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In the zone: An exploration of personal characteristics underlying affective responses to heavy exercise

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Abstract

Positive affective responses to exercise have been linked with longer term adherence. The Dual-Mode Model indicates that affective responses during heavy exercise (between the ventilatory threshold and the respiratory compensation point) are subject to interindividual variability (*zone of response variability*). Participants (N = 48) completed measures to assess personal characteristics prior to a graded exercise test (GXT). Responses to the Feeling Scale were recorded during the GXT and subsequently used to group participants as either Negative Responders or Neutral/Positive Responders to heavy exercise. Discriminant Function Analysis was applied and a significant weighted linear composite predicted affective response. Preference for exercise intensity and sex were significant predictors (p = .003). Negative Responders had lower Preference scores and were more likely to be men. The combination of these two variables successfully predicted group membership 71% of the time. Individual differences appear relevant when examining affective responses to heavy exercise.

Keywords: Personality, physical activity, pleasure, sensation seeking, preference

Introduction

Under the broader perspective of motivational hedonism, asserting that human behaviour is driven by a pursuit of pleasure and avoidance of displeasure (Mees & Schmitt, 2008), exercise researchers are seeking to understand alternative ways by which to tackle the physical inactivity crisis. There is renewed awareness of the role that affective responses to exercise might have in determining longer-term adherence (Ekkekakis, 2017; Ekkekakis & Dafermos, 2012). This awareness has, in part, been heightened by a number of studies that have demonstrated a link between acute affective responses to exercise and maintenance of exercise programs (Hagberg, Lindahl, Nyberg, & Hellénius, 2009; Williams, Dunsiger, Jennings, & Marcus, 2012). However, factors underlying individual affective responses to exercise are less well understood, with factors such as personality (Rhodes & Smith, 2006), Body Mass Index (BMI; Ekkekakis, Lind, & Vazou, 2010), and intensity of exercise (Ekkekakis, Parfitt, & Petruzzello, 2011) shown to be relevant.

The dual-mode model (DMM; Ekkekakis, 2003) conceptualises affective responses across a range of exercise intensities and the tenets of the model have received strong empirical support (Parfitt, Rose, & Burgess, 2006; Welch, Hulley, Ferguson, & Beauchamp, 2007; Rose & Parfitt, 2007). According to the model, affective valence (pleasure) changes as a function of exercise intensity. Pleasure typically increases during *low* and *moderate* exercise intensity up to the respiratory marker of ventilatory threshold (T_{vent}). Affective responses become more variable at *heavy* exercise intensities (i.e., proximal to T_{vent} and up to respiratory compensation point; RCP) wherein some people continue to experience an increase in pleasure and others experience a decline in pleasure. This exercise intensity has consequently been labelled as the "zone of response variability" (p. 47) in terms of affective responses (Ekkekakis, 2013). As exercise intensity transitions to *severe* levels (beyond RCP), there is typically a universal decline in pleasure. There is a lack of understanding regarding the reasons for the variable affective response during heavy exercise, but Ekkekakis (2003) proposed that the interplay of cognitive appraisal and interoceptive cues drives such variability. A greater understanding of what is driving these interindividual differences in affective responses to exercise may help practitioners to personalise exercise prescriptions and therefore deliver exercise experiences that are more consistently pleasurable, and in turn, more sustainable.

In a study seeking to further understand the cognitive factors influencing affective responses at an exercise intensity proximal to T_{vent}, Rose and Parfitt (2010) adopted a qualitative approach using a 'think aloud' procedure. Thematic analysis revealed concepts relating to pre-exercise affective state, perceptions of ability, immediate and anticipated outcomes, attentional focus, and perceptions of control as salient in determining affective response. This approach afforded the researchers a rich insight into participants' cognitions but limited the researchers' capacity to account for the role of traits in determining affective responses at this exercise intensity. Jones, Karageorghis, Lane, and Bishop (2017) examined dominant attentional style and motivation as predictors of affective responses to group exercise and results revealed that individuals with a dominant associative attentional focus and self-determined motivation derived the greatest pleasure from sessions. However, their study did not examine responses in relation to T_{vent} and it is unknown how influential these specific individual factors are in determining affective responses in the zone of response variability. There are a number of traits that are likely determinants of affective responses during exercise. Previous research has indicated that these might include preference for, and tolerance of, exercise (Ekkekakis, Hall, & Petruzzello, 2005), and traits from classic personality theories (e.g., extraversion, and sensation seeking; Ekkekakis, Hargreaves, & Parfitt, 2013; Zuckerman, 1983). However, few studies have sought to address these traits in direct relation to the tenets of the DMM.

