficacy group reported lower RPE accompanied by greater pleasurable and enjoyment feelings compared to the low-efficacy group, which supports previous work in adults during incremental exercise (McAuley & Courneya, 1992). Our data therefore supports the proposition that self-efficacy may influence what (i.e. RPE) and how (i.e. affect) individuals feel during HIIE in youth.

In the present study, we observed that at the end of incremental test to exhaustion in BIS/BAS and self-efficacy groups, 78% and 73% of participants, respectively, experienced negative affect responses compared to 75% and 80% of participants who experienced positive affect at the end of HIIE bout. These observations strengthen previous work on adolescents that indicates this HIIE protocol performed below 100% maximal effort does not elicit prominent unpleasant feelings (Malik et al., 2018a), as argued by others (Biddle & Batterham, 2015; Hardcastle et al., 2014). According to Kahneman et al., (1993) the peak (positive vs. negative) and end affect are the most important stimulus that provide overall interpretation of an exercise session (Parfitt & Hughes, 2009; Hargreaves & Stych, 2013) to predict future adherence (Rhodes & Kates 2015). Furthermore, HIIE elicited affect experienced to the boundary of the activated pleasant feelings on the circumplex model in all groups (see Figure 3) due to similar arousal (measured by FAS score). Therefore, our findings reinforce the feasibility of HIIE to preserve pleasurable feelings during exercise in adolescents with different personality characteristics and levels of self-efficacy.

Practical implications

An important implication of this present study is that individual differences in personality traits and self-efficacy may need to be considered when prescribing HIIE interventions in youth. We observed that low BAS/high BIS groups elicited lower positive affect responses at the mid-point to the end of the HIIE bout compared to high BAS/low BIS groups. Therefore, strategies could be adopted by educators or coaches when targeting high BIS and low self-efficacy individuals with HIIE interventions. For instance, low repetitions of HIIE may applicable for individual with low self-efficacy and high BIS individuals to promote future exercise behaviour in youth. Also, an attentional dissociation strategy (e.g. diverting attention away from the aversive stimuli by listening to self-selected music) could be used to help build positive perceptions of feelings (e.g. affect and enjoyment) and perceived ability towards the exercise. Indeed, Stork et al. (2015) showed that listening to self-selected music improved affect and enjoyment responses during sprint interval training in adults, although this has yet to be examined in youth. Verbal encouragement or persuasion technique towards the exerciser during HIIE could also boost self-efficacy to facilitate more enjoyment and positive affect during exercise.

Limitation and future directions

This study is limited to the single work intensity used to prescribed HIIE. Previous work has shown that the relationship between perceptual responses (e.g. affect and RPE) and cognitive factors (e.g. BIS/BAS and self-effficacy) may vary in magnitude as a function of exercise intensity (Hall, Ekkekakis, & Petruzzello, 2005). However, this is the first study that provides insight into the influence of cognitive factors on perceptual responses during HIIE in youth. Another important limitation is that the HIIE protocol comprised cycling performed in a laboratory setting. Therefore, the findings may not apply to other exercise modalities (e.g. running) and limit the representations of a participant's real world affective response to exercise. Despite this limitation, the HIIE protocol adopted shows similar findings to recent work in adolescents examining affect responses during HIIE running (Malik et al., 2018a). Another important limitation is that the HIIE was performed in a laboratory setting, which may reduce the ecological validity of the affect experienced during HIIE. A research design in a laboratory setting (e.g. lack of auditory, visual and social interaction) was required, so as to ensure accurate comparison of perceptual responses (i.e. affect, enjoyment and RPE) during HIIE. However, future studies may consider expanding the scope of the present investigation to school-based HIIE with long-term monitoring of adherence and dropout patterns.

Conclusions

In conclusion, our study further expands the understanding of the influence of cognitive factors on temporal changes in affect, enjoyment and perceived exertion during HIIE in adolescents. The present study showed that individual differences in personality and self-efficacy may decrease or increase the likelihood that a person will experience positive affective and enjoyment response to HIIE. Our findings provide advancement to the DMT by showing that cognitive factors are related to the changes in the affect responses during HIIE in youth, but are also dependent on the HIIE work interval. The present study extends the previous finding showing that HIIE does not generate prominent feeling of displeasure (Malik et al., 2018a) despite differences in personality and self-efficacy.

