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Exercisers' Affective and Enjoyment Responses: A Meta-Analytic and Meta-Regression Review

Abstract

Affective responses and enjoyment of exercise mediate exercise adherence, but previous research findings have failed to examine nuances that may moderate this relationship. We examined the effects of exercise on affective and enjoyment responses during and post exercise through a systematic literature review and meta-regression analysis. We searched major databases up to July 9, 2020 for studies evaluating healthy adults' acute and chronic responses to exercise, using either of The Feeling Scale or Physical Activity Enjoyment Scales. We calculated effect size (ES) values of 20 unique studies (397 participants; 40% females) as standardized differences in the means and expressed them as Hedges' g, together with the 95% confidence interval (95%CI). Among acute studies examining affective responses, we found a greater positive effect *post exercise* for continuous training (CT) compared to high intensity interval training (HIIT) (-0.61 (CI: -1.11 – -0.10); $p < 0.018$), but there was no significant difference between these modes for effects *during* exercise. Subgroup analyses revealed that moderate, and not high intensity, CT, compared to HIIT, resulted in significantly greater positive affective responses [-1.09 (CI: -1.88 – -0.30); $p<0.006$]. In contrast, enjoyment was greater for HIIT, compared to CT [0.75 (CI: 0.17 – 1.13); $p = 0.010$], but CT intensity did not influence this result. Among chronic studies, there was greater enjoyment following HIIT compared to CT, but these studies were too few to permit meta-analysis. We concluded that an acute bout of moderate intensity CT is more pleasurable, when measured post exercise than HIIT, but enjoyment is greater following HIIT, perhaps due to an interaction between effort, discomfort, time efficiency and constantly changing stimuli.

Keywords: Pleasure, Enjoyment, Continuous Training, HIIT

Introduction

Exercise has been defined as planned and structured activity (Caspersen et al., 1985) that induces several benefits on the human body, and it has been considered an important tool to improve health (Pedersen & Saltin, 2015; Sallis, 2009). There are various exercise classification options such as aerobic continuous, aerobic interval and resistance exercise. Aerobic exercise has been defined as any activity that uses large muscle groups, can be maintained continuously, is rhythmic in nature (e.g. cycling, walking jogging/ running, and swimming), and, as the name implies, relies upon aerobic metabolism (Pescatello et al., 2014). In resistance exercise, muscles are required to work or hold against an applied force or weight and primarily utilize anaerobic metabolism (Pescatello et al., 2014). Interval training involves short bouts of exercise with distinct intensity and short periods of rest between bouts with the contribution of aerobic to anaerobic metabolism dependent on the variables manipulated (Pescatello et al., 2014). It has been well established that exercise decreases the risk of all-cause mortality (Lee et al., 2018) and can be a protective factor against various diseases (Schuch et al., 2019; Zachariah & Alex, 2017).

The American College of Sport Medicine and the World Health Organization have recommended that most adults engage in physical exercise of at least 150-300 minutes per week at moderate intensity (64-76% HR_{max} and 46-63% VO_{2max}), 75-100 minutes per week at vigorous-intensity (77-95 % HR_{max} and 64-90% VO_{2max}) or a combination of moderate and vigorous exercise totaling a targeted energy expenditure (i.e. 500-1000 MET·min·wk) (Bull et al., 2020; Garber et al., 2011). Additionally, healthy adults should perform 2-3 days of resistance training (on non-consecutive days) per week (Garber et al., 2011). Resistance training sessions should include 8-10 exercises targeting major muscle groups involving at least one set of 15-25 repetitions with light loads (<50% 1RM) or 8-12 repetitions with moderate-heavy loads (60-80% 1RM). Despite the plethora of evidence surrounding the health benefits associated with exercise and these recommendations, most recent studies have shown that the general adult population spends considerable time being sedentary and little time engaged in exercise (Koyanagi et al., 2018; Werneck et al., 2019). While there has been extensive research into individual and environmental factors that may contribute to a sedentary lifestyle (Buck et al., 2019), it remains alarming that a large number of people (approximately 50%) who commence an exercise program cease it within six months (Linke et al., 2011). Feelings of pleasure and enjoyment associated with exercise have been linked to exercise adherence (Focht, 2009; Rhodes & Kates, 2015), making it prudent to consider prescribing exercise sessions that are associated with positive affective and enjoyment responses. Thus, affective responses negatively or positively influence individual goals and/or well-being and affect (e.g., pleasure or displeasure) (Hardy & Rejeski, 1989). In this same way, enjoyment responses promote acceptance or rejection of the exercise protocol (Kendzierski & DeCarlo, 1991).