Hall, Petruzzello, Ekkekakis, Miller, and Bixby (2014) discussed how individual differences could play a role in exercise testing and prescription, but noted that these differences have been understudied in this context. Hall et al. examined preference for, and tolerance of, exercise intensity across a range of exercise testing protocols. Preference for exercise intensity is described as the “predisposition to select a particular level of exercise intensity when given the opportunity” and tolerance is “a trait that influences one’s ability to continue exercising at an imposed level of intensity beyond the point at which the activity becomes uncomfortable or unpleasant” (Ekkekakis et al., 2013; p.354). Preference has been shown to be a relevant factor in self-selecting exercise intensity (Smith, Eston, Tempest, Norton, & Parfitt, 2015). Further, Hall et al.’s (2014) findings that preference and tolerance were positively correlated with performance in exercise tests indicated these characteristics are relevant for exercise testing and prescription. However, their study did not explore the relationship between preference, tolerance, and affective responses to exercise. Among the scant previous work exploring the relationship between preference and tolerance, and in-task affective responses was Ekkekakis et al.’s (2005) study where they found that preference and tolerance were significantly correlated with Feeling Scales scores above T_{vent}. Ekkekakis et al. also examined the ability of the PRETIE-Q scales to predict affective responses to bouts of physical activity at different levels of intensity using hierarchical multiple regression analyses. The Preference and Tolerance scales both accounted for significant portions of the variance in affective valence when exercise intensity was at T_{vent}, while only the Tolerance scale accounted for significant portions of the variance when the intensity exceeded T_{vent}. Neither scale was significantly related to affective responses below T_{vent}. It appears that preference and tolerance are relevant variables in the context of affective response during moderate to vigorous exercise and warrant additional research attention. The previous work done by Ekkekakis et al. involved young physically active participants; therefore, more attention should be given to examining these relationships in older and less active populations (Ekkekakis et al., 2005).

Outside of physical activity contexts, personality traits have been associated with affective experience in day-to-day life (e.g., Larsen & Ketelaar, 1989). The Big Five personality model (extraversion, neuroticism, openness, agreeableness, and conscientiousness) was proposed as a generalizable model to examine psychological and behavioural outcomes (De Raad, 2000), and has been the subject of voluminous empirical work. In their seminal work, Costa and McCrae (1980) demonstrated that extraversion related strongly to positive affect and neuroticism to negative affect. Further work has identified a link between conscientiousness and trait positive affect (Watson, David, & Suls, 1999), and this link has since been extended by Lochbaum and Lutz (2005) who found higher conscientiousness was associated with greater enjoyment of a step aerobics class. The influence of personality on exercise has been subject to extensive research (Rhodes & Smith, 2006; Rhodes & Pfaeffli, 2012) but early work in the area led to a number of inconsistent findings (see Hall et al., 2014). More recent meta-analyses have sought to clarify the role of personality in exercise and health contexts (Wilson & Dishman, 2015). Conceptually, it has been proposed that extraverts seek out strong sensory stimuli (Eysenck, Nias, & Cox., 1982), and that physical activity might fulfil a drive for stimulation. Neuroticism is related to heightened autonomic responsiveness to intense stimuli and individuals with high neuroticism tend to be predisposed to negative affect (Gray, 1991); this could account for negative affect during exercise if the increased physiological arousal is perceived negatively (Wilson & Dishman, 2015). Individuals with a greater degree of openness are receptive to new experiences and different types of physical activity, and a recent analysis by Wilson and Dishman (2015) revealed a correlation between openness and physical activity. It has been proposed that conscientious people might have more effective self-regulation (Ingledew, Markland, & Sheppard, 2004); a greater capacity to regulate feelings when interoceptive cues are challenging the maintenance of positive emotions (i.e., above T_{vent}) would be beneficial for maintaining a pleasant exercise experience.

There is evidence that high levels of extraversion and conscientiousness and low levels of neuroticism relate to high levels of physical activity among younger adults (Rhodes & Smith, 2006). Further, high levels of extraversion, openness, conscientiousness, or low levels of neuroticism in older adults results in greater energy expenditure at peak walking pace (Terracciano et al., 2013). However, there does not appear to be a relationship between agreeableness and physical activity (Wilson & Dishman, 2015). There is a pattern between personality dimensions and physical-activity levels that appears relatively consistent across age groups, culture, gender, and activity modes (Rhodes & Pfaeffli, 2012). While the evidence linking personality and behaviour has developed, there has been less focus on the role that personality can play in how people *feel* during exercise. Beyond the Big Five dimensions, Schneider and Graham (2009) found that behavioural inhibition was correlated with decreases in pleasure during “hard” intensity exercise (average of work rate at T_{vent} and VO_2peak). However, the “hard” exercise intensity employed in the Schneider and Graham (2009) study makes inference to the DMM difficult as this average work load might have been above or below RCP depending upon an individual’s fitness; if above RCP this would have likely led to a sharp decline in pleasure, but if below, would have led to a more variable response.

The links expounded in previous work between the Big Five dimensions and the amount of physical activity done might, in part, be a consequence of how individuals *feel* during exercise (i.e., they undertake more exercise because it feels good). An examination of whether individuals with certain personality traits respond more favourably during physical exercise appears warranted and could help to understand the drivers behind the relationships between personality traits and physical activity behaviour.