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Table 1 Descriptive characteristics of the participants (N = 30)

	Boys (n=15)	Girls (n=15)	P- value	ES
Age (y)	12.4 ± 0.5	12.6 ± 0.7	0.42	0.33
Body mass (kg)	44.0 ± 6.1	45.0 ± 8.7	0.71	0.13
Stature (m)	1.57 ± 0.08	1.55 ± 0.07	0.52	0.27
BMI ($kg \cdot m^{-2}$)	18.5 ± 2.0	19.0 ± 3.8	0.61	0.16
Body fat (%)	14.5 ± 4.3	22.7 ± 8.8	**0.003**	1.18
MVPA per day (min)	36 ± 13	30 ± 12	0.22	0.48
HR_{max} (bpm)	191 ± 6	188 ± 6	0.14	0.50
$\dot{V}O_2$ ($L \cdot min^{-1}$)	1.60 ± 0.24	1.57 ± 0.19	0.68	0.14
$\dot{V}O_{2max}$ ($mL \cdot min^{-1} \cdot kg^{-1}$)	37.0 ± 4.7	34.1 ± 3.3	0.06	0.71
VT ($L \cdot min^{-1}$)	0.87 ± 0.21	0.73 ± 0.11	0.05	0.84
VT (%$\dot{V}O_{2\,max}$)	53.4 ± 10.7	46.8 ± 6.1	0.05	0.76

Values are reported as mean ± standard deviation. Abbreviations: BMI, body mass index; MVPA, moderate to vigorous physical activity; $\dot{V}O_{2max}$, maximal oxygen uptake; HR_{max}, maximal heart rate; %$\dot{V}O_{2max}$, percentage of maximal oxygen uptake; VT, ventilatory threshold.

Table 2 Cardiorespiratory responses to HIIE

	Mean ± SD			
	Boys	Girls	P-value	ES
Average HR (bpm)	155 ± 8	158 ± 6	0.13	0.46
Average % HRmax	81 ± 4	83 ± 3	0.06	0.85
Peak HR (bpm)	180 ± 4	182 ± 5	0.92	0.44
Peak %HRmax	94 ± 4	96 ± 3	0.16	0.57
Average $\dot{V}O_2$ ($L \cdot min^{-1}$)	0.98 ± 0.11	0.96 ± 0.13	0.72	0.17
Average $\dot{V}O_2$ (%$\dot{V}O_{2max}$)	60 ± 6	61 ± 8	0.70	0.14
Peak $\dot{V}O_2$ ($L \cdot min^{-1}$)	1.26 ± 0.11	1.20 ± 0.12	0.11	0.52
Peak $\dot{V}O_2$ (%$\dot{V}O_{2max}$)	79 ± 10	76 ± 8	0.41	0.33

Values are reported as mean ± standard deviation. Abbreviations: HR, heart rate; HR_{max}, maximal heart rate; $\dot{V}O_2$, oxygen uptake: $\dot{V}O_{2max}$, maximal oxygen uptake; %$\dot{V}O_{2max}$, percentage of maximal oxygen uptake; VT, ventilatory gas exchange.

