Article

Perceptual and Motor Skills
2022, Vol. 129(3) 767–786

DOI: 10.1177/00315125221083180
journals.sagepub.com/home/pms
SAGE

Burpee Interval Training Is Associated With a More Favorable Affective Valence and Psychological Response Than Traditional High Intensity Exercise

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Abstract

Acute psychological responses to physical activity may help explain long-term adherence to it. Thus, we compared acute psychological responses to different exercise protocols with identical durations. Eighteen moderately active young adults [M_{age} = 23, *SD* = 3 years; MVO_{2max} (maximum oxygen consumption) = 42.8, *SD* = 4.3 mL·kg^{-1}·min^{-1}; M_{BMI} (body mass index) = 24, *SD* = 2 kg·m^{-2}] completed three low-volume exercise sessions in a crossover research design: (a) sprint interval training (SIT), (b) burpee interval training (BIT) requiring 10 × 5 second efforts with 35 seconds of passive recovery, and (c) a single bout of vigorous intensity continuous training (VICT) requiring 6 minutes and 5 seconds of running at ~85% of peak heart rate (HR_{peak}). We assessed participants' ratings of perceived exertion (RPE), affective valence, enjoyment, intention, preference, and self-reported recovery and wellness

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before, during, and after each session. BIT was associated with significantly greater enjoyment, preference, and exercise intention (at 5 × week) than VICT ($p \leq .05$). SIT elicited greater RPE ($M = 5.38$, $SD = 2.00$) than both BIT ($M = 2.88$, $SD = 1.23$) and VICT ($M = 3.55$, $SD = 1.38$) ($p \leq .05$), and we observed a higher increase in RPE over time with SIT versus BIT ($p = .019$). For affective valence, SIT ($M = 0.55$, $SD = 2.12$) elicited a more aversive response than both BIT ($M = 2.55$, $SD = 1.09$) and VICT ($M = 1.94$, $SD = 1.51$) ($p \leq .05$), and there was a higher increase in this aversive response to SIT over time ($p < .05$). Forty-eight-hour postexercise session muscle soreness was significantly lower with VICT than with BIT ($p = .03$). Overall, BIT was associated with more positive psychological responses than SIT and VICT.

Keywords

sprint interval training, high intensity functional training, continuous training, psychological responses

Introduction

Physical inactivity is a principal contributing factor to non-communicable diseases worldwide, as it has been associated with enhanced risks of type 2 diabetes, coronary heart disease, and some cancers (Lee et al., 2012). Thus, empirical research, to better motivate people toward physical activity (PA), may help develop evidence-based interventions that mitigate a sedentary lifestyle (Bauman et al., 2012). Prior research has shown that psychological variables are important correlates of adult PA (Trost et al., 2002). In fact, perceived self-efficacy and enjoyment from exercise are strong predictors of further PA participation (Trost et al., 2002; Bauman et al., 2012), and affective responses such as pleasure/displeasure are related to PA adherence (Rhodes & Kates, 2015). Overall, research on ways to optimize psychological responses to PA experiences can positively impact health promotion initiatives and public health outcomes (Bauman et al., 2012).

While 150–300 minutes/week of moderate intensity continuous training (MICT) has been consistently recommended to increase cardiorespiratory fitness and overall health status (Bull et al., 2020), most adults worldwide have reported insufficient available time for PA to be the primary barrier to increased PA (Trost et al., 2002), leading to both majority non-compliance with PA guidelines (Bull et al., 2020) and calls for more time-efficient exercise regimens. In the last two decades, interval training has gained popularity as an exercise alternative, as it improves cardiometabolic health with a lower exercise volume than MICT (Weston et al., 2014; Gibala & Little, 2020). Interval training can be implemented using repeated submaximal efforts [high intensity interval training (HIIT) at 80–100% of maximal heart rate (HR)] or "all-out" efforts [sprint interval training (SIT) at a workload greater than maximum oxygen consumption (VO_{2max})] (Weston et al., 2014).

A traditional SIT regimen of 4–6 × 30-second sprints requires substantial anaerobic metabolism (Yamagishi & Babraj, 2017) that can lead to hyperventilation and nausea, making this regimen impractical for non-athletic adults. Moreover, studies have shown that exercisers' affective valence significantly declined during traditional SIT, even falling to values perceived as "bad" (Townsend et al., 2017). SIT also promotes higher stress and tension than MICT in sedentary adults (Saanijoki et al., 2015). Nevertheless, shorter versus longer duration SIT regimens have elicited significantly greater exerciser enjoyment (Astorino, Clausen et al., 2020) and greater intentions to engage in future exercise (Townsend et al., 2017; Haines et al., 2020). Insufficiently active participants have preferred shorter (6-second) sprints to other interval training regimens of longer interval duration (Marques et al., 2020). A recent study observed that 5-second bouts were associated with lower neuromuscular fatigue, compared to 20-second bouts (Benítez-Flores et al., 2018), and affective valence was not different in these 5-second bouts than with vigorous intensity continuous training (VICT) (Benítez-Flores et al., 2021). Overall, shorter bouts of SIT lead to less aversive exerciser experiences and may be more easily tolerated over the long term by the average adult.