Traditionally moderate intensity aerobic exercise has been prescribed to the general population, despite evidence that people find it challenging to accumulate the recommended exercise volume due to lack of time (Trost et al., 2002). As such, high intensity interval training (HIIT) was designed as an option for achieving a high energetic expenditure in short exercise bouts. Some evidence has suggested that HIIT leads to greater clinical and physiological benefits (e.g. cardiac function, exercise capacity, inflammation, quality of life, VO_{2peak}, and endothelial function) when compared to continuous aerobic exercise (Ito, 2019). However, studies have suggested that high intensity exercises may result in poorer exercise adherence, due to the more negative affective responses and enjoyment associated with them, compared to lower intensity exercise (Ekkekakis, 2009; Nasuti & Rhodes, 2013; Tavares et al., 2020).

A previous systematic review and meta-analysis investigated affective and enjoyment responses to high intensity interval training and continuous training (Oliveira et al., 2018). The Oliveira et al. (2018) review concluded that HIIT exercise may be a viable strategy for obtaining positive psychological responses. However, data gathered during and after exercise were combined in this review, perhaps leading to an oversimplified impression of nuances within data characteristics. This possibility is supported by other evidence that intensity manipulation has a differential effect for responses measured either during exercise or post-exercise (Ekkekakis et al., 2018). In present review we attempted to update and more precisely describe participants' affective responses to HIIT and CT when measured both during and post-exercise. Additionally, we sought to include a more comprehensive range of exercises (i.e., aerobic continuous, interval exercise and resistance exercise) using both meta-analytical and meta-regression approaches. The aim of this review was to examine the acute and chronic effects of exercise on healthy adults' affective and enjoyment responses. Information gathered from this meta-analysis and meta-regression was expected to be useful to exercise specialists and clinicians devising and prescribing exercise programs that might promote greater exercise adherence.

Method

This systematic review and meta-analysis was conducted in accordance with the recommendations outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2009)**,** registered on Prospero: CRD42020167507.

Search Strategy and Study Selection

We first conducted a literature search from the earliest record up to July 9, 2020 using the following electronic databases: PubMed, PsycINFO, SPORTDiscus, and Web of Science. Our search strategy in PubMed combined the terms ‘walking’, ‘jogging’, ‘running’, ‘cycling’, ‘swimming’, ‘endurance training’, ‘aerobic exercise’, ‘aerobic training’, ‘resistance training’, ‘resistance exercise’, ‘strength training’, ‘weight training’, ‘weight lifting’, ‘high intensity interval training’, ‘interval training’, ‘interval exercise’, ‘high intensity intermittent training’, ‘high intensity intermittent exercise’, and ‘sprint interval training’, with ‘enjoyment’, ‘pleasure’, ‘emotion’, and ‘mood’. Search strategies for other databases were slightly adapted. One reviewer (V.T.) then individually evaluated the titles and abstracts of retrieved articles to assess their eligibility for review and meta-analysis (see eligibility criteria below). Studies to be included were checked again by a second reviewer (D.H.). These two reviewers were not blinded to the studies’ authors, institutions or journals of publication. Study abstracts that did not provide sufficient information according to the inclusion criteria (see below) were retrieved for full-text evaluation by the same two reviewers.

Eligibility Criteria

Articles were eligible for inclusion if they met the following criteria: (a) randomized and non-randomized comparative studies; (b) published in English; (c) included adult participants (≥ 18 years of age); (d) included participants with no known medical condition or injury; (e) compared continuous aerobic versus HIIT; (f) compared of intensities for resistance exercise/training; (g) involved either a single exercise session (acute response) or ≥ 3 exercise sessions (chronic adaptation); and (h) measured at least one outcome of enjoyment or affective response during and post exercise, using only two valid scales (Physical Activity Enjoyment Scale (PACES) and the Feeling Scale (FS), respectively). Briefly, the PACES is a measure with 18 items and is enjoyment-specific for physical activity. This scale assesses enjoyment for physical activity by asking participants to rate their immediate feeling about the physical activity they have just performed, using a 7-point bipolar Likert scale. Higher scores reflect greater enjoyment levels (Kendzierski & DeCarlo, 1991). This scale demonstrated internal consistency, with coefficient α = .90, and item-total correlations = .38 – .76 (Crocker & Gessaroli, 1995). The FS is an 11-point, single item, bipolar rating scale used to measure the affective dimension of pleasure - displeasure during exercise. The scale ranges from -5 to +5, with verbal descriptors, positioned on all odd integers and at zero point ("neutral") (Hardy & Rejeski, 1989). Previous research (Van Landuyt et al., 2000) found the FS to correlate between 0.51 and 0.88 with the valence scale of the Self-Assessment Manikin (Lang, 1980).

Data Extraction

One reviewer (V.T.) extracted data and compiled it into an Excel spreadsheet, recording such relevant data as participant characteristics [age, body mass index (BMI), $VO2_{Peak}$], study characteristics (type of exercise, intensity, frequency, study duration) and enjoyment and affective responses (during and post of exercise). Data presented in figures for seven studies (Decker & Ekkekakis, 2017; Hoekstra et al., 2017; Niven et al., 2018; Olney et al., 2018; Poon et al., 2018; Stork et al., 2018; Thum et al., 2017) were estimated using an online data extraction tool (WebPlotDigitizer https://apps.automeris.io/wpd/). For all enjoyment and affective responses, this researcher extracted absolute data [means (*M*) and standard deviations (*SD*)] and relative changes from baseline (percentage change and *SD*).

