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Original Article

Affective valence predictors from real-world based short sprint interval training

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ABSTRACT

Affective valence is typically positive at exercise intensities below the lactate threshold, yet more aversive responses occur at supra-threshold intensities. Nevertheless, the physiological and psychological predictors of affective valence during supramaximal intensities including short sprint interval training (sSIT) have not yet been elucidated. Seventeen (7 women/10 men) moderately active young adults (age = [28.2 ± 5.6] years; $\dot{V}O_{2max}$ [maximum oxygen consumption] = [52.9 ± 8.1] $mL \cdot kg^{-1} \cdot min^{-1}$; BMI [body mass index] = [24 ± 2] $kg \cdot m^{-2}$) completed four low-volume running sSIT sessions (10 × 4 s efforts with 30 s of passive recovery). We recorded participants' heart rate (HR), root mean square of successive differences of normal RR intervals (RMSSD), heart rate recovery (HRR), ratings of perceived exertion (RPE), feeling scale (FS), intention and self-efficacy during, and after each session. Overall, no significant correlation ($p > 0.05$) was found between FS and baseline clinical outcomes. No significant correlation ($p > 0.05$) was detected between FS and any training parameter. No significant correlations were noted between FS and exercise task self-efficacy and intentions ($p > 0.05$). The regression model was significant ($F_{3,61} = 5.57$; $p = 0.002$) and only three variables significantly entered the generated model: $\Delta HRR_{end\text{-}120s\ end}$ ($p = 0.002$; $VIF = 2.58$; 40.8%), time ≥ 90% HR_{peak} ($p = 0.001$; $VIF = 1.26$; 31.6%), and $RMSSD_{end}$ ($p = 0.025$; $VIF = 2.23$; 27.6%). These findings suggest that HR-based measures, particularly those related to in-task stress (time ≥ 90% HR_{peak}) and acute recovery ($\Delta HRR_{end\text{-}120s\ end}$, and $RMSSD_{end}$), may predict affective valence during real-world sSIT.

1. Introduction

The pandemic of physical inactivity is a critical public health problem as currently 7.2% and 7.6% of all-cause and cardiovascular deaths, respectively, are attributable to low moderate to vigorous physical activity (MVPA) levels (< 150 minutes[min]/week of moderate and < 75 min/week of vigorous physical activity).[1] Moreover, physical inactivity is estimated to cost US$ 54 billion in direct health care, of which 57% is incurred by the public sector worldwide.[1] Consequently, the lack of investment in PA to prevent onset of cardiometabolic diseases represents a missed opportunity to mitigate effects of sedentary lifestyle on the health care system.[2]

It has currently been suggested that there has been no improvement in global levels of PA participation over the last two decades.[3] For example, using accelerometry, Arias-Palencia et al.[4] showed likewise that only 30% of university students accumulated 30 min/day of MVPA at least five days a week. It can be assumed that this will worsen in the future because 81% of adolescents are sedentary.[3] Among young adults, it has been shown that psychological variables such as; self-efficacy, intention, and enjoyment from exercise are strong predictors of PA participation,[5,6] and affective valence is related to PA adherence.[7,8]

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Abbreviations

BMI	body mass index
CR10-RPE	rating of perceived exertion category ratio 10 scale
DBP	diastolic blood pressure
FS	feeling scale
HC	hip circumference
HIIT	high intensity interval training
HR	heart rate
$HR_{baseline}$	heart rate at baseline
HR_{end}	heart rate at the end of exercise
HR_{mean}	heart rate mean
HR_{peak}	heart rate peak
HRR	heart rate recovery
HRV	heart rate variability
$\%HR_{peak}$	percentage of heart rate peak
$\Delta HRR_{end\text{-}60s\ end}$	change between the heart rate at the end and after 60 s of recovery
$\Delta HRR_{end\text{-}120s\ end}$	change between the heart rate at the end and after 120 s of recovery
IPAQ	international physical activity questionnaire
MBP	mean blood pressure
MICT	moderate-intensity continuous training
MVPA	moderate to vigorous physical activity
$RMSSD_{baseline}$	the root mean square of successive differences between R–R intervals at baseline
$RMSSD_{end}$	the root mean square of successive differences between R–R intervals at end
RPE	rate of perceived exertion
$R\text{-}R_{baseline}$	interval between two successive R waves at baseline
$R\text{-}R_{end}$	interval between two successive R waves at end
SBP	systolic blood pressure
SIT	sprint interval training
sSIT	short sprint interval training
SRT	shuttle run test
time $\geq$ 70% HR_{peak}	time between 70% and 80% of the heart rate peak
time $\geq$ 80% HR_{peak}	time between 80% and 90% of the heart rate peak
time $\geq$ 90% HR_{peak}	time between 90% and 100% of the heart rate peak
VIF	variance inflation factor
$\dot{V}O_{2max}$	maximum oxygen consumption
WC	waist circumference
WHR	waist/hip ratio