Another key consideration for bridging the gap between laboratory and real-world experiences in exercise motivation research is for investigators to implement protocols that are sustainable outside of a laboratory environment (Gray et al., 2016). In this regard, high intensity functional training (HIFT) is feasible, as it can be performed at home and in the community without equipment, making it more accessible than lab-based protocols (Gray et al., 2016). HIFT involves multi-joint movements that combine strength and resistance exercise (Feito et al., 2018). Prior results in adults of various fitness levels showed that long-term HIFT significantly improved VO_{2max} and reduced fat mass (McRae et al., 2012; Feito et al., 2018). In addition, this regimen has promoted significant increases in neuromuscular function, in contrast to rowing HIIT or walking MICT (Buckley et al., 2015; Wilke et al., 2019).

Gist et al. (2014) showed that a HIFT protocol that included burpees induced similar increases in HR and a lower rating of perceived exertion (RPE) than SIT. In active individuals, Heinrich et al. (2020) reported that HIFT led to similar affective valence compared with MICT and HIIT. Other investigators found greater motivation, enjoyment and intention after chronic HIFT versus MICT in young adults (Heinrich et al., 2014; Wilke et al., 2019). However, to the best of our knowledge, there are no data comparing exercisers' acute perceptual responses to HIFT and SIT using shorter (i.e., ≤10-second) "all-out" efforts with VICT of the same session duration. Prior studies frequently used MICT as the comparison regimen, which did not provide a thorough understanding of the psychological effects of extremely low-volume SIT protocols.

As women have lower VO_{2max} and maximal anaerobic capacity than men (Ansdell et al., 2020), and lower blood lactate concentration has been reported in response to HIIT and SIT (Astorino & Sheard, 2019), perceptual changes to SIT may differ by gender. Evidence to date is not clear in this regard (Astorino & Sheard, 2019; Marques et al., 2020; Olney et al., 2018). Women have been found to be typically less active than men, and they have tended to accumulate a lower amount of vigorous PA than men

(Guthold et al., 2018). Research that compares the perceptual responses of women and men to identical vigorous exercise paradigms would be important to improving women's PA patterns.

With this background, our aim in this study was to compare women and men's acute psychological responses to three different field-based exercise protocols with identical total durations. We hypothesized that low-volume HIFT and SIT would promote significantly greater enjoyment, preference, and future exercise intention than would VICT.

Method

Study Design

We adopted a randomized crossover research design consisting of an initial session to measure various physical and morphological variables followed by three time-matched training sessions [SIT, VICT, and burpee interval training (BIT)]. Our design was intended to integrate into daily life both the exercise routine and simple psychometrically supported questionnaires on which participants might self-report their psychological responses to exercise. All procedures took place on a public 400-m outdoor public track. Exercise sessions were separated by 48–72 hours and took place from 8:00 a.m. to 1:00 p.m. with similar environmental conditions: (a) temperature of 15–22°C temperature; (b) humidity at 64–76%; and (c) wind velocity of 5–15 km·h^{-1}. We monitored participants' dietary intake over a 24-h period prior to the first training session (using participants' recall of theirs), and participants were requested to replicate the same food intake before all training sessions. We obtained self-report data for our variables of interest (perceptual and psychological responses) during and after each session (Figure 1). The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of Higher Institute of Physical Education, University of the Republic, Uruguay (2/2020 and date of final approval 4 November 2020). Prior to participant involvement in the study, we fully explained potential risks and benefits and procured informed consent from all participants.

Participants

Twenty-two volunteers contacted the primary investigator after a publicity campaign between October and December of 2020 in our Institute of Physical Education. Eighteen (nine women and nine men) healthy, young, and moderately active adults completed this study. Their demographic characteristics are presented in Table 1. The inclusion criteria for participation were (a) aged 18–35 years old; (b) free of any musculoskeletal injury or onset of cardiometabolic disease; (c) not consuming any nutritional supplement or tobacco products; and (d) exhibiting a VO_{2max} ≤55 mL·kg^{-1}·min^{-1}. Participants were instructed to abstain from exercise