Study Quality Assessment

We assessed the risk of within-study bias using the Tool for the assEssment of Study qualiTy and reporting in EXercise (TESTEX) (Smart et al., 2015). The TESTEX tool is a 15-point scale (5 points for study quality and 10 points for reporting) that assesses study quality and reporting in exercise training studies. When using this tool, if a criterion is met, a score of '1' is awarded and if not a score of '0' is awarded. For study quality, the criteria included: (a) randomization (e.g., coin-tossing); (b) allocation concealment (concealment before randomization); (c) groups similar at baseline; and (d) blinding of assessor. For reporting, the criteria included: (a) percentage of participants completing the study in both groups (1 point – if adherence >85%; intervention group; 1 point – if adverse events are reported; 1 point – if exercise attendance is reported); (b) intention-to-treat analysis; (c) between-group statistical comparisons reported; (d) point measures and measures of variability; (e) activity monitoring in control; (f) relative exercise intensity remained constant; exercise volume and energy expenditure. To interpret the assessment scores for both study quality and reporting the maximum total of 15 was divided into four classifications. A score of <4 was considered "poor", 4 - 7 as "moderate", 8 -11 as "good" and >11 as "excellent" study quality and reporting.

Statistical Analysis

Analyses were conducted for acute and chronic exercise interventions (e.g., HIIT versus continuous training, separately). For the acute studies, participant affect and enjoyment were reported immediately following exercise, using the Feeling Scale or Physical Activity Enjoyment Scales, respectively, and analyzed, separately. For the chronic studies the change in enjoyment (using the Physical Activity Enjoyment Scales) during and after the exercise interventions were analyzed. All analyses were conducted using Comprehensive Meta-Analysis version 3 software (Biostat Inc., Englewood, NJ, USA), with the level of significance set at $p \leq 0.05$. Effect size (ES) values were calculated as standardized differences in the means and expressed as Hedges' g, which corrects for parameter bias due to small sample sizes (Ugille et al., 2014). Hedges' g were classified as trivial or small (0.20 to 0.49), moderate (0.50 to 0.79), and large (>0.80) (Hedges, 1981). We examined between-study variability for heterogeneity, using the I^2 statistic for quantifying inconsistency (Higgins et al., 2003). Heterogeneity thresholds were set at I^2 = 25% (low), I^2 = 50% (moderate) and I^2 = 75% (high) (Higgins et al., 2003). In the presence of significant heterogeneity, the heterogeneity was further examined through: (a) subgroup analysis, exploring the role of intensity; or (b) meta- regression on age, BMI and gender. We applied a random-effects model meta-analysis to pool the data for each analysis. For adequate statistical power, we included a minimum of five studies in the pooled random-effects analysis (Jackson & Turner, 2017). We analyzed publication bias using funnel plots and Egger's test of effect size (mean difference) against its standard error. We applied the Trim and Fill procedure (Duval & Tweedie, 2000) if evidence of publication bias was noted. Additionally, we removed potential outlier studies, such as those with substantially larger effects, and we recalculated pooled ES as a part of the sensitivity analysis.

Results

Our initial search yielded 3,311 studies. After removing duplicates and excluding studies based on title and abstract, 77 studies remained. After the full-text review, there were 48 studies, and 20 unique studies (17 acute and 3 chronic) that met the eligibility criteria for inclusion (Alicea et al., 2020; Bartlett et al., 2011; Decker & Ekkekakis, 2017; Focht et al., 2015a; Heisz et al., 2016; Hoekstra et al., 2017; Mary E. Jung et al., 2014; Kilpatrick et al., 2015; Kong et al., 2016; Kriel et al., 2019; Martinez et al., 2015; Niven et al., 2018; Bruno R.R. Oliveira et al., 2013; Olney et al., 2018; Poon et al., 2018; Portugal et al., 2015; Sagelv et al., 2019; Stork et al., 2018; Thum et al., 2017; Vella et al., 2017) (see Figure 1).

[Insert here. Figure 1 – Flow Chart of Study Selection]

Acute Studies

The 17 acute studies were comprised of 310 participants (39% women). Further description of these participant characteristics is provided in Table 1. Fifteen of these studies analyzed the effects of HIIT versus CT. Twelve studies of this subset measured affective responses during and post exercise using the FS (Alicea et al., 2020; Decker & Ekkekakis, 2017; Hoekstra et al., 2017; Jung et al., 2014; Kilpatrick et al., 2015; Martinez et al., 2015; Niven et al., 2018; Oliveira et al., 2013; Olney et al., 2018; Poon et al., 2018; Stork et al., 2018; Thum et al., 2017), while ten studies applied the PACES after exercise (Bartlett et al., 2011; Decker & Ekkekakis, 2017; Hoekstra et al., 2017; Jung et al., 2014; Kriel et al., 2019; Martinez et al., 2015; Olney et al., 2018; Sagelv et al., 2019; Stork et al., 2018; Thum et al., 2017). Ten studies involved cycling and five studies involved treadmill exercise. Intensity was expressed as a percentage of peak power output in Watts in six studies, VO^2 peak in five studies, ventilatory threshold in three studies, and maximum heart rate in one study. The duration of the HIIT ranged from six seconds to four minutes compared to 20-50 minutes for CT (see Table 1).