Sensation seeking has been proposed as a distinct trait and has been linked to high-risk sport participation (e.g., Jack & Ronan, 1998), but its role in exercise is less well understood. Zuckerman (1994) defined sensation seeking as “the seeking of varied, novel, complex, and intense sensations and experiences and the willingness to take physical, social, legal, and financial risks for the sake of such experiences” (p.27). Hedonic allostasis theory (Koob & Le Moal, 1997) conceptualises certain behaviours (e.g., sensation seeking, compulsive exercise) as a response to hypoactivity in dopamine systems (Dishman & Holmes, 2012). The behaviors (i.e., physical activity) are engaged in to restore normal hedonic tone, and recent evidence has shown that sensation seeking might be more strongly characterised by the intensity of an experience, rather than the novelty (Minkwitz et al., 2016). The findings of Minkwitz et al. (2016) indicated that individuals with high sensation seeking scores expended more energy during everyday activities, and the intensity element of sensation seeking was significant in this relationship. The preference for experiences of greater intensity alludes to more positive affective response to such activities and the results of Minkwitz et al. (2016) could suggest that sensation seeking is a relevant variable in understanding affective responses in an exercise context where the intensity of the experience can vary greatly.

In his proposal for the DMM, Ekkekakis (2003) highlighted a void in the literature pertaining to personality and affective responses to exercise, stating that this “is partly due to the fact that the standard measures of relevant personality traits (e.g., extraversion, sensation seeking, behavioural activation/inhibition, etc.) emphasise social behaviour over responses to somatosensory stimuli…Nevertheless, individual differences are likely to play an important role” (p. 221). The purpose of this study was to explore the extent to which a range of personal characteristics influence affective responses in the zone of response variability (i.e., exercise intensity between T_{vent} and RCP) as identified in the DMM. This includes characteristics pertaining to social behaviour (cognitive) and responses to somatosensory stimuli (interoceptive). Given the exploratory nature of the study and the scant previous work examining the role of personality variables in determining affective responses at specific exercise intensities, we tentatively hypothesised that individuals who experience a decline in pleasure during heavy exercise will: report a lower preference for, and tolerance of, exercise intensity (H_1); lower scores on the personality dimensions of extraversion, openness, conscientiousness, and higher on neuroticism (H_2); score lower on the sensation seeking scale (H_3).

Methods

The experimental approach was approved by ethics committees at the host institutions in England and the USA. All aspects of the study conform to the Helsinki Declaration on Human Rights (2013).

Participants

Participants were recruited to this multisite study from England and the USA. Advertisements for participants were placed at two institutions and recruitment relied upon a snowball sampling strategy. Participants were eligible for inclusion if they were free from cardiorespiratory disease and had no other health contraindications; participation did not require a certain level of physical fitness or BMI and the upper and lower age limit was 64 years and 18 years, respectively. No significant mean differences (all *p*s > .05) were found in age, BMI, and VO_2peak between the two sites (Table 1). Experimental participants were aged between 18-50 years (M_{age} = 30.33, *SD* = 7.54) and included 21 women and 27 men. The physical fitness of the participants ranged from unfit to highly trained (self-reported) which was evident in the range of VO_2peak data recorded (Range 21.68–66.01ml/kg/min; *M* = 45.68, *SD* = 9.35). BMI ranged from 18.4–43.82 kg/m^2 (*M* = 25.3, *SD* = 4.4). Descriptive statistics for the demographics variables are presented in Table 1, broken down by gender and by testing site. The sample included participants from a wide range of ethnicities and sociocultural backgrounds.

Measures

Before Exercise. ***Preference for, and Tolerance of, the Intensity of Exercise Questionnaire (PRETIE-Q;* Ekkekakis, Hall, & Petruzzello, 2005*).*** Participants completed the PRETIE-Q to identify preferred intensity of exercise and tolerance of exercise intensity. The questionnaire comprises 16 items with a response scale ranging from 1 (*I totally disagree*) to 5 (*I totally agree*). Items to identify preference for exercise intensity included “I’d rather go slow during my workout, even if that means taking more time” and “When I exercise, I usually prefer a slow, steady pace”. Items to identify tolerance of exercise intensity included “When my muscles start burning during exercise, I usually ease off some” and “Feeling tired during exercise is my signal to slow down or stop”. Cronbach’s alpha levels of 0.84 for the Preference scale and 0.80 for the Tolerance scale represent satisfactory internal consistency (Hall et al., 2014). In the current study, Cronbach’s alpha was .84 for the Preference scale and .75 for the Tolerance scale.

International Personality Item Pool (IPIP - Inventory based on Costa and McCrae's [1992] NEO-PI-R Domains). Public domain scales from the IPIP (Goldberg et al., 2006) were used to measure the Big Five dimensions of personality (extraversion, openness, conscientiousness, agreeableness, neuroticism). The public domain scales have been shown to correlate highly with the commercial scales of the NEO Five-Factor Inventory (Costa & McCrae, 1992) and have strong evidence to support their validity (Goldberg et al., 2006; Ingledew & Markland, 2008). The 50-item questionnaire included 10 items for each of the five subscales and a response scale of 1 (*very inaccurate*) to 5 (*very accurate*) was used for each item. Items were phrased as statements (e.g., “Am interested in people”; “Keep in the background”) and participants were required to respond by indicating the extent to which the statement was accurate. Cronbach's alpha for the IPIP in the current study ranged from .76 (Conscientiousness) to .91 (Extraversion), and therefore was considered to have adequate internal consistency.