Affective valence represents an umbrella term for numerous inter-related constructs including core affect (e.g. pleasure/displeasure dichotomy and arousal), emotions, mood, and affect processing.[9] Hence, research identifying strategies to better understand predictors of affective valence in response to PA, may potentially enhance participation of PA interventions.[6]

A primary barrier to engaging in sufficient PA is the perceived lack of time.[5] In this sense, interval training may be an optimal strategy and since it improves cardiometabolic health with a low exercise training volume.[10–13] Indeed, a present meta-analysis observed that low-volume ($\geq$ 15 min) of interval training exhibited a significant change in cardiometabolic health and no differences were noted versus a high-volume of interval training or moderate-intensity continuous training (MICT).[12] As well, low-volume of interval training it was described as more enjoyable after long-term interventions compared to MICT.[14] Consequently, interval training was established as one of the main trends in the fitness field for more than ten years according to ACSM.[15,16] Interval training can be implemented using repeated: (1) submaximal efforts as high intensity interval training (HIIT) at 80%–100% of maximal heart rate (HR); (2) supramaximal efforts as sprint interval training (SIT) at a power output $\geq$ 100% of the workload associated with maximum oxygen consumption ($\dot{V}O_{2max}$).[10] Commonly, SIT protocols utilized Wingate-based SIT (4–6 $\times$ 30 seconds [s] “all-out” sprints) that induce several central and peripheral adaptations[10]; however, elicit severe fatigue, hyperventilation, and nausea, which make them impractical and unfeasible for most adults.[17] A time-efficiency alternative without attenuating the enhancement in the $\dot{V}O_{2max}$ and being well tolerated is the short sprint interval training (sSIT) ($\leq$ 10 s).[11] This effort duration has a strong dependence on the ATP-PCr pathway; although, the activation of oxidative metabolism has demonstrated to be essential mechanism for phosphocreatine resynthesis.[18]

It is evident that affective valence decreases significantly during Wingate-based SIT[18] but a low-volume of sSIT promotes greater exercise affective valence,[19] enjoyment,[20] preference,[21] and intentions to engage in future than longer bouts of SIT[18,22] in laboratory setting. Furthermore, responses are considerably positive for sSIT in self-efficacy and intention up to 3 $\times$ week frequency (i.e. $\geq$ 73/100 self-efficacy, $\geq$ 5/7 intention), and preference (i.e. $\geq$ 6/7)[23,24] in real-world setting. Previously, it was established that short versus long efforts (i.e. 5- s versus 20 s) induce lesser lactate accumulation and respiratory exchange ratio for equal external load.[25] In this sense, pleasure is reduced above the lactate threshold (i.e. $\geq$ 90% HR_{max} “red zone”) and homogeneous negative changes are detected at suprathreshold intensities.[26] In addition, it was detected that greater glycolytic activity was associated with a displeasure and slower HR recovery (HRR) after several intense exercise protocols in trained adults.[25,27] Likewise, da Silva et al.[28] observed that decreased HR variability (HRV) was related to displeasure at intensity near to exhaustion. In a sample of 71 non-obese young adults undergoing HIIT and SIT, it was exhibited a small significant correlation between changes in affective valence and blood lactate concentration ($r = -0.21$; $p = 0.03$), and enjoyment ($r = 0.25$; $p = 0.03$), with no association with baseline $\dot{V}O_{2max}$ ($r = 0.11$; $p = 0.16$).[29] More recently, it was revealed that affective valence was negatively correlated with rate of perceived exertion (RPE) ($r = -0.825$; $p < 0.001$) and HR_{max} ($r = -0.272$; $p = 0.018$) after completion of low-volume HIIT (10 $\times$ 60 s at 90% of maximal aerobic velocity).[30] Also, these authors noted that PA level and RPE are the most significant predictors of affective valence throughout a HIIT session.[30] These conclusions coincide with previous findings due to the level of PA[31] and RPE[32] have been detected to influence the behavior of affective valence in low-volume interval training.

