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HUTCHINSON, Jasmin C., JONES, Leighton <http://orcid.org/0000-0002-7899-4119>, VITTI, Steven N., MOORE, Andrew, DALTON, Paul C. and O'NEIL, Brendan J.

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The influence of self-selected music on affect-regulated exercise intensity and remembered pleasure during treadmill running

Jasmin C. Hutchinson[1], Leighton Jones[2], Steven N. Vitti[1], Andrew Moore[1], Paul C. Dalton[1], & Brendan J. O'Neil[1]

[1]Springfield College, Department of Exercise Science and Sport Studies, Springfield, MA.

[2]Sheffield Hallam University, Academy of Sport and Physical Activity, Sheffield, UK

Abstract

This study explored the influence of self-selected music on affect-regulated exercise intensity and Remembered Pleasure. Seventeen active male and female participants (28.1 ±9.9 years; BMI 23.8±3.2 kg/m^2; VO_2 peak 48.73±8.73 ml.min^{-1}.kg^{-1}) completed a maximal exercise test and each individual's ventilatory threshold (VT) was identified. Following this, two treadmill exercise trials were performed at an intensity that was perceived to correspond to a Feeling Scale value of +3 (i.e. 'good'). Sessions with either self-selected music or no music were completed 48 hr apart and in a randomized counterbalanced order. Affective responses (Feeling Scale) and heart rate were measured during exercise and Remembered Pleasure was measured 5-min post exercise. Results indicated that participants selected an exercise intensity that exceeded their VT during the two affect-regulated exercise sessions (p = .002, d = .99). Participants exercised with greater intensity during affect-regulated exercise with music than without (p = .045; d = 1.12) while maintaining a 'good' feeling. Furthermore, participants recalled the music session as more pleasurable than the no-music session (p = .001; d = .72). These results illustrate a positive ergogenic and psychological influence of music during affect-regulated exercise. Encouraging individuals to exercise at an intensity that feels 'good' elicits an exercise intensity sufficient to garner cardiorespiratory benefits and may lead to improved adherence. Moreover, the use of self-selected music appears to augment this effect.

(226 words)

Keywords: Affect, exercise, heuristics, remembered utility, physical activity

Introduction

Physical inactivity remains one of the most pressing societal issues with the economic burden and human cost having been clearly expounded (see Ding et al., 2016). In a drive to arrest the increasing incidence of physical inactivity, researchers are seeking alternatives to complement the raft of intervention strategies (e.g., motivational interviewing, fitness trackers) designed to promote physical activity. The role of affective responses to exercise has seen a resurgence of interest in recent years with hedonic theory providing a framework for research (Ekkekakis, 2017; Ekkekakis & Dafermos, 2012). The hedonic theory of exercise motivation asserts that behavior is driven by the desire for pleasure and the avoidance of displeasure (Mees & Schmitt, 2008); it has been proposed that pleasurable exercise is more likely to lead to greater adherence (for reviews; see Ekkekakis & Dafermos, 2012; Rhodes & Kates, 2015).

The role of exercise intensity in determining affective responses to exercise has been conceptualised in the dual-mode model (DMM; Ekkekakis, 2003). An underlying premise of this model is that exercise intensity is best defined with respect to the ventilatory threshold (VT) rather than as a percentage of maximum heart rate (HR max) or maximum oxygen consumption (Williams, 2008). VT is the point during incremental exercise at which ventilation starts to increase disproportionately to oxygen consumption, due to the need to expel excess carbon dioxide generated during anaerobic glycolysis (Beaver, Wasserman & Whipp, 1986). At this point physiological steady state cannot be maintained. During continuous exercise, the DMM describes a general increase in positive affective valence from low to moderate intensity (up to VT). Affective responses become more variable at *heavy* exercise intensities (i.e., those proximal to VT) wherein some people continue to experience an increase in pleasure and others experience a decline in pleasure. As exercise intensity increases beyond the respiratory compensation point (RCP; i.e. the onset of hyperventilation) there is a near universal decline in affective valence as information about critical disruptions of homeostasis enters consciousness (Ekkekakis, 2003). Not only does VT appear relevant in terms of affective responses, exercising at VT is associated with meaningful cardiorespiratory benefits in a range of populations (Vasiliauskas et al., 2007). Moreover, exercise prescription based on the individually determined VT leads to greater training adaptations when compared to a standardized heart rate based exercise program (Fabre, Massé-Biron, Ahmaidi, Adam, & Préfaut, 1997).