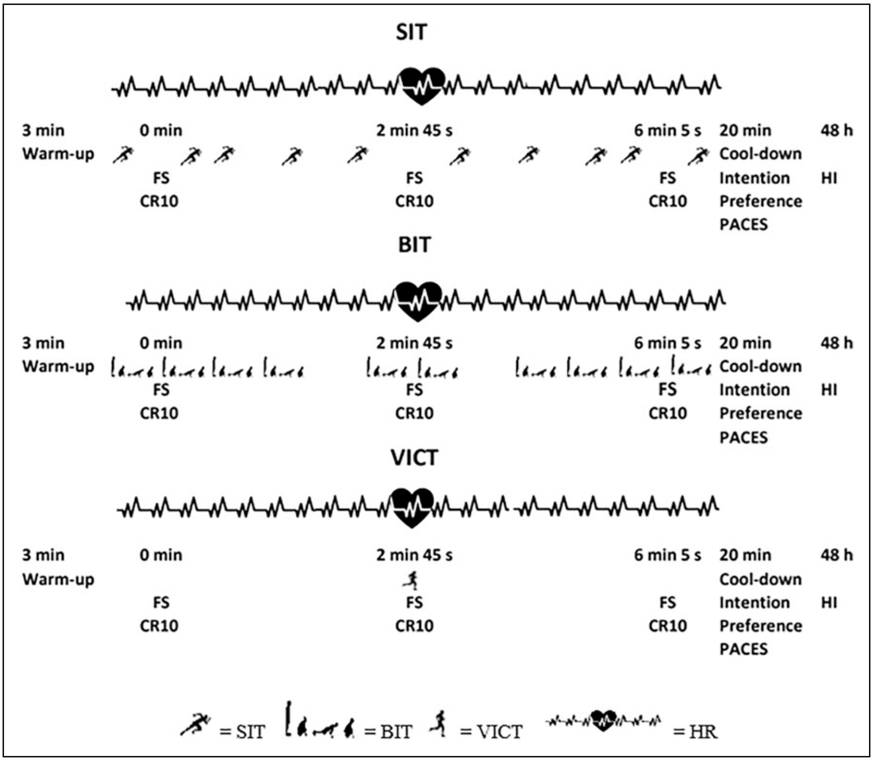

Figure 1. Overview of the Study Design. PACES = Physical Activity Enjoyment Scale; FS = feeling scale; HI = Hooper Index; CR10 = CR10 rating of perceived exertion; SIT = sprint interval training; BIT = burpee interval training; VICT = vigorous intensity continuous training.

during the experimental procedures (i.e., for 10 days), abstain from consuming alcohol for 48 h prior to exercise sessions, and to avoid consumption of stimulants (e.g., mate and coffee) in the mornings before exercising. Additionally, participants were asked not to change their usual lifestyle habits (e.g., work, sleep, and food) throughout the study.

Procedures

Baseline Session. Initially, we recorded the following anthropometric measurements: height (cm), body mass (kg), body fat (%) and body skeletal muscle mass (%), utilizing a digital body composition bioimpedance sensor HBF-514C, OMRON (Kyoto, Japan). Subsequently, we used the shuttle run test (SRT) to estimate cardiorespiratory fitness. This test has been found to be a valid means of estimating VO_{2max} (Léger & Gadoury, 1989). It consists of running as long as possible between two lines separated by 20 m. The pace was set by a sound signal, initially at 8.5 km·h^{-1} and increasing by 0.5 km·h^{-1}

Table 1. Participants' Physical Characteristics.

Variables	Men	Women
Age (y)	25.2 ± 4.2*	20.9 ± 1.6
Gender (men/women)	9	9
Body mass (kg)	73.9 ± 6.7*	57.4 ± 4.1
Height (cm)	170.6 ± 3.2*	159.7 ± 4.6
BMI ($kg \cdot m^{-2}$)	25.4 ± 2.1*	22.6 ± 1.7
Body fat (%)	22.4 ± 3.8*	33.9 ± 5.2
Muscle mass (%)	39.0 ± 2.1*	27.4 ± 2.1
Visceral fat (%)	7.8 ± 1.9*	3.7 ± 0.7
VO_{2max}($ml \cdot kg^{-1} \cdot min^{-1}$)	47.3 ± 4.6*	38.3 ± 4.1
HR_{peak}(b·min-1)	196.4 ± 4.5	194.0 ± 7.0

Data are mean±SD. BMI: body mass index; HR_{peak}: peak heart rate; VO_{2max}: maximum oxygen consumption.
* Difference of men versus women.

every minute. When participants failed to cover the 20-m distance within two consecutive sound signal repetitions, the test was concluded. The VO_{2max} was then estimated, using the formula proposed by Léger and Gadoury (1989): [VO_{2max} (6 × maximal aerobic speed) – 27.4]. Peak heart rate (HR_{peak}) was assessed using chest straps through a telemetric system Firstbeat Technologies Ltd. (Jyväskylä, Finland). All participants were verbally encouraged to exercise to exhaustion. Ten-minutes after this test, participants were familiarized with the questionnaires and with the three regimens: SIT (1–2 sprints of 5 s "all-out"), BIT (1–2 repetitions of 5 s "all-out"), and 1–2 minutes of VICT at 85% HR_{peak}.

Experimental Sessions. Exercise sessions began with a 3-minute warm-up of running at a self-selected pace. Total duration of each session was 9 minutes 5 seconds; total exercise time for each modality was 6 minutes 5 seconds. Sprint interval training and BIT consisted of 10 × 5-second "all-out" efforts interspersed with 35 seconds of passive recovery, while VICT required 6 minutes 5 seconds, of sustained running at ∼85% HR_{peak}. Furthermore, SIT and BIT were equated in relation to the type of stimulus (multi-joint) and work/recovery ratio. During SIT, participants were instructed to run as fast as they could, and after a brief recovery, participants were asked to run in the opposite direction. During BIT, participants performed modified burpees following an "all-out" style as previously implemented by Gist et al. (2014). The structure of both regimens was controlled by a mobile application that provided audible alerts for each phase of work and recovery. VICT was prescribed at a workload equal to 85% HR_{peak}. In order to comply with this, HR was monitored in real-time, and feedback was provided so that the participants maintained the target intensity. This internal load was chosen for VICT in order to equalize it with SIT since recent prior research has shown that the HR is sustained at 85% of the HR_{peak} during 5-second "all-out" bouts (Benítez-Flores et al., 2021). Internal load of the sessions was determined using HR data collected with Firstbeat Sports software version 4.7.3.1, Firstbeat Technologies Ltd. (Jyväskylä, Finland). During all regimens, participants were verbally encouraged to continue exercising at the desired intensity until the end of the session.