Sensation Seeking Scale-V (SS-V; Zuckerman, Eysenck, & Eysenck, 1978). The SS-V was administered to assess the participant's need for varied, novel, intense, and complex sensations and experiences. The scale comprises 40 items that require a forced-choice between two statements. Participants are instructed to indicate "which of the choices most describes your likes or the way you feel", and the overall score for the 40 items represents a general sensation seeking score. Internal consistency coefficients for the subscales within the SS-V ranged from 0.67 – 0.84 (Zuckerman, 1979). In the current study, Kuder Richardson KR-20 coefficient was calculated as .83 for the general sensation seeking score.

During Exercise. ***The Feeling Scale (FS; Hardy & Rejeski, 1989).*** In-task affective valence was assessed using Hardy and Rejeski's (1989) 11-point Feeling Scale which has a single-item response scale ranging from +5 (*very good*) to -5 (*very bad*). The scale has demonstrated satisfactory validity (Hardy & Rejeski, 1989).

Procedure

Participants attended a single testing session during which they completed the questionnaires prior to exercise. Participants were familiarised with the in-task measures and then began a treadmill protocol designed to elicit maximal capacities (a continuous ramp test based on the Bruce Protocol [Will & Walter, 1999]). The protocol maintained the 3 min stage markers of the Bruce Protocol (e.g., 12% gradient and 2.5mph at min 6, 14% gradient and 3.4 mph at min 9), but the gradient and treadmill belt velocity increased gradually every 15s rather than steeply every 3 min. Participants were asked to respond to the FS 10s prior to the end of each 1-min of the protocol, and were asked to exercise until volitional exhaustion. The use of a facemask to collect expired gases prohibited a verbal rating, therefore participants pointed to a number on the scales, which were held directly in front of them whenever responses were required. After each response, a researcher repeated the participant's selection aloud to ensure accuracy; the participant confirmed the number non-verbally with a nod or 'thumbs up' gesture.

Breath-by-breath data were collected throughout the exercise protocol using gas analysers (Ultima, Medical Graphics [UK]; Sensor Medics 2900, Sensor Medics Corp [USA]). These data were analysed independently by two members of the research team who identified the ventilatory threshold (T_{vent}) and respiratory compensation point (RCP). Analysis was conducted using Winbreak software (Ekkekakis, Lind, Hall, & Petruzzello, 2008) and was based on the three-method procedure described by Gaskill et al. (2001) for $T_{vent.}$ and a slightly modified version of Beaver, Wasserman, and Whipp's (1986) procedure for RCP, based upon the relationship between minute ventilation and carbon dioxide output (see Ekkekakis et al., 2008). In instances where the identification of T_{vent} and RCP differed between the members of the research team (*n* = 2), data were referred to an independent, accredited physiologist to decide upon the threshold points.

Data Analysis

A change in FS score (ΔFS) during heavy exercise (i.e., zone of response variability) was calculated for each participant by subtracting the FS score reported immediately prior to reaching RCP from the FS score reported during the minute in which T_{vent} was reached. Participants were then divided into two groups based on this score: Negative Responders (*n* = 28), among whom change in FS score ranged from -3 to -1, and Neutral/Positive Responders (*n* = 20), among whom the change in FS ranged from 0 to +2. Neutral responders were grouped with positive responders owing to the assumption that maintaining or increasing pleasure at this exercise intensity is beneficial compared to a decline in pleasure with regards to future exercise adherence.

Responder Group was used as the dependent variable in a series of Predictive Discriminant Function Analyses (PDA). The purpose of Discriminant Analysis (DA) is to predict group membership from a series of continuous predictor models. DA can be used to test a prediction hypothesis (PDA) or as a multivariate post hoc to a significant one-way or factorial MANOVA (Descriptive Discriminant Analysis) to describe the nature of the differences between groups (Barton, Yeatts, Henson, & Martin, 2016; Warner, 2013). Like Multiple Regression, DA develops an optimal weighted linear composite or function from a set of continuous predictors for the purposes of prediction. However, in DA the purpose is to develop one or more optimal functions (depending on the number of groups and/or predictors) which optimize between groups variance and minimize within groups variance (Warner, 2013).

In the first model, personal factors including Tolerance, Preference, Extraversion, Agreeableness, Conscientiousness, Neuroticism, Openness, and Sensation Seeking, were identified as predictor variables. Alpha was set at .05. An arbitrary cut-off point to evaluate structure and standardized coefficients was set at 0.5 (Warner, 2013). A classification table was requested to more fully examine the extent of the discrimination by the weighted linear composite. All data were analysed using SPSS version 23.