There are likely numerous factors that account for the variable affective response between VT and RCP. To date, preference for exercise intensity has been shown to be related to affective responses proximal to VT (Ekkekakis, Hall, & Petruzzello, 2005) and tolerance of exercise intensity has been shown to influence affective responses beyond VT (Ekkekakis et al., 2005). 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., 2005, p.354). The role of Preference and Tolerance in affective responses to exercise have been examined experimentally (e.g., Hall, Petruzzello, Ekkekakis, Miller, & Bixby, 2014; Tempest & Parfitt, 2015) and these traits appear relevant considerations for researchers seeking to examine the role of affective responses to exercise. Preference is the most relevant trait in studies where participants are not subject to imposed exercise intensities. In previous work, preference was positively correlated with, and accounted for approximately 36 % of the variance in, self-selected exercise intensity when controlling for age, BMI and fitness level (Smith, Eston, Tempest, Norton, & Parfitt, 2015).

Affect-regulated exercise has been cited as a viable way in which to minimise feelings of displeasure during exercise (Parfitt, Alrumh, & Rowlands, 2012). During affect-regulated exercise, the role of preference for a particular intensity will likely be a salient factor in determining the intensity that an individual will select. Affect-regulated exercise offers an easily implementable way for individuals to regulate their exercise intensity while ensuring a pleasant experience. Preliminary evidence has demonstrated that exercising at an intensity that feels ‘good’ leads to a meaningful intensity for cardiovascular benefits and is a strategy that can be implemented by sedentary adults in ecologically valid settings (Hamlyn-Williams, Tempest, Coombs, & Parfitt, 2015) and by adolescents (Schneider & Schmalbach, 2015).

The use of affectively regulated exercise sessions represents a departure from traditional methods of regulating exercise intensity that often make use of ‘rule of thumb’ prescriptions (i.e., %HR max) to guide sessions (ACSM, 2014). The practical ease with which individuals can monitor and regulate exercise based on their core affect could confer benefits on a large scale without the need for additional equipment such as HR monitors and has the added benefit of ensuring a pleasant experience regardless of fitness.

In addition to affective responses during exercise, the role of *recalled affect* or *remembered pleasure* (how pleasant or unpleasant an event is remembered) is being examined as a relevant factor in determining future exercise behavior. Remembered pleasure plays a central role in the determination of future behavior; indeed it is posited that “the memory of an affect-laden experience determines future behavior with respect to that experience, not the experience itself” (Rozin, 2002, p. 847). Thus, novel strategies to positively improve the remembered pleasure of exercise sessions are being explored. Zenko, Ekkekakis, and Ariely (2016) demonstrated that an exercise session beginning with high intensity exercise and ramping down to low intensity exercise led to greater remembered pleasure than a session that ramped from low to high intensity. The innovative approach by Zenko et al. (2016) offered an insight into the possibility that affective associations can be influenced by the way in which exercise is administered. Additional strategies on how to influence the remembered pleasure of an exercise session would be beneficial for the exerciser and practitioner alike.

The application of music before, during, and after exercise has been subject to much empirical research. Evidence has emerged to support the use of music as a psychological (Karageorghis & Jones, 2014) and ergogenic (Waterhouse, Hudson, & Edwards, 2010) aid to exercise. Music has been shown to have beneficial effects on performance across a number of exercise tasks and intensities (e.g., rowing [Rendi, Szabo, & Szabó, 2008]; cycling [Hutchinson et al. 2011]; running [Ramji, Aasa, Paulin, & Madison, 2015]; circuit training [Karageorghis et al. 2010]). Furthermore, music can strongly influence affective state. Pleasurable music engages the brain's mesolimbic reward system (Zatorre & Salimpoor, 2013), and can thereby enhance the affective experience of exercise (Karageorghis, Ekkekakis, Bird, & Bigliassi, 2017).