Psychological Variables

Rating of Perceived Exertion. We assessed participants' ratings of perceived exertion (RPE) (Borg, 1998) using the CR10 scale which was designed to estimate the intensity of exercise and is strongly correlated with HR (Foster et al., 2001). This instrument has shown validity and good reliability in several physical exercises for men and women (Haddad et al., 2017). This scale is graduated numerically from 0 to 10, with 0–2 ratings deemed easy effort, 3–6 ratings moderate to hard effort, and 7–10 ratings hard to maximum effort (Foster et al., 2001). The CR10 was administered pre-exercise, half-way through the exercise session duration (50% session), and immediately postexercise.

Affective Valence. We used the Feeling Scale (FS) to quantify the participants' general affective valence and assess emotional aspects of the exercise experience, focusing on the pleasure–displeasure dichotomy (Hardy & Rejeski, 1989). This scale was validated with physically active individuals (Alves et al., 2019). The FS contains values from +5 to −5 (+5 equal "very good" and −5 represents "very bad"). Each participant completed this instrument pre-exercise, half-way through their session (50% session), and immediately postexercise.

Enjoyment. Participant enjoyment was examined using a valid and reliable Spanish short version of the Physical Activity Enjoyment Scale (PACES) (Fernández García et al., 2008). The instrument is an adaptation of the original PACES scale that showed good reliability and validity (Kendzierski & DeCarlo, 1991). This scale presents six items with descriptive phrases in relation to the sentence "Tell us how you feel about the physical activity you have done," in a format of bipolar affirmations (e.g., "I am bored" or" I am interested"). Participants rated the degree to which they agreed with the statement, with the minimum value 1 and the maximum value 7. We obtained a total score for responses to the scale, by summing scores on all its items (of note, items 1, 3, 4, and 6 were inversely scored). This scale was administered 20 minutes postexercise for each session.

Exercise Intentions. We used the Intention Scale (Jung et al., 2014) to examine the participants' intentions to engage in the training regimens in the future at rates of three times or five times a week (intention 3 × week or intention 5 × week) over the next month. Specifically, participants were asked "Please rate the extent to which you agree with the following statements": (a) "I intend to engage in the type of exercise I performed today at least 3 times per week during the next month"; (b) "I intend to engage in the type of exercise I performed today at least 5 times per week during the next month." The scores were registered using a Likert-type 7-point scale, ranging from 1 (very unlikely) to 7 (very probable). This scale was administered 20 minutes postexercise for each session.

Preference. The Preference Scale was used to quantify participant's inclination for each protocol (Jung et al., 2014). First, they were asked, "If it were entirely up to you, which type of exercise would you choose to do?" Three responses were available based on the three exercise conditions of SIT, BIT, and VICT. Using a three-item measure, participants also ranked their fondness of the different protocols performed, with the instruction: "Please rank your fondness for each type of workout you performed." The scores were registered using a Likert-type 7-point scale, ranging from 1 (very much dislike), 4 (neutral), 7 (extremely like). This scale was administered 20 minutes postexercise for each condition.

Recovery and Wellness. The Hooper Index (HI) is a valid field technique used to assess athletes' recovery and wellness (Hooper et al., 1995). The HI is based on ratings regarding fatigue, stress level, muscle soreness, and sleep quality and scored on a 7-point Likert scale from 1 to 7, where 1 corresponds to very, very low (very, very good in the case of sleep) and 7 corresponds to very, very high (very, very bad in the case of sleep). The lower the index, the better the wellness status. This scale was administered 48 hours postexercise in all conditions.

Data Analysis

We estimated a required sample size with the following assumptive parameters, using G*Power version 3.1.9.7 (Faul et al., 2009) (Düsseldorf University, Düsseldorf, Germany): (a) F test for one group and three measurements; (b) effect size of 0.35; (c) alpha-value of 0.05; (d) statistical power of 0.80; and (e) correlations between measures of 0.5. The calculated estimated required sample size was 15, which is lower than our actual sample size of 18.

We used the Shapiro–Wilk test to assess normality of data distributions for all variables. Data are reported as *M*s and *SD*s and 95% confidence intervals (CI). We conducted baseline comparisons of men and women on selected variables using unpaired two-tailed *t* tests. Generalized estimating equation (GEE) and Bonferroni post hoc testing were used to identify differences among conditions and time for all variables. The choice of the GEE method is justified since such a model allows the analysis of continuous outcomes, such as those used in the present study, even when the variables do not have a normal distribution and/or sphericity (Liu et al., 2009; Guimarães & Hirakata, 2012). In addition, when adopting the GEE, if there is a loss of information from an individual in the sample, it is possible to include missing data ("missing data") by regression model, a method that can help to avoid some type of bias selection (Liu et al., 2009), but this was not necessary in the present study. Furthermore, this model was used to compare delta or changed scores (pre- vs. postexercise) between conditions. Effect sizes were identified by η^2 with the following criteria: 0.02–0.13 small; 0.14–0.26: medium; and >0.26: large (Cohen, 1988). Pairwise effect sizes were identified by Cohen's d for paired data with the following explanatory criteria: 0–0.19 trivial, 0.2–0.59 small, 0.6–1.19 moderate, 1.2–1.99 large, 2.0–3.99 very large, and >4.0 nearly perfect (Cohen, 1988). All analyses were performed with the Statistical Package for the Social Sciences (SPSS, version 23.0; IBM Corp., Armonk, NY, USA). In all cases, we set the alpha level for statistical significance at $p < .05$. All graphics were made with GraphPad Prism version 6.01 (San Diego, CA, USA).