Low-volume sSIT has been shown to be a practical manner for inducing mixed aerobic/anaerobic adaptations in diverse populations,[11] establishing better affective valence than Wingate-based SIT.[19] Affective valence in-task (e.g. negative and positive peak, rate of change and affect at the end of the exercise session) predicted the attendance rate during long-term interval training interventions.[7,8] To the best of our knowledge, the physiological (i.e. HR, HRR, and HRV) and psychological predictors (i.e. RPE, intention and self-efficacy) of affective valence during low-volume sSIT sessions are unknown.

Thus, the aim of this study was to describe the physiological and psychological predictors of affective valence in the course of sSIT in real-world scenarios recruiting university students. This can be used to understand how the university students respond to low-volume intense exercise, given it has been seen that vigorous PA is practically null for these populations,[4] and the economic cost and lack of time was reported as a barrier.[33] These data may be used to improve tolerance and adherence to time-efficient interval training protocols, which can bridge the gap between laboratory and field-based exercise prescription.[34] We hypothesize that time ≥ 90% HR_{max}, RPE and reduced HRV will be associated with more negative affective valence response to sSIT.

2. Materials and methods

2.1. Study design

2.1.1. Ethical approval

(1) Informed consent from each participant was collected; (2) the study was reviewed and received approval to implement by the Ethics Committee of Instituto Superior de Educación Física, Universidad de la República, Uruguay (2/2020 and date of final approval November 4, 2020); and (3) the study was implemented in accordance with the Declaration of Helsinki.

This study used a cross-sectional design in which participants performed one testing session and four equal SIT sessions (~8 min) over a 2-week period. Each session was separated by 72 h of recovery. Our design was intended to integrate into daily life using ecologic tools and simple psychometrically supported questionnaires to measure physiological and psychological responses, respectively (Fig. 1). We employed the methodological checklist for critically appraising studies examining the affective valence during interval training.[35] Sessions were performed on an indoor basketball court with constant environmental conditions (temperature = 20–22 °C, relative humidity = 60%–70%), since it is assumed that varied temperature could change the physiological (e.g. HRV)[36] or the psychological response (e.g. affective valence).[37] All procedures were performed by the same evaluators and, to avoid effects of the circadian cycle, at the same time of day (8:00–12:00 p.m.). Before starting the training sessions, the participants were familiarized with the "all-out" sSIT. Active steps were taken to minimize the risk of communicating researcher expectations during the experiments and the potential effects of interval training. This study was carried out in accordance with the Declaration of Helsinki following the update of Fortaleza 2013.[38]

2.2. Participants

Seventeen Hispanic (7 women and 10 men) healthy young adults (university students of several faculties) completed this study (age = [28.2 ± 5.6] years; body mass = [69.8 ± 12.2] kg; height = [169.7 ± 10.1] cm; BMI [body mass index] = [24 ± 2] kg·m^{-2}; $\dot{V}O_{2max}$ = [52.9 ± 8.1] mL·kg^{-1}·min^{-1}) after a publicity campaign at the University. They were not recruited from courses taught by the investigators. The participants were instructed to maintain their lifestyle habits (work, hours of sleep, nutrition, etc.) during the experiment, abstain from consuming alcohol for 48 h prior to each session, and to avoid consumption of stimulants (mate, coffee, etc.) in the morning of assessments. Furthermore, they were instructed to avoid any additional PA in the course of study period. They were asked to wear loose clothing, be dehydrated, and not cycle or walk to the court prior to each session. The inclusion criteria were: (1) be classified as moderately physically active (≥ 600 MET·min/week) according to the International Physical Activity Questionnaire (IPAQ) Spanish short version,[39] since PA level influences the affective response[30,31]; (2) not consuming any nutritional supplement, drugs, or tobacco products; (3) free of risk factors associated with cardiometabolic diseases, any musculoskeletal injury, and COVID-19 diagnosis; (4) age between 18 and 40 years old; (5) if they were women, not be pregnant or lactating; and (6) familiarity with interval training.