The predominant focus of music and exercise research to date has been on whether music can be of benefit during prescribed exercise (i.e., exercising at a set workload), whereas the role of music in benefitting affect-regulated exercise is not as well understood. In addition, the majority of previous studies examining the effects of music on physical and psychophysical measures have used a predetermined selection of music in an attempt to find fundamental characteristics that elicit positive responses (Biagini et al., 2012). However, personal preference plays an important role in maximizing the impact of music on exercise experience (Clark, Baker & Taylor, 2016), therefore familiar self-selected music with personally emotive qualities is purported to yield the most beneficial effects (Karageorghis & Priest, 2012).

Aims and Hypotheses

The aims of this study were (1) to examine the intensity of exercise that active individuals would choose to work at when asked to exercise at an intensity that felt 'good', and (2) to explore whether listening to music would influence affect-regulated exercise intensity while still maintaining a ‘good’ feeling. Finally, (3) remembered pleasure was examined to further understand the role that music can play in influencing the recalled affective experience of exercise.

We tested three hypotheses: (H_1) when instructed to exercise at an intensity corresponding to a ‘good’ feeling, participants would select an intensity of exercise that is proximal to intensities associated with meaningful cardiorespiratory benefits (i.e., VT); (H_2) when controlling for preference of exercise intensity, participants’ exercise intensity would be higher in the music condition than in the no-music condition; (H_3) participants’ remembered pleasure would be greater (i.e. more positive) in the music condition than in the no-music condition. As a manipulation check, participants’ affective responses during the conditions were assessed.

Method

Participants

Based on an expected large effect (Cohen’s $d = 0.8$) for differences in intensity between conditions (e.g. Almeida et al., 2015), an alpha level of 0.05, and power at 0.8, a power analysis indicated that 15 participants would be required. Following institutional ethical approval, a convenience sample of seventeen male ($n = 9$) and female ($n = 8$) volunteers (mean ± SD; age 28.1 ± 9.9 years) were recruited for participation in the study. To be eligible, participants had to be between 18 and 50 years of age, and habitually active (per ACSM guidelines) with no known or symptoms of cardiovascular, metabolic or renal disease (Riebe et al., 2015). Participants were recruited through poster advertisement on a College campus. All participants read and signed an informed consent form prior to participation. Descriptive data for participants are displayed in Table 1.

Measurement Instruments

Each participant's body mass (kg) and height (cm) were determined using a physician's scale (Detecto 437). A heart rate monitor (Polar E600, Kempele, Finland) was used to measure heart rate (HR) via telemetry. Oxygen uptake (VO_2), carbon dioxide production (VCO_2), and minute ventilation (VE) were assessed with a metabolic cart (SensorMedics 2900) which was calibrated with known gases before each use.

Affective valence was assessed from the perspective of the circumplex model of affect (Russell, 1980) in which the valence dimension represents "pleasantness" and can be assessed along a continuum from pleasure to displeasure. The Feeling Scale (FS; Hardy & Rejeski, 1989) was used to assess in-task affective valence. The FS is a single-item scale that utilizes the stem "How do you currently feel?" with possible responses ranging from -5 (*very bad*) to +5 (*very good*). Hardy and Rejeski established the validity of the FS through a series of small-scale studies. Drawing on the results of a discriminant function analysis, the researchers concluded that the good/bad dimension of the FS was representative of a core affective expression. Specifically, using the discriminant function equation, items from the revised Multiple Affective Adjective Check List (Zuckerman & Lubin, 1985) were classified as associated with either a "good" or "bad" feeling during exercise with an overall success rate of 95.52%. According to Hardy and Rejeski, these data also provide face and content validity for the FS (i.e. the good/bad bipolarization of affect during exercise appears to be assessing the core affective domain of pleasure/displeasure). Single-item scales are not subject to traditional reliability assessments, such as item analysis and assessments of internal consistency. Moreover test-retest estimates of reliability are inappropriate for any scale that measures a state that can fluctuate quickly (Russell, Weiss & Mendelsohn, 1989). As a solution to this, Russell et al. recommend obtaining ratings of the same stimuli on other measures that purport to measure the same construct "because reliability sets an upper bound on validity, we can conversely say that an index of convergent validity estimates a lower bound of reliability" (p. 495). The FS has been shown to correlate with other valance measures, such as the positive well-being (r = .61) and psychological distress (r = -.69) sub-scales of the Subjective Exercise Experiences Scale (McAuley & Courneya, 1994) and the valence scales of both the Self-Assessment Manikin (Lang, 1980) (r = .51—.88; Van Landuyt, Ekkekakis, Hall & Petruzzello, 2000), and the Affect Grid (Russell et al., 1989) (r = .41—.59; Van Landuyt et al., 2000).