Results

Two women participants dropped out of the study for personal reasons after the first day of data collection. Additionally, one man and one woman dropped out of the study due to injuries (external ankle sprain and rectus femoris tear) experienced during the SIT protocol. One participant had a feeling of discomfort and intention to vomit throughout the SIT session but managed to complete it, leaving 18 participants who completed the study and whose data were entered into analyses.

Differences in Internal Load

The participants' $\%HR_{peak}$ was significantly different ($p < .001$; $\eta^2 = 0.68$) across the exercise conditions (SIT $M = 87.8$, $SD = 4.3$; BIT $M = 77.1$, $SD = 7.0$; VICT $M = 85.3$, $SD = 4.6$), and, more specifically, it was lower in BIT than in both SIT and VICT ($p < .001$), but there was no significant difference in $\%HR_{peak}$ between SIT and VICT ($p > .05$).

Differences in Rating of Perceived Exertion and Affective Valence

For both the RPE and FS scales, data showed significant main effects of condition ($p < .001$) and time ($p < .001$), but there was no gender effect (CR10 $p = .69$; FS $p = .85$). There was a significant condition × time interaction for both variables ($p < .001$; see Table 2). Post hoc testing showed that CR10 significantly increased from pretest to mid-session to posttest in SIT, BIT, and VICT (all $p<0.001$ and all d's >1.03; except in BIT from mid to post-session: $p = .015$; d = .54). FS significantly declined from pretest to mid-session to posttest during SIT ($p < .001$); but, in response to BIT, the only reduction occurred from mid-session to post-session ($p = .024$). For VICT, the decreases were noted from pre- and mid-session to post-session ($p < .05$). The η^2 (overall) and Cohen's d (pairs) values in response to each condition for CR10 and FS are shown in Table 2.

For comparisons of RPE change scores over time (i.e., ΔCR10), significant differences were detected ($p = .025$; $\eta^2 = 0.13$) such that ΔCR10 was higher in SIT ($M = 3.8$, $SD = 2.5$) versus BIT ($M = 2.2$, $SD = 1.4$; $p = .019$; d = 0.78). In the case of change scores for FS, significant differences were noted ($p = .02$; $\eta^2 = 0.21$); and, in post hoc

Table 2. Changes in CR10 and Feeling Scale in Response to Sprint Interval Training, Burpee Interval Training, and Vigorous Intensity Continuous Training. Pairwise Effects Sizes (Cohen's d) Are Reported Across Time in Each Condition and Inter-Conditions in Each Time.

	SIT				BIT				VICT			
	Pre	50%	Post	Time η^2	Pre	50%	Post	Time η^2	Pre	50%	Post	Time η^2
CR10	1.55 ± 1.61	3.83 ± 1.54*	5.38 ± 2.00**	0.65	0.72 ± 1.01	2.50 ± 1.33	2.88 ± 1.23	0.65	1.00 ± 0.97	2.77 ± 1	3.55 ± 1.38	0.77
	0.75 to 2.35	3.00 to 4.60	4.39 to 6.38		0.21 to 1.22	1.83 to 3.16	2.27 to 3.50		0.51 to 1.48	2.27 to 3.27	2.88 to 4.24	
FS	3.61 ± 0.69	1.83 ± 1.29*	0.55 ± 2.12**	0.59	3.38 ± 1.50	2.88 ± 1.02^	2.55 ± 1.09	0.18	3.16 ± 2.12	2.44 ± 1.33	1.94 ± 1.51	0.28
	3.26 to 3.95	1.18 to 2.47	−0.49 to 1.61		2.64 to 4.13	2.38 to 3.39	2.01 to 3.10		2.11 to 4.22	1.77 to 3.10	1.19 to 2.69	

Cohen's d inter-times in each condition							Cohen's d inter-conditions in each time						
	CR10 SIT	FS SIT	CR10 BIT	FS BIT	CR10 VICT	FS VICT		CR10 PRE	FS PRE	CR10 50%	FS 50%	CR10 POST	FS POST
Pre vs. 50%	1.44	1.72	1.5	0.39	1.8	0.41	SIT vs BIT	0.62	0.21	0.92	0.90	1.78	1.2
	0.7 to 2.1	0.9 to 2.4	0.74 to 2.2	−0.28 to 1.04	0.99 to 2.53	−0.2 to 1.06		−0.06 to 1.2	−0.4 to 0.85	0.2 to 1.6	0.2 to 1.57	0.9 to 2.5	0.4 to 1.9
Pre vs. post	2.1	1.94	1.9	0.64	2.1	0.67	SIT vs. VICT	0.42	0.29	0.82	0.46	1.3	0.76
	1.27 to 2.9	1.1 to 2.61	1.09 to 2.66	0.05 to 1.29	1.2 to 2.9	−0,02 to 1.3		−0.2 to 1.06	−0.4 to 0.94	0.1 to 1.5	0.2 to 1.12	0.6 to 2.0	0.06 to 1.4
50% vs. post	0.87	0.73	0.29	0.31	0.7	0.35	BIT vs. VICT	0.28	0.12	0.2	0.36	0.51	0.46
	0.17 to 1.53	0.04 to 1.44	0.37 to 0.95	−0.35 to 0.96	0.04 to 1.3	−0.3 to 1.0		−0.9 to 0.38	−0.54 to 0.7	−0.8 to 0.4	−0.3 to 1.0	0.16 to 1.16	−0.2 to 1.11