After reviewing the model, predictors that did not contribute substantially to the model were removed. A second model was developed to assess how the remaining personal factors as well as key demographics (age, sex, BMI, and VO_2peak), predicted group membership. Sex was dummy coded (men = 0, women = 1). A final model was developed with only substantially contributing predictors.

Results

Descriptive statistics for the predictor variables are presented in Table 2 and intercorrelations of the predictors is depicted in Table 3. Prior to beginning the inferential analysis, data were screened for normality, skewness, and other basic assumptions. No major deviations from skewness or normality were detected. No outliers were found in the data beyond 3.29 standard deviations of the mean (Warner, 2013).

Basic assumptions of the PDA were reviewed. The Box M test was non-significant ($p > .05$), suggesting the assumption of homogeneity of variance/covariance was met. A single weighted linear composite was generated as a result of the PDA. The weighted linear composite was statistically significant, $\Lambda = 0.679$, $\chi^2(8) = 16.27$, $p = .039$. The resulting moderate eigenvalue and large squared canonical correlation (R_c^2) were .473 and .321, respectively. A review of the structure coefficients identified that only Preference (-.642) had a structure coefficient greater than the identified cut-off value of 0.5, suggesting it is the only predictor which substantially correlated to the outcome of the predictive function. Scores on the Preference scale explained 41.2% of the variance in the composite. This finding is further supported when reviewing univariate one-way ANOVAs, where the two groups significantly differed only on Preference when using a Bonferonni correction ($\alpha = .05/8 = .006$), among the eight predictor variables, $\Lambda = .837$, $F(1, 46) = 8.977$, $p = .004$ (mean data are presented in Table 1).

A standardized weighted linear composite was developed to predict group membership. When examining the standardized coefficients (analogous to the standardized slopes or betas in regression; Barton et al., 2016), Preference (-1.023) was the only slope above the cut off value. Participants predicted to be in the Negative Responder group reported lower scores on the Preference scale. While Sensation Seeking (.496) and Conscientiousness (.477) approached the cut off value, the corresponding structure coefficients were weak (.175 and .257, respectively). All other measured trait variables only weakly influenced the predicted scores. A summary of the structure and standardized coefficients is presented in Table 3. The weighted linear composite accurately predicted group membership for 70.8% (*n*

= 34) of participants in the current study. More specifically, membership for 64.3% (*n* = 18) of Negative Responders and 80% (*n* = 16) of Neutral/Positive Responders was predicted correctly. The classification table is presented in Table 5.

In a second model, Preference was retained as a predictor, while age, sex, BMI, and VO_2peak were added as predictors to the model. The weighted linear composite was significant, $\Lambda = .741$, $\chi^2(5) = 13.047$, $p = .023$, $R_c^2 = .259$. When reviewing the standardized slopes in the second model, Preference (.611) and sex (.816) were substantial contributors to predicting group membership such that members of the predicted Negative Responder group had lower Preference scores and were more likely to be male. Only Preference and sex substantially correlated with the function in Model 2 (.747 and .657, respectively). Structure and standardized coefficients are presented in Table 4. Overall, 68.8% (*n* = 35) of participants were correctly classified by the weighted linear composite, where 67.9% (*n* = 19) of Negative Responders and 70% (*n* = 14) of Neutral/Positive Responders were correctly classified. Classification results are presented in Table 5.

A final model was run with only Preference and sex as the critical predictors of group membership. The weighted linear composite was significant, $\Lambda = .769$, $\chi^2(2) = 11.821$, $p = .003$, $R_c^2 = .231$. Preference and sex substantially contributed to the prediction of group membership (.714 and .599 standardized coefficients, respectively) and correlated with the weighted linear composite (.806 and .709 structure coefficients, respective). 70.8% (*n* = 34) of participants were classified correctly by the resulting function, where 67.9% (*n* = 19) of Negative Responders and 75% (*n* = 15) of Neutral/Positive Responders were classified correctly. Model 3 coefficients are presented in Table 4 and classification results for are presented in Table 5.

Discussion

The purpose of this study was to explore the influence of a range of personal characteristics on affective responses to exercise in the zone of response variability (i.e., exercise intensity between T_{vent} and RCP). Participants were grouped as either Negative Responders or Neutral/Positive Responders based upon the trajectory of affective valence (i.e. ΔFS) between T_{vent} and RCP. Negative responders had lower scores on the PRETIE-Q Preference subscale, and were more likely to be male.