Following exercise, remembered pleasure was assessed using a visual analog scale (VAS). The employment of a different measurement format to that of the FS served to minimize common-method variance (Zenko et al., 2016). Respondents were administered the question, "How did the exercise session make you feel?", and provided a rating by placing a pencil mark on a horizontally positioned 200-mm line anchored by the descriptors "*very unpleasant*" (-100) to "*very pleasant*" (+100). Remembered pleasure was scored in 1-point intervals by measurement in mm of the distance from the left end of the VAS to the pencil mark, providing a range of scores from -100 to 100. The two verbal descriptors were visible to participants, but the numbers were not. To avoid clustering of scores around a preferred numeric value, numbers or verbal descriptors at intermediate points are not recommended with the use of a VAS (Scott & Huskisson, 1976). The reproducibility and validity of VAS scores has been well studied in other research domains, particularly pain research, where VAS is used as `the gold standard' (Yarnitsky, Sprecher, Zaslansky, & Hemli, 1996). The use of a VAS for the assessment of both the intensity and unpleasantness (affective magnitude) of pain has resulted in excellent test-retest reliability coefficients for experimentally induced pain (r = .97) and positive correlations with physician's ratings of the patients improvement for clinical pain (r = .70; Price, McGrath, Rafii, & Buckingham, 1983). Monk (1989) has demonstrated the validity of the VAS in the measurement of core affect, reporting negative correlations between global affect and number of days of voluntary seclusion (rho = -.89 to -.97). Lingjærde & Føreland reported high test-retest reliability (*r* = 0.96) for two consecutive affect ratings between which the respondent stated that there had been no change.

To account for individual differences in preferred exercise intensity, participants completed the Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q; Ekkekakis, Hall, & Petruzzello, 2005). The PRETIE-Q comprises 16 items (8 items for Preference and 8 items for Tolerance) with a response scale ranging from 1 ("*I totally disagree*") to 5 ("*I totally agree*"). Only scores from the Preference subscale were used in the present study, owing to the relevance of this subscale during self-paced exercise. The eight-item preference scale contains four items that tap preference for high intensity (e.g., ‘‘I would rather have a short, intense workout than a long, low intensity workout’’) and four that tap preference for low intensity and are reverse-scored (e.g., ‘’When I exercise, I usually prefer a slow, steady pace’’; Ekkekakis et al., 2005).

Concurrent validity of the PRETIE-Q has been established via significant associations with other trait measures of arousability and sensory modulation. For example, Ekkekakis et al. (2005) report the PRETIE-Q preference subscale is positively correlated ($r = .31$, $p < .001$) with the Revised Reducer-Augmenter Scale (Clapper, 1990). In assessing construct validity, Preference is significantly related to self-reported frequency of strenuous exercise ($r = 0.30$, $p < .001$), but not moderate or mild exercise (Ekkekakis, Thome, Hall, & Petruzzello 2008). Moreover, preference scale score can account for 18–19% of the variance in self-selected exercise intensity, beyond that accounted for by age, body mass index, and cardiorespiratory fitness (Ekkekakis, Lind, & Joens-Matre, 2006). Consistent with the conceptualization of preference as a trait, test-retest reliability estimates for the Preference subscale are high (0.67-0.80; Hall et al., 2014). Internal consistency (Cronbach's alpha) of the scale for the present sample was 0.73.