Data are mean±SD and 95% CI. CR10: CR10 rating of perceived exertion; FS: feeling scale; 50%: 50% of session duration; SIT: sprint interval training; BIT: burpee interval training; VICT: vigorous intensity continuous training. * Difference of SIT versus BIT and VICT at 50% of session. ** Difference of SIT versus BIT and VICT at Post ^ Difference of SIT versus BIT at 50% of session.

analyses, ΔFS during SIT ($M = -3.1$, $SD = 2.4$) was greater than both BIT ($M = -0.8$, $SD = 1.6$; $p < .001$; d = 1.13) and VICT ($M = -1.2$, $SD = 1.6$; $p = .037$; d = 0.93).

Difference in Enjoyment, Intentions, and Preference

Figure 2 shows the differences in PACES, training intentions at rates of 3 × week, and 5 × week, and training preference in response to the three exercise conditions. Results showed higher PACES ($p = .014$; d = 0.92) and preference ($p = .041$; d = 1.0) in response to BIT than VICT. Also, an intention 5 × week was higher in response to BIT than to both SIT ($p = .036$; d = 0.66) and VICT ($p = .031$; d = 0.68). There was a gender effect for an intention 5 × week for VICT, as women expressed lower values than men ($p = .041$; d = 0.85).

Differences in Recovery and Wellness

There was no significant difference ($p > .05$) between exercise conditions for HI sleep quality ($M_{SIT} = 2.8$, $SD = 1.0$; $M_{BIT} = 2.7$, $SD = 0.8$; $M_{VICT} = 2.7$, $SD = 1.3$), fatigue ($M_{SIT} = 2.3$, $SD = 0.9$; $M_{BIT} = 2.5$, $SD = 0.9$; $M_{VICT} = 2.3$, $SD = 0.9$) or stress level ($M_{SIT} = 2.5$, $SD = 1.2$; $M_{BIT} = 2.4$, $SD = 0.9$; $M_{VICT} = 2.5$, $SD = 1.2$). However, HI muscle soreness values were lower ($p = .03$; d = 0.51) in VICT ($M = 2.1$, $SD = 0.7$) than BIT ($M = 2.7$, $SD = 1.3$) without differences with SIT ($M = 2.3$, $SD = 0.9$). Data showed a significant main effect of gender for HI fatigue in response to SIT, as women ($M = 2.6$, $SD = 0.7$) expressed higher values ($p = .034$; d = 0.31) than men ($M = 2.0$, $SD = 0.9$); and for HI sleep quality in VICT, during which women ($M = 3.2$, $SD = 1.2$) expressed higher values ($p = .016$; d = 1.07) than men ($M = 2.3$, $SD = 1.1$).

Discussion

This study compared active young adult men's and women's psychological responses to three time-matched field-based high intensity protocols. Prior data showed that longer bouts of lab-based SIT elicited near-maximal values of RPE and aversive affective valence (Townsend et al., 2017; Astorino, Clausen et al., 2020), while shorter SIT bouts yielded a less aversive response (Haines et al., 2020). Our data indicated that running-based SIT elicited a more negative perceptual response than both BIT and VICT. However, our findings partially supported our initial hypothesis that BIT (relative to VICT) would lead to a significantly higher PACES, preference, and intention (at a 5 × week frequency).

Although previous research has shown that SIT significantly increased VO_{2max}, autonomic balance and glycemic control in active and inactive adults (de Sousa et al., 2018; Gibala & Little, 2020), a session of traditional SIT has been perceived as too stressful for untrained populations (Saanijoki et al., 2015) and has typically been reported as an aversive experience (Townsend et al., 2017). Therefore, shorter sprints with a lower volume of training might attenuate fatigue (Benítez-Flores et al., 2018) and