Preference for Exercise Intensity

The lower PRETIE-Q Preference scores observed in Negative Responders are in line with theoretical predictions. In previous work, both the Preference and Tolerance subscale of the PRETIE-Q accounted for significant portions of the variance in affective valence at $T_{vent,}$ and the Tolerance scale accounted for significant portions of the variance when the intensity exceeded T_{vent} (Ekkekakis et al., 2005). In the present study, Preference was a substantial predictor of group membership based on affective response to exercise in the zone of response variability but Tolerance was not, therefore H_1 is partially accepted. Our findings pertaining to Preference demonstrate the importance of considering preferred exercise intensity when prescribing exercise in order to optimize affective response, and in turn, adherence. Exercise is often prescribed based on intensity zones (e.g., by personal trainers or training plans) but these prescriptions do not account for individual affective responses to different exercise intensities. For example, high-intensity interval training (HIIT) receives notable media coverage and endorsement as it is portrayed as a time efficient way for individuals to garner physiological benefits from exercise (e.g., Gillen & Gibala, 2014). However, exercise at such intensities might not be suitable for all individuals and a negative affective response to high intensity exercise could lead to poor adherence (Oliveira, Slama, Deslandes, Furtado, & Santos, 2013; Saaniloki et al., 2015). ACSM exercise prescription guidelines (2018) identify moderate intensity exercise as 46-63%VO_2max and vigorous intensity as 64-<91%VO_2max. The mean % VO_2peak recorded at T_{vent} and RCP in the present study were 61.9±10.1% and

91.7±6.5% VO_2peak, respectively. This offers additional support that the present data are of relevance to exercise professionals as the intensity examined is within the ranges of moderate and vigorous intensity exercise that are currently part of the PA guidelines worldwide.

Affect is viewed within behavioral economics as one of the major factors driving human decision-making. Put simply, humans tend to repeat what makes them feel better and avoid what makes them feel worse (Ekkekakis & Dafermos, 2012). Preliminary findings in exercise psychology show that affective responses to exercise predict subsequent exercise behaviour (e.g., Williams et al, 2012; Rhodes, Fiala, & Connor, 2009). Therefore, using preference for exercise intensity to tailor exercise prescriptions to optimize the subjective experience of exercise may be a promising way to improve exercise adherence. The preference scale of the PRETIE-Q could be used to develop a protocol for screening individuals who might be predisposed to negative affective response during heavy exercise (i.e., above T_{vent} but below RCP). In practice, the questionnaire could be administered prior to the commencement of an exercise program and if an individual reported a score >30 (according to present data; Table 2) the practitioner could be more confident that an individual would respond to heavy exercise in a neutral or positive manner. If an individual reports a score <30, then the practitioner could consider programming exercise at intensities below T_{vent} as the individual will likely respond negatively to exercise intensities above T_{vent}, which will in turn impact upon adherence.

Present results also lend support to the implementation of affect-regulated exercise, which has been cited as a viable way in which to minimise feelings of displeasure during exercise (Parfitt, Alrumh, & Rowlands, 2012). Recent evidence has demonstrated that exercising at an intensity that feels 'good' leads to a meaningful intensity for cardiovascular benefits (Schneider & Schmalbach, 2015) across active (Hutchinson et al., 2018) and sedentary populations (Hamlyn-Williams, Tempest, Coombs, & Parfitt, 2015). Affect-regulated exercise offers an easily implementable way for individuals to regulate their exercise intensity per their individual preference while ensuring a pleasant experience.

The findings for Tolerance are inconsistent with previous reports (Ekkekakis et al., 2005; Tempest & Parfitt, 2016) and this might be a consequence of the limited amount of time spent working above T_{vent}. In the present study, participants spent an average of 3.18±1.13 min working at intensities between T_{vent} and RCP, whereas previous work has employed a continuous workload protocol (e.g., 15min [Ekkekakis et al., 2005]). The short period of time might have been insufficient to capture the unique contribution of tolerance of exercise intensity.

Big Five Personality Factors and Sensation Seeking

Research on personality and exercise behaviour has largely focused on the relationship with volume of physical activity, as well as long-term health outcomes. Minimal attention has been paid to the role that personality can play in how people *experience* exercise, despite accumulating evidence that the pleasure or displeasure experienced during exercise can influence subsequent physical activity (e.g., Hagberg et al., 2009; Williams et al., 2012). In the present study, personality dimensions from the Big Five factor structure and Sensation Seeking did not effectively discriminate between the two affective response groups, thus H_2 and H_3 are not accepted.

To our knowledge, there is no previous work to draw upon regarding the relationship between personality factors and affective experiences during exercise at varying workloads. In one of the few studies to investigate the influence of personality on the subjective experience of exercise, Lochbaum and Lutz (2005) observed that participants who reported greater enjoyment of a step-aerobics exercise session were more conscientious and less neurotic. There is also consistent evidence that conscientiousness is positively related to general positive affect in non-exercise contexts (DeNeve & Cooper, 1998) and is associated with greater self-reported PA (Rhodes & Smith, 2006). In the present study, Conscientiousness (.477) approached the standardized coefficient cut off value of 0.5, although the corresponding structure coefficient (.257) indicated it was a relatively weak predictor of group membership.