Procedure

Session 1: Graded exercise test (GXT). The purpose of the first session was to (a) collect anthropometric and PRETIE-Q data; (b) determine peak aerobic capacity and ventilatory threshold (VT); and (c) familiarize participants with the self-report measures. Upon arrival at the laboratory, participants verbally confirmed no caffeine within 6 h of testing, no vigorous exercise within 24 h of testing, and a normal prior night's sleep (within 1 h of typical sleep duration). Participants' height and weight were measured while lightly clothed and without shoes. Each participant was then fitted with a HR monitor and fitted with a facemask equipped with a low-resistance one-way valve for the collection of expired gases. Prior to testing, 2 min of resting data were collected while the participant was standing on the treadmill (Precor, TRM 833) to ensure the proper functioning of the metabolic system. The GXT consisted of a ramped Bruce protocol (Will & Walter, 1999) to the point of volitional fatigue. The highest level of oxygen uptake averaged over 20 s was designated as VO_2 peak. The VT was later determined by consensus of three judges who worked independently, analyzing the gas exchange data offline with the aid of a software program (WinBreak 3.7, Epistemic Mindworks, Ames, IA). The VT was determined as the intensity at which breakpoints were identified (both by computerized algorithms and by visual inspection) for at least two of the following three relationships: (i) CO_2 production over O_2 utilization, (ii) ventilatory equivalent for O_2 over O_2 utilization, and (iii) excess CO_2.

Sessions 2 and 3: Experimental Testing. There were two experimental conditions (music and no-music) and these were completed 48 hrs apart, in a randomized order. For each testing session participants completed a brief dynamic warm up, followed by a 20 min affect-regulated exercise bout on a motorized treadmill. Participants were specifically instructed to select an exercise intensity that felt '*good*' (i.e. corresponding to the FS value of +3) during the session and to change the speed and/or gradient of the treadmill at any time to achieve this feeling state. This is similar to previous approaches used for affective regulation of exercise intensity (e.g. Parfitt et al., 2012).

Prior to the music condition, each subject was asked to compile a playlist of self-selected music that they would like to listen to during treadmill exercise. Participants listened to music on their own electronic devices and using their own headphones (in order to maximize participant comfort level). Headphones were not used during the no-music condition in order to maintain external validity (c.f. Bird, Hall, Arnold, Karageorghis, & Hussein, 2016). During each testing session, affective valence was measured immediately prior to the mid-point and end-point (i.e. 15s before min-10 and min-20) of the exercise bout. HR was monitored continually, and recorded at intervals corresponding to affective valence measurement (i.e. 15s before min-10 and min-20). Once the 20 min exercise session was over, participants warmed down for 2 min, and then rested in a seated position for 5 min before responding to the VAS scale.

Data Analysis

To assess affect-regulated intensity relative to VT (H_1) a paired-samples *t*-test was applied to examine differences between HR recorded at VT during the GXT and an average of the HR recorded at min-10 and min-20 across both experimental conditions. To determine the effects of the experimental conditions, while accounting for preference of exercise intensity, on affect-regulated intensity (H_2), a 2 (condition) x 2 (time) analysis of covariance (ANCOVA) was used, with Preference as covariate and heart rate difference to VT (at min-10 and min-20) as the dependent variable. A paired-samples *t*-test was applied to compare Remembered Pleasure between conditions (*H3*). The manipulation check for in-task affective responses comprised a 2 (condition) x 2 (time) ANOVA of FS scores at 10 min and 20 min. All effect sizes are reported as Cohen's *d*.

Results

Data screening revealed no univariate (*z* ± 3.29) or multivariate outliers ($p < .001$). Tests of normality revealed four violations ($z > \pm 1.96$). The violations were not considered sufficiently extreme (i.e., all $z < \pm 3.29$) to warrant transformation and the inferential statistics were sufficiently robust to withstand such minor deviations from normality.

Ad Hoc Analysis

A partial correlation analysis controlling for age, BMI and VO_2 peak (c.f. Smith et al., 2015) was conducted to establish relationships between preference for exercise intensity and affect-regulated intensity in each experimental condition. The analysis revealed a significant positive relationship between Preference and HR (mean across time points) in the music condition ($r = .643$, $p = .013$), and a positive, but non-significant correlation in the no-music condition ($r = .405$, $p = .150$). This amounted to an additional 33.6% of the variance in HR in the music condition and 14.5% of the variance in the no-music condition, on top of that accounted for by age, BMI and fitness (VO_2 peak). The results of the ad hoc analysis support our previously outlined conceptual decision to include Preference as a covariate, (i.e. to remove noise variance unrelated to the independent variable; Miller & Chapman, 2001).