2.3. Baseline clinical data

2.3.1. Body composition

Initially, we recorded height (cm), body mass (kg), body fat (%) and skeletal muscle mass (%) utilizing a reliable digital body composition bioimpedance sensor (HBF–514C, OMRON, Kyoto, Japan).[40] We measured waist (WC) and hip circumference (HC) according to Norton & Eston.[41] Two measurements were taken with an anthropometric tape (SN-4010, Sanny Medical Starret, Sao Paulo, Brazil), using the mean value for analysis. The waist/hip ratio (WHR) was calculated by dividing WC and HC.

2.3.2. Blood pressure

Blood pressure was measured in a sitting position after 3 min of rest utilizing a previously validated digital sphygmomanometer (CH-432, CITIZEN, Tokyo, Japan).[42] Throughout the measurement, we followed specific recommendations.[43] The subject was seated with the arm slightly bent, the palm facing up, and the forearm supported nearly horizontal at the level of the heart.[43] In addition, the arm was free of tight clothing that could occlude blood flow.[43] Throughout the evaluation, the legs were not crossed, and isometric muscle contraction was to be avoided, such as pressing the legs down, hanging the feet off the ground, or sitting upright with the back unsupported.[43] We positioned the cuff on the right arm with the lower margin about 2.5 cm above the antecubital space.[43] Two measurements were performed with a 3 min recovery between assessments, and the mean value for diastolic blood pressure (DBP) and systolic blood pressure (SBP) were used for analysis. Mean blood pressure (MBP) was calculated as follows: MBP = DBP + (0.333 [SBP – DBP]).

Fig. 1. Descriptive image of the sSIT sessions. sSIT: short sprint interval training.

2.3.3. *Cardiorespiratory fitness*

We used the valid shuttle run test (SRT) to estimate cardiorespiratory fitness.[44] The test consists of running for as long as possible between two lines separated by 20-m with a rhythm imposed by audio. The test starts with a velocity equivalent to 8.5 $km \cdot h^{-1}$ with increments equal to 0.5 km h^{-1} every minute. The end of the test is determined when the 20-m distance cannot be covered in two consecutive efforts. For $\dot{V}O_{2max}$ estimation, the equation from Stickland et al.[45] was applied: (1) Men $\dot{V}O_{2max} = 2.75 \times$ (last half-stage complete) + 28.8; (2) Women $\dot{V}O_{2max} = 2.85 \times$ (last half-stage complete) + 25.1. Also, heart rate peak (HR_{peak}) was recorded using a valid and reliable telemetric system employing chest straps (Firstbeat Sports software version 4.7.3.1, Firstbeat Technologies Ltd., Jyväskylä, Finland).[46] The HR_{peak} was the highest value recorded during the SRT. All individuals were verbally encouraged to exercise to exhaustion, following two criteria to classify the effort as maximum: (1) peak HR $\geq$ 90% of the age-predicted maximum (208 − [0.7 $\times$ age]); and (2) volitional exhaustion.[47]

2.4. *Short sprint interval training sessions*

Initially, for the warm-up participants ran for 3 min at a self-selected submaximal pace. Total exercise time was 40 s, total exercise with recoveries was 5 min and 10 s, and total volume session time was 8 min and 10 s. The individuals performed four training sessions in a 2-week period, from which we analyzed data from a total of 68 sessions. Short sprint interval training was executed "all-out" and consisted of 10 $\times$ 4 s efforts followed by 30 s of passive recovery. The workout was monitored by a mobile application that provides audible alerts for each series. A passive recovery while standing was completed to facilitate energy restoration which is appropriate for non-athletes.[48] Moreover, we selected the 30 s recovery period for the reason that this duration optimizes power output without affecting HR response compared to shorter or longer durations (i.e. 15 or 45 s) after 4 s sprints.[49] During the sessions, participants were instructed to run as fast as they could and, after recovery, were asked to run in the opposite direction. Typically, they covered ~25-m each running bout. Throughout the sessions, the researchers provided strong verbal encouragement for individuals to achieve maximum effort.