It is somewhat surprising that extraversion did not differ between the two affective response groups given the extensive body of literature linking extraversion with positive affect (e.g., Watson & Clark, 1992). Indeed, the experience of positive emotions is considered to be a facet of extraversion (Costa & McCrae, 1992). Future investigations might benefit from studying the lower-order facets of personality, which often show differential relationships with performance criteria. For example, conscientiousness has been characterized as having both proactive (e.g., need for achievement, self-discipline) and inhibitive (e.g., cautiousness, self-control) aspects which may differentially influence health and exercise behavior (O'Connor, Conner, Jones, McMillan, & Ferguson, 2009). With respect to the affective experience of exercise, the lower-order extraversion facets of *positive affectivity*, and *activity* seem particularly worthy of investigation (Rhodes, Courneya, & Jones, 2002).

Our hypothesis pertaining to sensation seeking (H_3) was based on findings that suggest high sensation seekers expend more energy during everyday tasks (Minkwitz et al., 2016), and sensation seekers seek out "intense sensations". In light of our null findings, it is possible that the intensity of sensations experienced between T_{vent} and RCP were not high enough to satisfy high sensation seekers. Alternatively, the task itself may have been unappealing to high sensation seekers. Sensation seeking is highly correlated with impulsivity and involves pursuit of targeted rather than merely general stimulation (Arnett, 1994). Moreover, sensation seekers express a greater need for autonomy (Zuckerman, 1994) which is largely absent in the context of a constrained laboratory task.

The weak contribution of personality variables (the Big Five and Sensation Seeking) suggests that accounting for such social cognitive variables is of limited utility when seeking to understand and predict affective responses to heavy exercise. It appears that measures including greater acknowledgement of interoceptive sensations are more effective at accounting for affective responses during heavy exercise. The dual-mode model (Ekekkakis, 2003) postulates that there is interplay between social cognitive factors and interoceptive cues in the zone of response variability; the present results indicate that the interplay is dominated by an individual's interpretation of those interoceptive cues (manifest in an expression of preference for exercise intensity), and it is that which predominates affective responses during heavy exercise. The capacity of broad personality dimensions (extraversion, neuroticism, openness, agreeableness, conscientiousness, and sensation seeking) to help researchers and practitioners individualise exercise programs appears limited.

Sex and affective response

Relevant demographics (age, sex, BMI, and VO_2peak) were added to the model with the aim of enhancing the practical application of the findings. The significant contribution of sex indicates that practitioners could consider this alongside preference for exercise intensity when designing exercise programmes. There is scant work examining sex differences in affective responses to exercise, with studies typically including one sex (e.g., Ekekkakis et al., 2010; Jones et al., 2017) or not exploring differences between their participants (e.g., Kwan & Bryan, 2010; Schneider & Schmalbach, 2015; Sheppard & Parfitt, 2008). This preliminary finding could indicate that future investigations examining different affective responses to exercise between the sexes could be fruitful and offers further options in the personalisation of exercise programs.

In non-exercise settings, men and women have been found to differ in the use of emotion regulation strategies. Men use suppression, which involves attempts to hide, inhibit or reduce emotion-expressive behavior more often than women (Gross & John, 2003). This pattern of gender differences is often explained in terms of social norms (Smieja, Mrozowicz, & Kobylińska, 2011), but there is accumulating evidence of sex-related structural differences in the prefrontal cortex that are "meaningfully related to affective individual differences, including emotion-regulation strategies, expression and experience" (Welborn et al., 2009, p.334). A review of functional neuroimaging studies supports the notion that men and women use different strategies to down-regulate negative emotions, and that these strategies might be mediated by different neural circuitry (Whittle, Yücel, Yap, & Allen, 2011).

Limitations and Future Research

Affective responses were recorded during a GXT to account for the entire range of exercise intensities and to anchor responses around relevant respiratory markers. This laboratory-based exercise test is not representative of a typical exercise session or setting, therefore different modes of exercise and environments may yield different results.

Future work could include investigations of whether there are other personal characteristics that might explain affective response to exercise in the zone of response variability. This could lead to greater understanding of how individual difference factors influence affective responses to exercise, which may in turn hold meaningful implications for exercise prescription and adherence. The characteristics presented here represent an initial exploration, but there are likely other salient characteristics such as BIS/BAS (Schnneider & Graham, 2009), and perceived evaluative threat (Focht & Hausenblas, 2004) that will likely provide additional understanding of individual affective responses during heavy exercise.

A seemingly promising avenue for future research is the role of hereditary influences on individual differences in exercise-related affect. Initial evidence of the genetic contribution to the affective response to exercise has been offered by Schutte, Nederend, Hudziak, Bartels, and de Geus (2017). Schutte et al. report that genetic factors explained 15% of the individual differences in FS responses during a cycle ergometer test. Moreover, significant correlations were observed between affective responses during exercise and regular voluntary exercise behaviour (*r* = .15-.21).