There were two studies (Focht et al., 2015b; Portugal et al., 2015) that examined the acute affective responses of resistance exercise and due to their low number (<5) no meta-analysis was conducted for them. Briefly, Portugual et al., (2015) showed that, regardless of resistance exercise intensity, even if self-selected, resistance exercise did not influence affective responses in a cohort of young healthy men with between 3-12 months of resistance training experience. This suggests that manipulation of resistance exercise intensity may not promote positive affective responses in novice to intermediate resistance trained males. In contrast, Focht et al. (2015b), found that self-selected and imposed intensities can improve affective response in recreationally resistance trained (i.e. ≥ 3 sessions of resistance per week over the past 12 months) young women. Ratings of pleasure were found to increase from baseline during resistance training performed at 40% 1RM and at a self-selected load compared to during 70% 1RM. It should be noted that pleasure was significantly increased in all conditions 15 minutes post-resistance training.

[Insert Table 1. Descriptions of Acute Studies.]

Affective Responses

Acute HIIT vs. CT During Exercise. We observed no significant difference in affective response during exercise when comparing acute HIIT and CT [-0.34 (-0.78 – 0.10); p = 0.133] (Supplementary Figure SF1). Heterogeneity of the effect among participants of acute HIIT versus CT on affective responses during exercise was high (I^2= 91.34). Egger's regression did not indicate publication bias (intercept = - 4.63, SE = 4.43, p = 0.30). No significant *Kendall's rank* correlation coefficient was observed (τ = -0.07, p = 0.59) indicating funnel plot symmetry. Based on the meta regression for the FS during exercise the following covariates were unrelated to the results: age [coefficient= 0.006 (-0.012 – 0.025); p = 0.500], BMI [coefficient= 0.009 (-0.006 – 0.024); p>0.251], and gender [coefficient= -0.003 (-0.008 – 0.001); p = 0.136].

The subgroup analysis of HIIT versus moderate intensity CT showed no significant effect of affective response during exercise [-0.27 (-0.98 – 0.42); p = 0.441]. Egger's regression did not indicate publication bias (intercept = - 6.61, SE = 5.69, p = 0.27). High heterogeneity was also found for this analysis (I^2= 91.33) and there was no significant *Kendall's rank* correlation coefficient (τ = -0.13, p = 0.59). Similarly, for the subgroup analysis of HIIT versus high intensity CT on affective responses during exercise there was no significant effect [-0.15 (-1.08 – 0.78); $p = 0.755$]. Egger's regression did not indicate publication bias (intercept = -3.79, SE = 11.57, $p = 0.75$). Heterogeneity was found to be high ($I^2 = 94.06$), but there was no significant *Kendall's rank* correlation coefficient ($\tau = -0.25$, $p = 0.34$).

Acute HIIT vs. CT Post-Exercise. We found a significant moderate effect of affective response post-exercise favoring CT, compared to HIIT [-0.61 (-1.11 – -0.10); $p = 0.018$] (Supplementary Figure, SF2). Again, heterogeneity among participant responses was high ($I^2 = 92.90$). We found a ssignificant Kendall's rank correlation coefficient for this analysis ($\tau = -0.31$, $p = 0.02$), indicating significant funnel plot asymmetry. Egger's regression indicated publication bias (intercept = - 7.21, SE = 4.21, $p = 0.05$). Trim and fill analyses changed the overall effect (ES = -0.96; 95% CI= -1.52 – -0.40) suggesting that the asymmetrical funnel plot for acute HIIT versus CT on affective responses was influenced by publication bias. The meta regression for the FS showed no significant effect for any of the covariates including age [coefficient= 0.019 (-0.002 – 0.041); $p = 0.077$], BMI [coefficient= 0.006 (-0.009 – 0.0021); $p = 0.451$], and gender [coefficient= -0.003 (-0.008 – 0.001); $p = 0.149$].

The subgroup analysis of HIIT versus moderate intensity CT revealed a significant large effect in favor of moderate intensity CT for a positive affective response post-exercise [-1.09 (-1.88 – -0.30); p = 0.006]. Egger's regression did not indicate publication bias (intercept = - 3.90, SE = 8.83, $p = 0.66$). High heterogeneity was also found for this analysis ($I^2 = 92.34$), and there was no significant Kendall's rank correlation coefficient ($\tau = -0.26$, p = 0.28) (Supplementary Figure, SF3). The meta regression for the FS showed no effect for any of the covariates including age [coefficient= -0.009 (-0.037 – 0.017); $p = 0.486$], BMI [coefficient= 0.017 (-0.037 – 0.003); $p = 0.095$], and gender [coefficient= -0.011 (-0.018 – -0.005); $p = 0.002$].