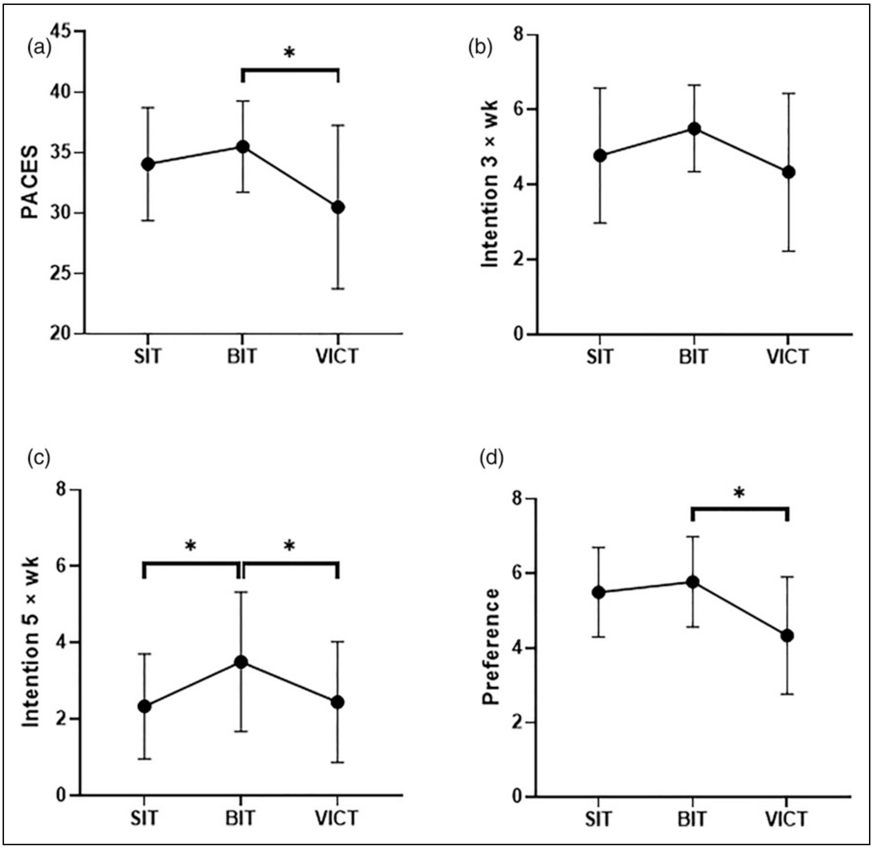

Figure 2. Comparison of Enjoyment, Intentions, and Preference Between Conditions. PACES = Physical Activity Enjoyment Scale; SIT = sprint interval training; BIT = burpee interval training; VICT = vigorous intensity continuous training; A) PACES: $p = .001$; $\eta^2 = 0.14$; B) intention 3 × week: $p = .019$; $\eta^2 = 0.07$; C) intention 5 × week: $p = .005$; $\eta^2 = 0.10$; and D) preference: $p = .006$; $\eta^2 = 0.18$. * $p \leq .05$.

induce a better emotional state (Townsend et al., 2017; Haines et al., 2020). Complementarily, current findings emphasized that different exercises with brief efforts (e.g., cycling, running, paddling, etc.) are capable of improving VO2max, aerobic, and anaerobic performances in physically active adults (Boullosa et al., 2022). Furthermore, this mode of SIT might improve adherence to PA since lack of time is a perceived barrier to engaging in regular PA (Trost et al., 2002). Our results showed significantly higher RPE and more negative reports on the FS for SIT in comparison to both BIT and VICT at mid-session and at postexercise. We also found a higher total change in each of these outcomes throughout the session (Table 2). At 50% of the SIT session, RPE significantly increased, from a mean of 1.55 to 3.83 (d = 1.44), and FS declined, from a mean of 3.61 to 1.83 (d = 1.72), indicating that only five 5-second "all-out" sprints requiring only 25 seconds of total work induced an adverse response. Additionally, 95% CI do not coincide for postexercise CR10 between SIT versus both BIT and VICT. Also of note, two participants dropped out of this study due to injuries during SIT, and one self-reported feeling an urge to vomit following SIT. This suggests that running-based sprints of extremely low-volume still elicited substantial changes in the participants psychological responses compared to time-matched BIT or VICT. One explanation for this result is that participants' $\%HR_{peak}$ was higher during SIT than during BIT, and time spent near HR_{peak} above the ventilatory threshold can modify RPE and FS (Kilpatrick et al., 2007; Ekkekakis et al., 2011). However, as the $\%HR_{peak}$ was not significantly different between SIT and VICT, further research is necessary to fully interpret these findings.

According to dual mode theory, the increased contribution of anaerobic metabolism characteristic of progressive exercise elicits a reduction in affective valence related with the exercise (Ekkekakis et al., 2011; Niven et al., 2020). In this regard, a smaller decline in negative affect during MICT was associated with a greater commitment to this modality at 4-week follow-up (Stork et al., 2018). Data from Gist et al. (2014) showed significantly higher RPE in response to Wingate-based SIT (17, very hard) versus BIT (14, hard). We found similar RPE findings with lower CR10 scores with BIT than SIT. This information may be related to a lower blood lactate concentration during BIT (Gist et al., 2014), that can be caused by a greater muscle mass involved during repeated burpees that can attenuate blood lactate accumulation and peripheral fatigue. Lastly, our regimens revealed less substantial changes in RPE (≤5, Hard) and FS (≥1, Fairly good) (Table 2) than had been evident in other studies implementing higher-volume interval training regimens (Astorino, Clausen et al., 2020; Benítez-Flores et al., 2018; Follador et al., 2018; Gist et al., 2014; Haines et al., 2020; Marques et al., 2020; Olney et al., 2018; Saanijoki et al., 2015; Townsend et al., 2017; 2021). Consequently, SIT protocols similar to our regimens should be considered if clinicians seek to implement "all-out" bouts that do not induce a severely aversive perceptual response.