Exercise Intensity

The paired samples *t*-test indicated that participants' HR during the affect-regulated intensity conditions was significantly higher than HR at VT recorded during the GXT, t (16) = -3.792, $p = .002$, Cohen's $d = .99$. The mean value for HR at VT recorded during the GXT was 149.59 ±16.48 bpm, and the mean value for HR recorded at minutes 10 and 20 during the experimental conditions was 163.5 ± 11 bpm.

The 2 (condition) x 2 (time) RM ANCOVA revealed no significant interaction effects, $F(1, 15) = .378$, $p = .548$, $d = .35$, or main effect for time, $F(1, 15)$, = .639, p = .436, $d = .41$

The analysis identified a significant main effect for condition, $F(1, 15) = 4.780$, $p = .045$, d = 1.12, with follow-up pairwise comparisons indicating that heart rate was higher during the music condition compared to the no-music condition ($p = .037$). Heart rate in the no-music condition was 12.1 bpm above HR at VT compared to 15.71 bpm during the music condition. Expressed as a percentage of each participants' HR max (achieved during the GXT) affect-regulated HR was 87% max and 90% max for the no-music and music conditions respectively.

Affective Responses

Remembered Pleasure. There was a significant difference for Remembered Pleasure, $t(16) = 4.181$, $p = .001$, $d = .72$ with higher scores reported for the music condition ($M = 53.53 \pm 29.30$) compared to the no-music condition ($M = 32.35 \pm 29.53$).

In-task Feeling Scale (manipulation check). There were no condition x time interaction effects, $F(1, 16) = .715$, $p = .410$, $d = 0.42$, or main effects for time, $F(1, 16)$ = .212, $p = .615$, $d = 0.23$. There was a main effect for condition, $F(1, 16) = 10.922$, $p = .004$, d = 1.65, with follow-up pairwise comparisons indicating that the music condition was rated as more pleasant ($M = 3.38 \pm .67$) than the no-music condition ($M = 2.79, \pm .81$).

Discussion

The aims of this study were to examine the intensity of exercise that active individuals would choose to work at when asked to exercise at an intensity that felt 'good', and to explore whether listening to self-selected music would influence affect-regulated exercise intensity and/or the remembered pleasure of the exercise session.

Exercise Intensity

In support of the first hypothesis, when instructed to select an exercise intensity that felt 'good' (i.e. corresponding to the FS value of +3), participants selected an exercise intensity that exceeded their VT. The mean exercise intensity across the two conditions equated to 10% above HR at VT, and 89% of HR max. This falls within the “vigorous” classification of relative exercise intensity for cardiorespiratory endurance (i.e. 77-95% HR max; Garber et al, 2011). This exercise intensity is higher than has been reported in previous investigations using affect-regulated exercise. In a study using directly comparable data points to the present study (i.e. min-10 and min-20 of a 20 min treadmill bout), Hamlyn-Williams et al. (2015) reported that sedentary women (mean age ~25 years) selected an average intensity equating to 5% above VT and 72 % predicted HR max at FS +3. A likely explanation for these differences is that individuals with previous exercise experience are more accustomed to the physiological sensations associated with exercise and may respond more favorably to vigorous exercise. However, current results also differ from those previously reported with active participants. In the only other located study to examine affect-regulated exercise with active participants, Parfitt, Blisset, Rose and Eston (2011) measured the exercise intensity associated with affective responses of ‘fairly good’ (FS +1) and ‘good’ (FS + 3) in active females. When referenced relative to VT, the exercise intensity chosen by participants in the FS +3 condition was 10 % below HR at VT, and 81 - 83% of HR max. Such differences in preferred exercise intensities likely reflect multiple sources of interindividual variability in response (see Ekkekakis, 2009). Participants recorded a mean score of 28.29 ± 4.92 (see Table 1) on the Preference for exercise intensity subscale (PRETIE-Q; Ekkekakis et al. 2005). This represents a score in the ~70th percentile based on normative data provided by Ekkekakis et al. (2008) and is 4 points higher than the normative mean of 24.22 ± 6.47. The relatively high Preference score for the participants in the present study might account for a difference in the intensity selected compared to that of participants in the Parfitt et al. (2011) study.