There was a small but still non-significant effect for the subgroup analysis of HIIT versus high intensity CT on affective responses post exercise [0.27 (-0.27 – 0.82); $p = 0.332$]. Egger's regression did not indicate publication bias (intercept = - 3.68, SE = 4.74, $p = 0.45$). Heterogeneity was high ($I^2 = 86.12$), and there was no significant Kendall's rank correlation coefficient ($\tau = -0.26$, $p = 0.24$).

Enjoyment Response

Acute HIIT vs. CT post-exercise. We observed a significant small effect favoring HIIT compared to CT for enjoyment post-exercise [0.31 (0.05 – 0.57); p = 0.017] (Supplementary Figure, SF4). Participant heterogeneity for enjoyment was high (I^2= 63.54). Egger's regression did not indicate publication bias (intercept = 2.37, SE = 1.46, p = 0.12). We found no significant Kendall's rank correlation coefficient (τ = 0.30, p = 0.09). The meta regression found no significant effects for the following covariates: age [coefficient= -0.004 (-0.030 – 0.021); p = 0.733], BMI [coefficient= 0.000 (-0.021 – 0.020); p = 0.950], and gender [coefficient= -0.009 (-0.016 – -0.002); p = 0.009].

For the subgroup analysis we found no significant effects for HIIT versus moderate intensity CT on enjoyment [0.36 (-0.10 – 0.84); p = 0.130]. Egger's regression did not indicate publication bias (intercept = 2.95, SE = 2.01, p = 0.18). This subgroup analysis presented with high heterogeneity (I^2 = 76.6) and no significant Kendall's rank correlation coefficient (τ = 0.25, p = 0.34). There were too few studies (n=3) to run this sub-analysis.

Chronic Studies

A total three chronic studies were included in this review, representing 79 participants (72% women). A further description of these participant characteristics is provided in Table 2. All three studies examined the effects of HIIT versus CT using the PACES (Heisz et al., 2016; Kong et al., 2016; Vella et al., 2017). Due to the low number of these studies (<5) no meta-analysis was conducted.

Kong et al., (2016) compared HIIT to moderate to vigorous intensity CT (five week intervention) in a group of sedentary adults with obesity and found stronger positive affective responses to be associated with HIIT (p <0.05). Cardiorespiratory fitness improvement was similar for both groups, but HIIT was a more time-efficient strategy. Heisz et al., (2016) evaluated sedentary adults who undertook six weeks of either HIIT or moderate intensity CT, and found that HIIT compared to moderate intensity CT had more positive affect at week 4, and was associated with significantly more positive affect at week 5 (p <0.05) and 6 (p <0.01). There were no differences in reported enjoyment between HIIT and moderate intensity CT between weeks 1 to 3. Changes in enjoyment were predicted by changes in workload ($p < 0.05$) but not by aerobic fitness (VO_2 peak), suggesting that workload predicted changes in exercise favouring strength adaptations may be a major contributor to enjoyment with exercise training. Finally, Vella et al. (2017) compared three weeks of either HIIT or moderate intensity CT in seventeen sedentary adults who were either overweight or obese. Mean enjoyment across the intervention was high for both groups ($p > 0.05$), however enjoyment did not change over time, nor were there any differences in enjoyment observed between groups. Therefore, two of the three chronic studies showed that HIIT resulted in greater enjoyment compared to CT.

[Insert Table 2. Descriptions of Chronic Studies.]

Study Quality Analysis

Using the TESTEX scale, the mean total score for acute study quality was 2.5 (median 2.0) of a possible 5 points, and the mean total score for reporting was 3.9 (median 4.0) of a possible 10 points (see Supplementary Table, ST1). The mean overall score out of a possible 15 points (5 points for study quality and 10 points for reporting) was 6.4 (median 6.0). Overall, study quality and reporting were considered a moderate level, acceptable for all studies achieving this threshold. Most studies met the following criteria: (a) randomization specified; (b) groups similar at baseline; (c) between-group statistical comparisons reported; (d) point measures and measures of variability for all reported outcome measures; and (e) exercise volume and energy expenditure. Most studies did not meet the following criteria: (a) eligibility criteria specified, (b) allocation concealed, and (c) blinding of assessor. Regarding the few chronic studies, the mean score for study quality was 3.7 (median 3.0) of 5 points and the mean total score for reporting was 5.7 (median 6.0) of 10 points (see Supplementary Table ST2), while the mean overall score was 9.3 (median 9.0) (5 points for study quality and 10 points for reporting).