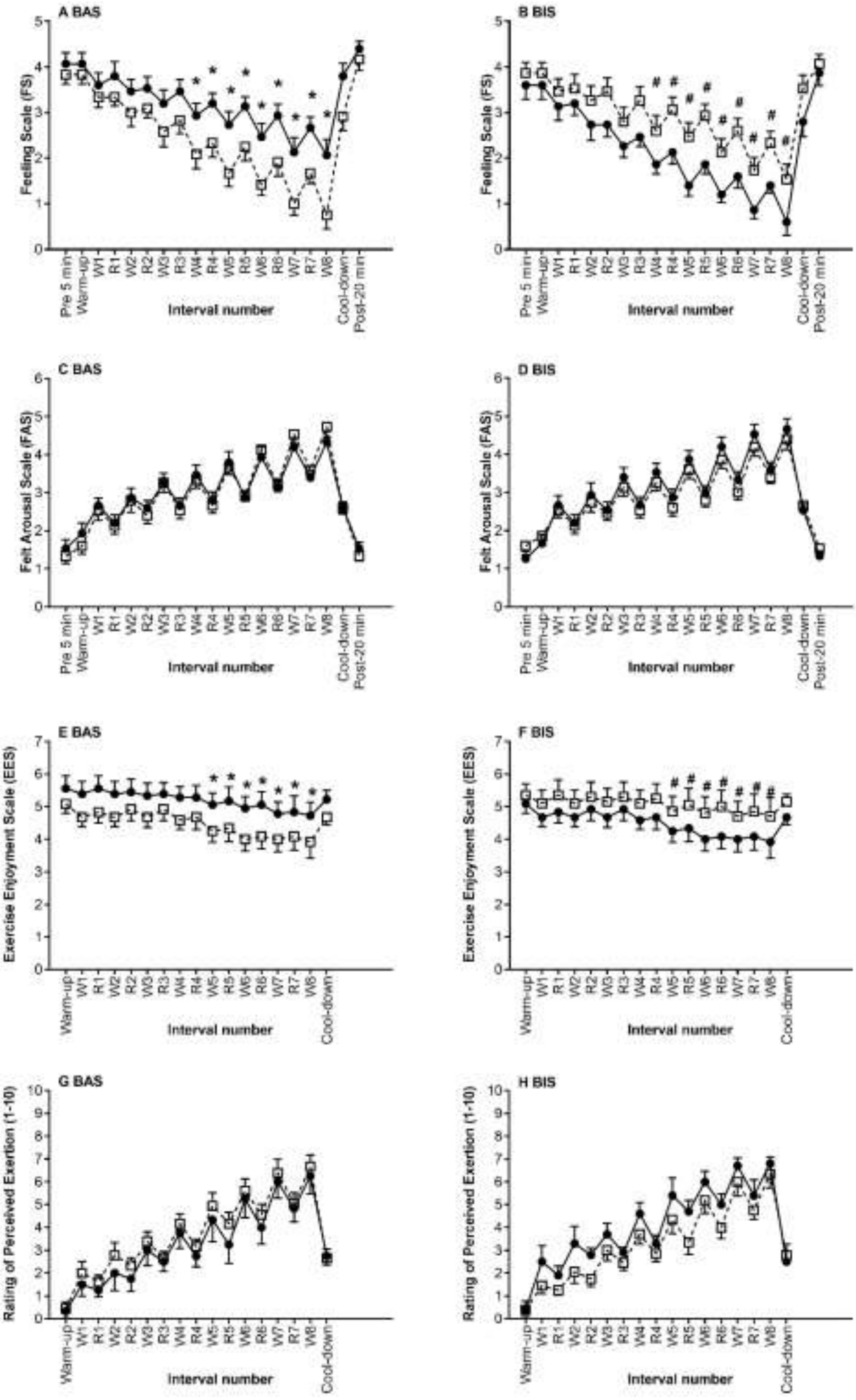

Figure 1. Feeling scale for behavioural activation (BAS) (A) and behavioural inhibition (BIS) (B), Felt arousal scale for BAS (C) and BIS (D), exercise enjoyment scale for BAS (E) and BIS (F), and rating of perceived exertion for BAS (G) and BIS (H) during the interval and recovery phases of the HIIE for the high (●) and low (□). Where, W= work interval and R= recovery

interval. *Significant difference between high and low BAS (P<0.05). #Significant difference between high and low BIS (P<0.05). Error bars are presented as SD. See text for details.