2.5. *Physiological data obtained during short sprint interval training*

2.5.1. *Internal training load*

Heart rate data were collected with a telemetric system (Firstbeat Sports software version 4.7.3.1, Firstbeat Technologies Ltd., Jyväskylä, Finland). To describe internal training load, we employed the heart rate baseline ($HR_{baseline}$), the heart rate mean (HR_{mean}), the percentage of heart rate peak ($\%HR_{peak}$), time $\geq$ 70% HR_{peak} (i.e. time between 70% and 80% of the heart rate peak), time $\geq$ 80% HR_{peak} (i.e. time between 80% and 90% of the heart rate peak), and time $\geq$ 90% HR_{peak} (i.e. time between 90% and 100% of the heart rate peak).

2.5.2. *Heart rate variability and heart rate recovery*

To assess the impact of sSIT on cardiac autonomic function, we analyzed the HRV during parasympathetic reactivation and HRR. Participants remained in a supine position, which has greater reliability than other positions,[50] and completed 2 min records pre- and post-exercise. They were requested to breathe normally and avoid any movements throughout data acquisition. To assess HRV, we selected only the second minute of recording, because the first minute is required for HR stabilization during resting,[51] and by a greater increase of the HR oscillations than the first minute during the recovery period.[52] This approach can accurately assess cardiac autonomic balance in field environments and it is easily applied in daily training routines.[53] The variables selected were the R–R intervals (interval between two successive R waves) and the root mean square of successive differences between R–R intervals (RMSSD), which is recognized as the strongest index of parasympathetic modulation[54] and it has been validated as a parasympathetic reactivation index.[52] Likewise, this HRV parameter is not influenced by breathing frequency.[54] Furthermore, the HRR was evaluated and defined as the change between HR at the end of exercise (HR_{end}) and after 60 and 120 s of recovery ($\Delta HRR_{end\text{-}60s\ end}$, $\Delta HRR_{end\text{-}120s\ end}$).

2.6. *Psychological data obtained after short sprint interval training*

2.6.1. *Rating of perceived exertion and affective valence*

Rating of perceived exertion category ratio 10 scale (CR10-RPE) was used to estimate the intensity of exercise as it is strongly correlated with HR.[55] This instrument 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.[55] This scale shows validity and good reliability for men and women.[56] Additionally, the feeling scale (FS), a psychometric tool which describes emotional aspects of the exercise experience, focusing on the pleasure–displeasure dichotomy,[57] was used to assess affective valence. This scale was previously validated in physically active individuals.[58] The FS contains values from +5 to −5 (+5 equal "very good" and −5 represents "very bad"). Participants were asked to indicate their perception for both scales on a spreadsheet, preventing that oral expression influence the responses of others. Both scales were recorded immediately post-exercise (i.e. few seconds after the last bout) in the four training sessions in the same order. It is evident that the final sprint captures the most intense part of the SIT; so, it is likely that this is the moment in which the lowest affective valence is reported (i.e. affective valence valleys).[19,35] In fact, this outcome was verified in different studies applying sSIT with active adults.[18,22,23,25,59,60]

2.6.2. *Exercise task self-efficacy and intentions*

After 20 min of the last training session, participants' confidence to repeat the sSIT protocol with different frequency/week (i.e. one $\times$ week to five $\times$ week) was assessed using a 5-item scale.[61] Each question included the stem, "*How confident are you that you can …* ''. The 5-items were: (1) "perform one bout of exercise a week for the next 4 weeks that is just like the one you completed today?"; (2) "perform two bouts of exercise a week for the next 4 weeks that is just like the one you completed today?''; (3) "perform three bouts of exercise a week for the next 4 weeks that is just like the one you completed today?''; (4) "perform four bouts of exercise a week for the next 4 weeks that is just like the one you completed today?''; and (5) "perform five bouts of exercise a week for the next 4 weeks that is just like the one you completed today?''. Responses were scored on a scale of 0% (Not at all) to 100% (Extremely confident) in 10 % increments. Previously, the instrument has demonstrated good internal consistency (α's > 0.95).[61] Moreover, we asked the participants regarding their ability to engage in the training regimen performed in the future at rates of three times or five times a week (intention 3 $\times$ week or intention 5 $\times$ week) over the next month.[61] Specifically, participants were asked "Please rate the extent to which you agree with the following statements": (1) "I intend to engage in the type of exercise I performed today at least 3 times per week during the next month"; (2) "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).