Discussion

In this systematic review with meta-analysis and meta-regression we examined the research literature on the acute and chronic effects of exercise on affective and enjoyment responses in healthy adults. This review indicated a greater positive affective response post-exercise for CT compared to HIIT. In particular, a greater positive affective response appeared to occur following acute exercise of moderate intensity CT compared to HIIT. In contrast, enjoyment measured post-exercise was greater following acute HIIT compared to CT.

Based on a small number of studies of chronic exercise, enjoyment seemed to progressively increase following HIIT compared to CT, although no meta-analysis could be performed. Studies were methodologically sound (categorized as "moderate"); however, there was high heterogeneity among respondents, and publication bias against publishing non-significant findings, while evident, did not appear to influence the results of the meta-analyses regarding effect sizes.

Affective responses measured with the FS (during and post-exercise) (Hardy & Rejeski, 1989) assessed how respondents were feeling on a bipolar scale from very bad (-5) to very good (+5). Most studies in this meta-analysis reported a positive effect of exercise on affective responses measured post-exercise, but this might be expected in light of classic opponent process theory which predicts a rebound effect after a negative stimulus (Solomon, 1980). Therefore, it is important to mention that both types of acute exercise (CT and HIIT) were associated with this positive affective response. Moreover, our meta-analysis showed a positive effect of acute exercise on affective response measured post exercise. However, only moderate, and not high intensity, CT was found to be more pleasurable compared to HIIT post-exercise.

Although HIIT and moderate CT protocols have been shown to improve cardiorespiratory fitness (Jung et al., 2020; Martland et al., 2020), cardiovascular and brain health (Myers et al., 2015; Zhu et al., 2015), these benefits have been associated with long-term engagement in exercise programs (Pedersen & Saltin, 2015). Having a greater positive experience during or post exercise may be important for improving adherence to exercise programs. This idea is largely based on hedonic theory which holds that individuals are likely to repeat experiences that make them feel good (Kahneman et al., 1999). During exercise, if a novice trainer experiences high levels of displeasure, discomfort, pain or a feeling of exhaustion the chances of them repeating the activity or long-term adherence is reduced (Ekkekakis et al., 2000). For these reasons, a robust body of evidence has shown that the affective response to exercise should be considered when prescribing exercise intensity in order to ensure each individual feels good enough to facilitate future exercise (Ekkekakis et al., 2008; Rhodes & Kates, 2015). Some evidence has suggested that the affective or pleasure response during, as compared to post-exercise, is of greater importance to exercise adherence (Ekkekakis & Brand, 2019; Williams et al., 2016). Thus, affective responses during exercise may be particularly predictive of future exercise participation (Kwan & Bryan, 2010; Schneider et al., 2009; Williams, 2008). On the other hand, it is not clear what effect post exercise perceptions may have on future exercise behavior (Rhodes & Kates, 2015; Williams et al., 2016).

The present meta-analysis indicated that high intensity exercise may be associated with a less positive affective response (when measured post-exercise) than moderate continuous training, regardless of age, BMI and gender. Thus, CT may improve the rate of adherence to physical exercise more than HIIT (Ekkekakis & Lind, 2006; Elsangedy et al., 2018). Our meta-analysis showed a small significant positive effect of enjoyment measured post-exercise favoring HIIT over moderate CT. For the sub-analysis HIIT vs Moderate Intensity Continuous Training (MICT) and HIIT vs High Intensity Continuous Training (HICT), we found no significant difference. Interestingly, across this meta-analysis, we also found no effect from participant gender, despite a prior report that men and women have different affective responses that may be attributable to their different thermoregulation and possibly the menstrual cycle (Rocheleau et al., 2004). Our finding of an enjoyment advantage for HIIT, when measured post-exercise, may be explained by post-exercise reflections or comparisons with expectations in participant involvement in physical activity. Arguably, high intensity exercise has the ability to promote a sense of accomplishment and competence contributing to enjoyment (Burn & Niven, 2019), perhaps related to strategies with HIIT to optimize enjoyment responses and improve the exercise experience. In addition, some motivational factors were evident. Generally, a preference of intense exercise may be related to its contribution to enhancing the efficiency of achieving personal health goals such as changes in body composition (e.g., decreased fat mass and increased lean mass). Otherwise, in choosing exercise of a moderate or light intensity, if there is a noticeable delay of benefits for health and fitness, there may be frustration and possibly dropout (Ekkekakis et al., 2005).

Fitness and health benefits from performing resistance training (RT) have been well established (Cavarretta et al., 2018; Gordon et al., 2017; Grgic et al., 2019), with 2-3 sessions per week recommended (Garber et al., 2011). Therefore, it is imperative to examine factors that may influence adults' adherence to RT. A previous systematic review found numerous factors were associated with participation in RT, some of which included education, perceived health status, quality of life, affective judgements, self-efficacy, intention, and self-regulation behaviors (Rhodes et al., 2017). The authors concluded that when promoting RT, there should be focus on creating an enjoyable experience along with self-efficacy, planning and self-monitoring behaviors. Therefore, the present study attempted to extend beyond prior findings (Rhodes et al., 2017) and was is the first systematic review of the impact of RT variables on affective and enjoyment responses. This is highly relevant, considering the dose–response relationships generally observed for key RT variables (i.e., volume, intensity, rest) for achieving fitness and health outcomes (Borde et al., 2015; Schoenfeld et al., 2017). Unfortunately, very few RT studies were identified in the present systematic review (n = 2), and this prevents any conclusions concerning the effect of RT on affective and enjoyment responses. However, the present review highlighted the need for future studies to examine how to optimize RT variables to enhance affective and enjoyment responses, in an attempt to positively influence RT adherence.