The large amount of inter-individual variability in self-selected and affect-regulated exercise intensity underscores the "urgent need for a research agenda aimed at improving the current understanding of the factors underlying these differences" (Ekkekakis, 2009, p. 883). Nonetheless, it is clear is that when self-regulating their exercise to feel 'good', participants consistently select exercise intensities that surpass the minimum intensity for improving cardiorespiratory fitness (Swain & Franklin, 2002). The present findings are in agreement with those of Parfitt et al. (2011) who contend that exercisers can use affect to regulate exercise intensity at a level "that would confer fitness and health benefits if maintained" (p.104). These findings lend support to the call for self-paced exercise prescriptions based on feeling state rather than at a specific prescribed intensity (Williams, 2008). Yet there remains a clear need to assess the influence of affect-regulated exercise on long-term adherence to exercise training and health-related outcomes.

Regarding the influence of music on affect-regulated exercise intensity, the ANCOVA analysis showed that, when accounting for individual variations in exercise intensity preference, affect-regulated exercise intensity was significantly higher during the music condition compared to the no-music condition. Thus our second hypothesis was supported, and the associated effect size (d = 1.12) was large (Cohen, 1988). This finding is consistent with previous reports of the ergogenic effects of music on running performance (e.g. Bigliassi, León-Domínguez, Buzzachera, Barreto-Silva, & Altimari, 2015; Ramji et al., 2015). The results of the present study are novel in demonstrating that self-selected music enables runners to work harder when contrasted to a comparable condition where participants still maintain a 'good' feeling. There is a positive dose-response relationship between exercise intensity and health benefits (Garber et al., 2011). Therefore, strategies that result in an increase in exercise intensity while still maintaining a positive affective response (i.e., feeling good) will be beneficial for exercisers. From a hedonic theory perspective, exercising at an intensity that feels ‘good’ should support decisions to repeat the behavior (Rhodes & Kates, 2015). Furthermore, this method of exercise–intensity regulation leads to greater feelings of autonomy or self-determination, which in turn enhance intrinsic motivation and affective responses to exercise (Vazou-Ekkekakis & Ekkekakis, 2009).

Affective Reponses

Manipulation Check. Participants were instructed to exercise at an intensity that felt ‘good’ (i.e. corresponding to a score of +3 on the Feeling Scale). An examination of mean FS scores indicate that participants were successful in doing so, (means scores for each condition round to 3 as the nearest integer), however a significant difference emerged between the music and no-music conditions wherein the music condition was rated as more pleasant (M = 3.38 ± .67) than the no-music condition (M = 2.79, ± .81). It is postulated that participants were not prompted about their feeling state with sufficient regularity. It is plausible that participants became guided by other stimuli or sensations (e.g., music) rather than the instruction to exercise at an intensity that felt ‘good’. Although a significant difference was found, participants were exercising at a pleasant intensity rather than unpleasant exercise intensity in both conditions. Therefore, the use of affect-regulated exercise still appears to ensure a positive exercise experience, which will likely lead to greater adherence. As a practical consequence, regular reminders of how exercisers ‘should’ be feeling (i.e., good) during affect-regulated exercise could be crucial as it is unusual for most people to exercise according to their feelings, and many may revert to a default running/exercising pattern.

Remembered Pleasure. At any point in time, the human experience can be partitioned into three temporal frames; the past, the present, and the future (Zimbardo & Boyd, 1999). These learned time perspectives “exert a dynamic influence over many important judgements, decisions, and actions” (p.1272). Until relatively recently, research attention in the domain of exercise-related affect has focused on the present experience of affect. However, drawing from the work of prominent behavioral economists such as Ariely (1998), and Kahneman (2003), researchers have begun to examine the other temporal frames of remembered and anticipated pleasure (c.f. Zenko et al. 2016), which may play a role in decisions to engage or disengage from exercise. In the present study, we report a significant difference for Remembered Pleasure, wherein higher scores were reported for the music condition compared to the no-music condition (d = .72). To the best of our knowledge, this is the first study to show that music can positively influence the domain of remembered pleasure in an exercise setting. This finding supports and builds upon previous reports of the association between music and enhanced affective states during exercise while extending them to a new temporal domain.