Conclusions

This study offers an initial exploration of personal characteristics underlying affective responses to heavy exercise (i.e., in the zone of response variability within the dual-mode model; Ekkekakis, 2003). Findings suggest that individuals in the current study could be correctly classified as either Negative Responders or Neutral/Positive Responders 71% of the time by measuring preference of exercise intensity and accounting for sex. Preference for exercise intensity was the strongest predictor among these measures. Individuals who experience no change or a positive change in pleasure (Neutral/Positive Responders) reported higher preferred exercise intensity and were more likely to be female than individuals who experienced a decline in pleasure (Negative Responders) during heavy exercise. Researchers and practitioners might seek to account for the role of individual differences when examining affective responses and when designing exercise programs for clients. While the reasons for non-adherence to exercise are multifarious and complex, negative affective responses to heavy exercise might play a role. Through more accurate predictions of how an individual will feel during exercise, we can seek to make the exercise experience more consistently pleasurable.

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Table 1

Descriptive Statistics for Demographic Variables

	Total (N = 48)		Male (n = 27)		Female (n = 21)		Independent Groups t-test (df = 46)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*t*	*p*
Age[a]	30.3	7.5	29.4	8.1	31.5	6.8	-0.97	.34
BMI[b]	25.3	4.4	25.8	2.9	24.8	5.8	0.72	.47
VO_2peak[c]	45.7	9.4	49.9	7.2	40.2	9.1	4.15	.00
			England (N = 21)		USA (N = 27)		*t*	*p*
Age[a]			31.0	3.9	29.8	9.5	0.63[d]	.53
BMI[b]			25.0	2.9	25.7	5.4	-0.56	.50
VO_2peak[c]			46.4	7.6	45.1	10.6	0.49	.63

Note. [a]years; [b]kg/m^2; [c]ml/kg/min; [d]df = 36.4 due to adjustment for heterogeneity of variances

Table 2

Descriptive Statistics for Predictor Variables

Variables	All (N = 48)		Negative Responders (n = 28)		Positive/Neutral Responders (n = 20)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Tolerance	27.7	4.6	28.1	5.1	27.2	3.9
Preference*	28.1	5.5	26.2	5.1	30.8	3.1
Extraversion	33.2	8.1	33.3	7.8	33.9	8.1
Agreeableness	40.4	6.3	39.5	7.2	41.7	4.7
Conscientiousness	38.3	6.1	39.1	5.7	37.0	6.6
Neuroticism	33.5	7.1	33.3	7.5	33.7	6.7
Openness	37.1	5.3	36.4	5.4	38.1	5.2
Sensation Seeking	19.9	6.6	20.5	6.2	19.0	7.2
Age	30.3	7.5	31.1	8.4	29.3	6.2
Male[a*]	27.0	56.3	20.0	71.4	7.0	35.0
Female[a*]	21.0	75.0	8.0	28.6	13.0	65.0
BMI	25.3	4.4	25.5	3.8	25.2	5.3
VO_2peak	45.7	9.4	46.0	9.1	45.2	9.9

Note. [a] Sex is reported in *n*/%; *Significantly different (all *p*s < .05) between groups.

Table 3

Intercorrelations of the Personal Predictor Variables (N = 48)

	1	2	3	4	5	6	7	8
1. Tolerance	--	.363*	.045	.005	.228	.213	.042	.164
2. Preference		--	.047	.250	.043	.298*	.019	.071
3. Extraversion			--	.402**	-.165	-.003	.299*	.206
4. Agreeableness				--	.087	.081	.250	-.150
5. Conscien-tiousness					--	.157	.008	-.350*
6. Neuroticism						--	.003	-.114
7. Openness							--	.117
8. Sensation Seeking								--

Note. $*p < .05$, $p < .01$

Table 4

Summary of Structure Coefficients and Standardized Coefficients from the Predictive Discriminant Function Analyses

	Structure Coefficient	Standardized Coefficient
Model 1		
Tolerance	-.642	0.402
Preference	.257	-1.023*
Extraversion	-.246	0.035
Agreeableness	-.228	0.027
Conscientiousness	.175	0.477
Neuroticism	.143	0.163
Openness	-.402	-0.402
Sensation Seeking	.496	0.496
Model 2		
Preference	.747	0.611*
Sex	.657	0.816*
Age	-.199	-0.216
VO_2Peak	-.077	0.360
BMI	-.052	0.145
Model 3		
Preference	.806*	0.714*
Sex	.709*	0.599*

Note. *Above the cut-off value (.5) identified by Warner (2013)

Table 5

Predicted Classification of Positive and Negative Responders

		Predicted Group Membership	
		Negative Responders	Neutral/Positive Responders
Model 1[a]			
Original	Negative Responders	64.3 (18)	35.7 (10)
	Neutral/Positive Responder	20.0 (4)	80.0 (16)
Model 2[b]			
Original	Negative Responders	67.9 (19)	32.1 (9)
	Neutral/Positive Responder	30.0 (6)	70.0 (14)
Model 3[c]			
Original	Negative Responders	67.9 (19)	32.1 (9)
	Neutral/Positive Responder	25.0 (5)	75.0 (15)

Note. Reported in % (*n*); [a]70.8% of participants were correctly classified; [b]68.8% of cases were correctly classified; [c]70.8% of participants were correctly classified.