Limitations and Directions for Further Research

Limitations of the present study included the wide variety of exercise application methods within the category of HIIT, perhaps interfering with an attempt to summarize them collectively. Second, most studies had small participant sample sizes with high heterogeneity, perhaps influencing these meta-analytic results. For instance, greater effect sizes are generally reported in smaller as compared to larger studies, and this may result in reporting bias (Sterne et al., 2000). Additionally, biases can occur from methodological flaws in studies with small sample sizes or may result from differences in the underlying effects of studies with smaller and larger sample sizes (Kjaergard et al., 2001; Turner et al., 2013). Finally, there were few studies that examined the effects of chronic exercise, limiting the ability to fully explore responses to long-term exercise. Future research on this topic should carefully consider (a) participant sample size, (b) length of training, (c) what exercise characteristics differentiate perceived pleasure from perceived enjoyment, and (d) whether pleasure or enjoyment is more important for exercise adherence.

Promoting physical exercise to the general population is a priority, however 63% of exercisers abandon new activities within 12 weeks (Sperandei et al., 2016). Therefore, the general population has not been engaging in physical exercise programs that in the long term can provide improvement to general health. Thus, different exercise programs are required to optimize affective and pleasure responses, both during and after exercise. Our results suggest that exercise selection and intensity may play important roles towards developing an exercise habit for people with a limited exercise history. Therefore, exercise programs should be individualized to match the fitness levels and goals of the individual to assist with adherence to an exercise program.

Conclusion

The present review of past research found that a greater positive affective response post-exercise occurs following CT compared to HIIT. This finding was present regardless of the influence of age, BMI and gender. Moderate, and not high intensity CT, appeared to promote a more positive affective response post-exercise, compared to HIIT. However, enjoyment tended to be greater following HIIT compared to CT. The disparity between the affective and enjoyment responses following CT and HIIT may be due to an interaction between effort, discomfort, and task accomplishment.

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Table 1. Descriptions of Acute Studies

Author	Participants (n)	BMI	VO2	Age	Women %	Condition	Intensity Variable	Configuration	Type	Outcome
Bartlett et al., 2011	8	24.2	57	25	-	HIIT	%Vo2peak	7min-70% + 6x (3min-90%)/(3min-50%) + 7min-70%	Treadmill	PACES
						MCT	%Vo2peak	50min - 70%		
Oliveira et al., 2013	15	24.2	47.9	24	0	HIIT	%Vo2peak	6.6x (120s-100%)/(57s-0%)	Treadmill	FS
						MCT	% RCP	20min - 85%		
Jung et al., 2014	44	24.1	36.3	33.1	63	HIIT	%Wpeak	10x (60s-100%)/(60s-20%)	Cycle Ergometer	PACES and FS
						CVI	%Wpeak	20min - 80%		
						CMI	%Wpeak	40min - 80%		
Martinez et al., 2015	20	29	28.5	22	45	HIIT30-s	%Vo2peak	24x (30s-SI)/	Cycle Ergometer	PACES and FS
						HIIT60-s	%Vo2peak	12x (60s-SI)/		
						HIIT120-s	%Vo2peak	6x (120s-SI)/		
						HC	%Vo2peak	20min - HC		
Kilpatrick et al., 2015	24	23	41	22	50	HI	% VT	10x (60s-0% VT)/ 60s -< 20% VT	Cycle Ergometer	FS

						SI	% VT	10x (60s-20% > VT)/ (60s -at %VO2Peak)		
						HC	% VT	20min - < 20% VT		
						MC	% VT	20min – at %VT		
Thum et al., 2017	12	23.1	41.4	29.5	35	HIIT	%Wpeak	8x (60s-85%)/(60s-25%)	Cycle Ergometer	PACES and FS
						MCT	%Wpeak	20min - 45%		
Decker & Ekkekakis, 2017	24	34.9	19.5	39.2	100	HIIT	% VT	3min-20W + 4x (3min-115%)/(2min-85%) + 5min-20W	Cycle Ergometer	PACES and FS
						MCT	% VT	25min 85%		
Hoekstra et al., 2017	12	-	35.5	22.5	-	HIIT	%Wpeak	10x (60s - 200%) / (60s - 40%) 20 min	Cycle Ergometer	PACES and FS
						MCT	%Wpeak	30 min - 80%		
Poon et al., 2018	12	23.5	44.9	24.3	-	HIIT	%Vo2peak	10x (60s - 100%) / (60s 50%)	Treadmill	FS
	12	23.4	39.5	46.8	-	MICE	%Vo2peak	40 min - 65%		
						VICE	%Vo2peak	20 min - 80%		