The mechanisms by which music imbues a positive effect on the exercise experience include alterations in attentional focus (distracting from sensations of fatigue and discomfort; Hutchinson & Karageorghis, 2013), and activation of the prefrontal cortex (Bigliassi et al., 2017), which is associated with enhanced motivational and affective states (Jones, Karageorghis & Ekkekakis, 2014). Shifting attention away from noxious afferent stimuli is a well-known central (non-pharmacological) intervention in the management of pain (termed '*audio-analgesia*'). Familiarity is a key factor in the influence of the cognitive and emotional mechanisms of audio-analgesia; listening to preferred music in particular provides an emotionally engaging distraction capable of reducing both the sensation of pain itself and the accompanying negative affective experience (Mitchell, MacDonald & Brodie, 2006). The present study made use of listener-selected rather than experimenter-selected music, which potentially maximized this effect.

Limitations and Future Directions

The results of this study should be considered preliminary given that the current sample is small (N = 17) and relatively narrow in terms of age and fitness level. Moreover, participants constituted a convenience sample, which has the general limitation of sampling bias (individuals willing to participate in an exercise-based study are likely positively oriented toward exercise), which reduces the generalizability of the results. Nonetheless, our findings regarding affect-regulated exercise intensity were broadly in-line with those previously reported in both sedentary and active populations. Still, one should not assume that the present results generalize beyond a normal weight, habitually active population. More research is needed to determine whether our current findings can be replicated; it would be particularly useful to attempt to do so among participants with lower cardiorespiratory fitness or those with hypokinetic diseases such as type-2 diabetes or cardiovascular disease.

There are additional limitations to this study, which future investigations should address. First, remembered pleasure was assessed 5-min post-exercise. While this is consistent with other research where global affect evaluations were made immediately or shortly after the experience (e.g. Fredrickson & Kahnman, 1993; Rode, Rozin, & Durlach, 2007) it would be desirable to explore a wider range of durations to better understand how people retrospectively evaluate past exercise experiences. Multiple time point assessments would capture both stable levels of and/or dynamic changes in remembered pleasure. Measurements that span the period where an individual is likely to make a decision to re-engage (or not) in exercise would be of particular interest. Second, it is possible that the use of a treadmill task may have limited our findings. Treadmill running is not fluid in terms of intensity changes — such changes need to be made explicitly using the console controls. We recommend the use of a running track or a stationary cycle in future research to allow for better assessment of dynamic changes in affect-regulated exercise intensity.

Additional recommendations for future research are to consider perceived autonomy as a possible mediator of the effects of both affect-regulated exercise and self-selected music. Autonomy is a strong determinant of exercise behavior and the efficacy of affect-regulated exercise (rather than prescribed exercise) might be a consequence of an increased sense of autonomy. It might also be of interest to explore discontinuous exercise protocols such as high-intensity interval training (HIIT). The affective responses to HIIT have received recent research attention (e.g. Jung, Bourne & Little, 2014) and been the topic of healthy debate in the literature (Biddle & Batterham, 2015). Exploratory work could be conducted to understand what an affectively regulated HIIT protocol might look like, and whether such a protocol can confer similar positive health outcomes compared to more recognised protocols.

Summary

The results of this study support previous indications that, when instructed to regulate exercise intensity based on affective perceptions, participants select a level of exercise intensity that is associated with meaningful cardiorespiratory benefits. The results also provide the first evidence that affect-regulated exercise intensity can be influenced through the use of self-selected music. Moreover, that higher intensity exercise accompanied by self-selected music is recalled as a more pleasant experience, which has positive implications for adherence. Further studies are needed in order to confirm these findings.

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Table 1

Mean Descriptive Statistics for Participants

Variables	*Mean*	*SD*
Height (cm)	171.74	9.75
Mass (kg)	70.46	12.8
BMI (kg/M^2)	23.80	3.24
VO^2 Peak (ml.min^{-1}.kg^{-1})	48.73	8.73
HR max (bpm)	184.65	11.31
HR at VT (bpm)	150.63	16.44
PRETIE-Q preference score	28.29	4.92