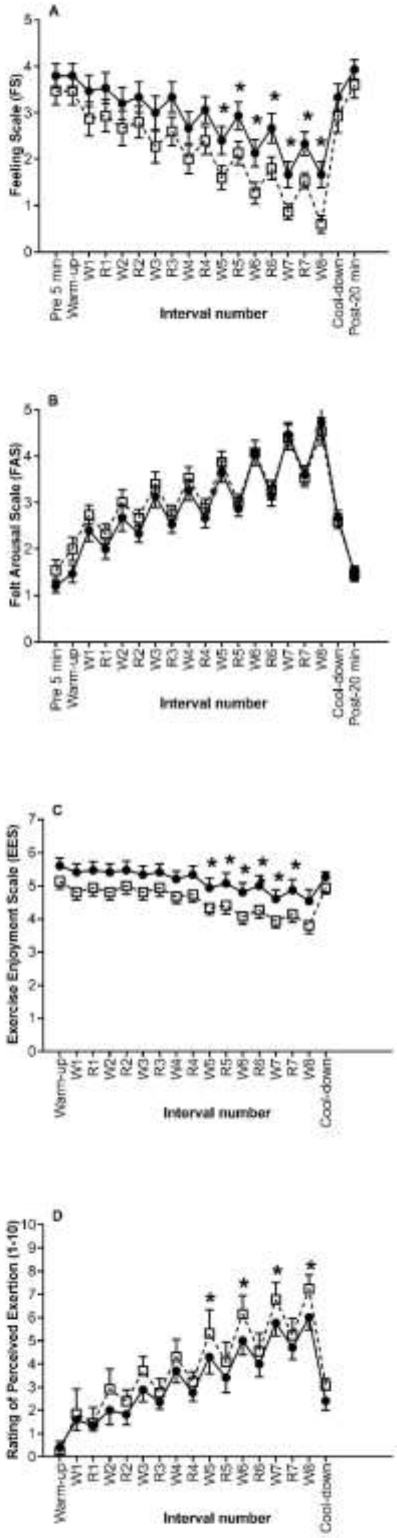

Figure 2. Feeling scale (A), felt arousal scale (B), exercise enjoyment scale (C) and rating of perceived exertion (D) during the interval and recovery phases of HIIE for high-efficacy (●) and low-efficacy (□). Where, W= work interval and R= recovery interval. *Significant difference between high and low self-efficacy (*P*<0.05). Error bars are presented as SD. See text for details.

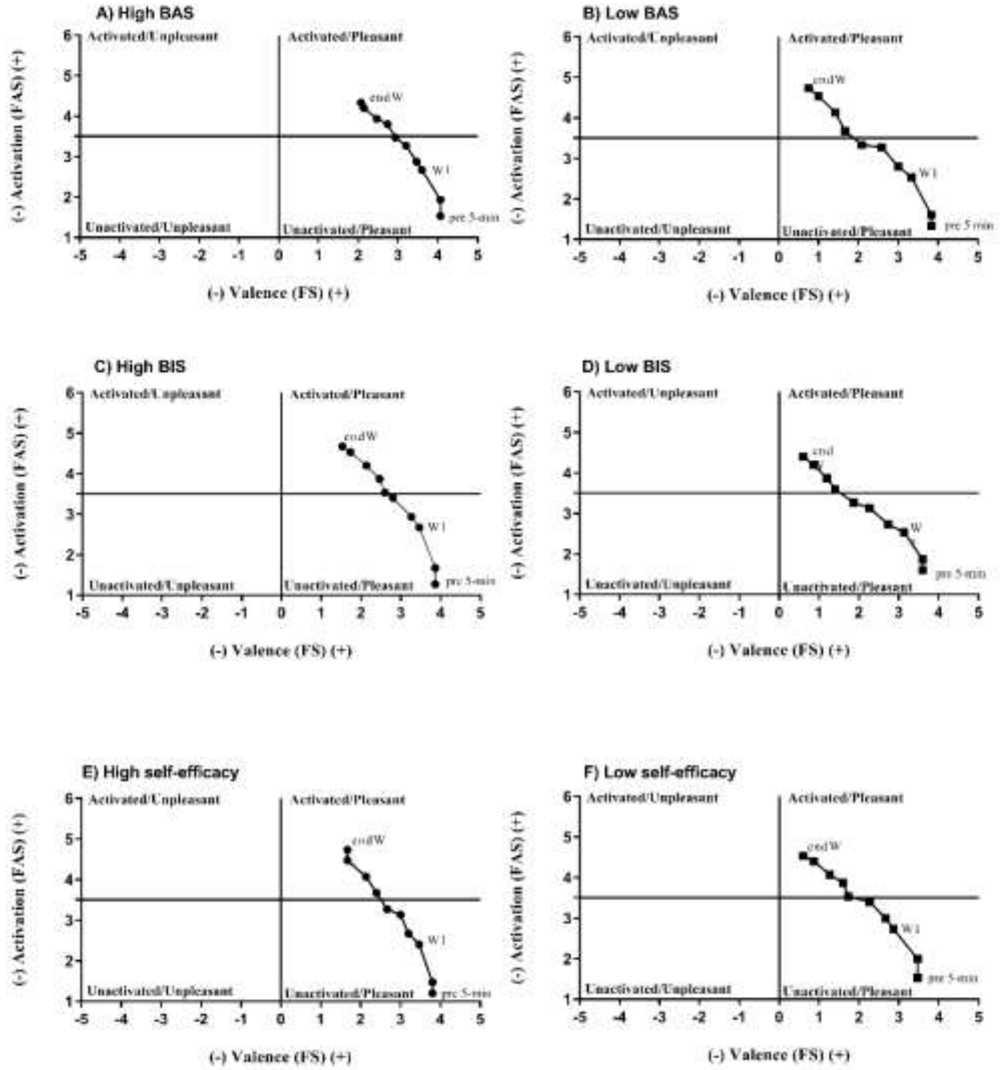

Figure 3. Valence (FS) and activation (FAS) during the work interval of high BAS (A), low BAS (B), high BIS (C), low BIS (D), high self-efficacy (E), and low self-efficacy (D) plotted onto the circumplex model. Where, W= work interval and endW= work interval 8 in HIIE. See text for details.