Stork et al., 2018	30	22.4	31.3	21.2	60	HIIT	All out	10x (60s -70%)/ 60s - rest	Cycle Ergometer	PACES and FS
						SIT	All out	3x20-s / 2 min - rest		
						MCT	%Wpeak	50 min - 35%		
Niven et al., 2018	20	-	48.2	25.7	-	HIIT	All out	10 × 6 s - all out / 60s - rest	Cycle Ergometer	FS
						MCT	% VT	30 min - 85%		
Olney et al., 2018	19	23.1	40.3	24	48	HIIT HIGH	%Wpeak	8x (60s-85%)/75s - 20%)	Cycle Ergometer	PACES and FS
						HIIT LOW	%Wpeak	6x (2min 70%)/60s - 20%)		
						SIT	%Wpeak	6x (“all-out” 20s - 140%Wpeak) - (140s at 20%Wpeak)		
						MCT	%Wpeak	25 min - 40%		
Kriel et al., 2019	11	-	40.7	23	-	SIT	All out	4 x 30 s - all out / 120s - rest	Cycle Ergometer	PACES
						MCT	%Weak	38 min - 50%		
Sagelv et al., 2019	7	23.9	52.1	23.4	60	HIIT	HRmax	4x 4 min - >90% / 4x 3 min - 70%	Treadmill	PACES

						MCT	HRmax	45 min - 70%		
Alicea et al., 2020	12	-	44.7	22.3	100	HIIT	%Vo2peak	14 x (60s - 100%) / (60s - 50%)	Treadmill	FS
						MCT	%Vo2peak	28 min - 80%		
Portugal et al., 2015	16	-	-	25.1	0	RT	80% 1RM (vgs)	3 x (8 rep) – 20 min	RE	FS
							40% 1RM (lgt)	3 x (8 rep) – 20 min		
Focht et al., 2015	20	-	-	23.1	100	RT	80% 1RM (vgs)	3 x (10 rep) - 45 min	RE	FS
							40% 1RM (lgt)	3 x (10 rep) - 45 min		

Note: HIIT: High intensity interval training; HI: Heavy intensity; SI: Severe intensity; MCT: Moderate continuous training; W: watts; CVI: continuous vigorous intensity; CMI: continuous moderate intensity; HC: heavy continuous; RCP: respiratory compensation point; %VO2peak: Percentage peak of oxygen consumption; VT: ventilatory threshold; SIT: Sprint interval training; MICE: Moderate intensity continuous exercise; VICE: Vigorous intensity continuous exercise; HRmax: Heart rate maximal; HRR: Heart rate reserve; RM: Repetition maximal; HIIT#: High impact intensity training; VGS: Vigorous; LGT: Light; RT: Resistance Training; RE: Resistance Exercise; PACES: Physical Activity Enjoyment Scale; FS: Feeling Scale.

Table 2. Descriptions of Chronic Studies

Author	Participants (n)	BMI	VO2	Age	Women %	Training Frequency and Duration	Condition	Intensity Variable	Configuration	Type	Outcome
Heisz et al., 2016	17 (T)	21.1 ± 0.5	31.8 ± 1.6	21.4 ± 2.9	70	3/wk, 6 wk	HIIT	HRmax	10 x (60s - 95%) / (30% Wpeak)	Cycle ergometer	FS
	19 (T)	23.0 ± 1.0	30.2 ± 1.5	20.4 ± 1.3	68.5		MCT	HRmax	27 min – 70-75%		
Kong et al., 2016	13 (S)	25.8 ± 2.6	32.0 ± 6.6	21.5 ± 4.0	100	3/wk, 5 wk	HIIT	%Vo2peak	60 x (8s – 80%) / (12s – 50w)	Cycle ergometer	FS
	13 (S)	25.5 ± 2.1	32.0 ± 5.0	20.5 ± 1.9	100		MVCT	%Vo2peak	40 min - 71%		
Vella et al., 2017	8 (S)	29.9 ± 29.9	34.8 ± 2.9	23.1 ± 6.6	40	4/wk, 5 wk	HIIT	HRR	10 x (60s – 75-80%) / (60s 35-40%)	Cycle ergometer/ Treadmil	FS
	9 (S)	33.1 ± 6.0	34.5 ± 2.1	28.9 ± 8.1	40		MVCT	HRR	20 min – 55-59%		

Note: HIIT: High intensity interval training; MCT: Moderate continuous training; MVCT: Moderate to vigorous continuous training; HRmax: Heart rate maximal; HRR: Heart rate reserve; %VO2peak: Percentage peak of oxygen consumption. T = trained; S = sedentary; FS: Feeling Scale; WK: weak.