Our data show that participants' exercise intention reports on PACES (d = 0.92) and their preference ratings (d = 1.0) were significantly higher after BIT than VICT (Figure 2). Previous observational-studies found that enjoyment was a strong predictor of PA participation (Trost et al., 2002; Bauman et al., 2012). Moreover, data from a recent meta-analysis denoted a significantly greater enjoyment in adults from HIIT compared with MICT (Niven et al., 2020). However, research comparing enjoyment between acute bouts of interval training and load-matched VICT has been minimal. Similar to our data, Jung et al. (2014) reported that 10 bouts of HIIT completed at ∼100% peak power output was more enjoyable and preferable than VICT (20 minutes at 80% peak power output) in healthy adults. We decided to implement HIFT due to previous evidence that suggested greater levels of motivation from HIFT versus MICT in untrained individuals (Wilke et al., 2019). Our results showing higher HIFT enjoyment in response to BIT corroborates data from Heinrich et al. (2014) who found that HIFT elicited significantly higher enjoyment compared to combined resistance and strength training in active young adults. Similar findings were previously reported by McRae et al. (2012). Potential explanations for this result include opponent process theory, indicating that pleasant affective states are easier to achieve after an adverse physical stimulus, as a kind of reward mechanism (Solomon, 1980). In addition, the intermittent nature of interval training promotes a "rebound effect," which generates a better balance of post-session pleasure after each interval (Niven et al., 2020). Also, we detected a moderate effect size preference for BIT versus VICT which is likely due to monotony and lack of challenges during the VICT (Jung et al., 2014). Finally, similar to prior studies, we did not find gender differences in PACES or preference (Astorino & Sheard, 2019; Marques et al., 2020) for any of the three high intensity sessions, suggesting that gender may not influence perceptions to extremely low-volume protocols.

Our results showed that the participants had an acceptable interest in participating in the three regimens at a frequency of 3 × week. Nevertheless, intention to participate at a frequency of 5 × week declined and was significantly higher in BIT than in both SIT (d = 0.66) and VICT (d = 0.68) (Figure 2). Townsend et al. (2017) reported that very short "all-out" efforts elicited higher exercise intention at 3 × week (~5) versus 5 × week (~3). Additionally, Stork et al. (2018) observed no difference in exercise preference within their laboratory conditions or later in leisure time between SIT, HIIT, and MICT among inactive adults. In contrast, Jung et al. (2014) found significantly greater intentions to exercise at 3 × week or 5 × week after HIIT or MICT, compared to VICT. Although the previous evidence is equivocal, we observed a greater intent to complete future BIT. In addition, women expressed lower intentions to perform VICT at a rate of 5 × week than men (d = 0.85) which may be considered when promoting PA for women. Baseline VO_{2max} was lower for women, and this discrepancy could partially explain these results. Frazão et al. (2016) reported that a low level of physical fitness induces a more unpleasant feeling when faced with an intense physical stimulus, which may mitigate the intention to exercise in the future. On the other hand, future studies should include an analysis of diverse training modes (Astorino, Oriente et al., 2020) (i.e., cycling and rowing) compared to HIFT.

Our data show that HI was not significantly different across conditions for three of our four indicators (i.e., sleep quality, fatigue, and stress level) at 48 hours post-session. We only found differences in muscle soreness, indicating more soreness in BIT than in VICT (small effect size d = 0.51). Thus, it can be deduced that when the volume of exercise is standardized, the impact on the exerciser's homeostasis and recovery is similar. Moreover, women had a poorer recovery than men after SIT, which could be related to their lower anaerobic capacity (Ansdell et al., 2020).

Limitations and Directions for Further Research

Several limitations should be noted when interpreting the findings of this study, including sample size. A power analysis based on our sample size of 18 suggested satisfactory power (i.e., 0.85) for an effect size of 0.35, but power may have been smaller and insufficient for actual effect sizes that were smaller than 0.35, meaning that more participants may have been necessary to detect small effect sizes. Baseline cardiorespiratory fitness was different between genders, and participants were moderately trained young adults. Thus, our outcomes are not generalizable to older or diseased populations. We only reported acute data, making it unclear whether the participants' perceptions about their experiences would change over time and this could be associated with different later intent and preference. Therefore, we are unable to infer causal relationships from these results, as this was a cross-sectional rather than longitudinal design. Also, for intention and preference variables, we used the instruments applied by Jung et al. (2014) in seminal paper, although we did not find a specific validation article. Because our study was carried out under field conditions, environment or behaviors were less controlled than in laboratory conditions. On the other hand, we find a great variability in the responses of the selected parameters since the psychological response is conditioned by the training background. Lastly, we included only one type of functional training exercise (i.e., burpees). Although this exercise is very popular in HIFT routines, further work is needed to better understand exercisers' perceptual responses to other regimens of functional training.

Conclusions

Our results from this study suggest that HIFT leads to more positive psychological responses among active healthy young adults when compared to SIT and VICT and when applied under real-world conditions. Our findings highlight the potential utility of HIFT in comparison to traditionally prescribed high intensity regimens for enhancing adherence to exercise in order to address sedentary lifestyles and improve general population health. Functional training can be practiced at home without equipment, and it elicits increased cardiometabolic and neuromuscular health. Future researchers should utilize larger research samples and study long-term adherence to exercise with different exercise modalities.

Acknowledgments

We want to thank all the participants, as well as Emiliano San Martín, Mathias Ipata, Agustín Pioli, Leonel Ortiz, and Lucía Silva for their assistance during data collection. We greatly acknowledge the support of Pista Oficial de Atletismo "Darwin Piñeyrúa," Montevideo, Uruguay.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the Proyectos I+D, Comisión Sectorial de Investigación Científica, University of the Republic, Uruguay under Grant 192, 2018.

Data Availability Statement

Data pertaining to this research study are available from the corresponding author upon reasonable request.

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