2.7. *Data analysis*

The sample size was estimated with the following input parameters in G*Power version 3.1.9.7 (Düsseldorf University, Düsseldorf, Germany): (1) correlation; (2) one-tail; (3) estimated effect size (0.55); (4) alpha-value (0.05); and (5) statistical power (0.80). The calculated sample size was 16, which is lower than the actual sample size equal to 17. Data normality was tested with the Shapiro–Wilk test. The mean, standard deviation (*SD*), and the 95% limits of the mean confidence were calculated. Additionality, no analysis was performed to compare genders, only within-individuals.

The correlations between *FS* (mean of the training sessions) and (1) the baseline clinical variables; (2) the Exercise Task Self-Efficacy; and (3) the Intentions were tested with Spearman's ρ test, as mean *FS* was not assumed as parametric ($n = 17$).

The correlation among the variables obtained from the 4 training sessions ($n = 68$) with *FS* was tested with ρ test. All the others training parameters were analyzed with the Pearson's r test, except with the time $\geq$ 70% HR_{peak}, time $\geq$ 80% HR_{peak}, and time $\geq$ 90% HR_{peak}, when the correlation coefficient used was the Kendall's τ b. Correlation thresholds was: $\leq$ 0.1, trivial; > 0.1–0.3, small; > 0.3–0.5, moderate; > 0.5–0.7, large; > 0.7–0.9, very large; and > 0.9–1.0, almost perfect.[62] For these correlations, a posteriori static power ($1 - \beta$) was calculated and $1 - \beta$ was 0.99.

To verify the relationship between *FS* (dependent variable) and variables obtained from training sessions, multiple linear regression was applied to identify the relative contributions of the variables to the *FS* (stepwise method). In the application of regression models, the residuals must present a parametric distribution, as found in the present study, differently from the predicted and predictive variables.[63] Adjusted R^2 was calculated, and the Fisher exact test was used to identify the significance of each model. The Durbin–Watson test was used to analyze the ordinary least squares residuals' independency, with expected value between 1.5 and 2.5. Multicollinearity was identified with variance inflation factor (VIF), and values under 5 were accepted. For the multiple linear regression, the f^2 was calculated[64] and a posteriori static power ($1 - \beta$) was calculated and the result was 0.93. To express the relative importance of each predictor in explaining the *FS*, the β standardized regression coefficients were transformed in relative values ($\sum |\beta\text{standardized}| = 100\%$). Alpha was set at 0.05. 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 $p < 0.05$. All graphics were made with GraphPad Prism version 6.01 (San Diego, CA, USA).

3. Results

3.1. Side effects

Each participant was able to complete all 4 sessions. No participant reported fainting, respiratory events, nausea, dizziness, and vomiting. No musculoskeletal injuries were observed.

3.2. Descriptive data

Baseline clinical and training descriptive data are presented in Tables 1 and 2. Overall subjects had a healthy BMI (i.e. 18.5$\geq$ BMI $\leq$ 24.9 $kg{\cdot}m^{-2}$), did not have hypertension (i.e. SBP $\leq$ 130 mmHg and DBP $\leq$ 80 mmHg),[65] and $\dot{V}O_{2max}$ elicited the 85% percentile for women (i.e. > 45.3 mL $kg^{-1}{\cdot}min^{-1}$ age 20–29 years) and 95% percentile for men (i.e. > 56.2 mL $kg^{-1}{\cdot}min^{-1}$ age 20–29 years).[47] The sSIT sessions were categorized as vigorous exercise (i.e. 77%–93% of HR_{peak}).[47] An original HR record of one typical sSIT sessions was included in Fig. 2.

3.3. Correlation between feeling scale and baseline clinical data

No correlation ($p > 0.05$) was found between *FS* and most clinical parameters. Although, a significant correlation was exhibited between muscle mass and body fat with *FS* ($\rho \geq 0.62$; $p < 0.01$; large) (Table 3).

3.4. Correlation between physiological and psychological training data

No significant correlations ($p > 0.05$) were detected between *FS* and any training parameter (Fig. 3). Exact ρ and p-values are in Fig. 3. Significant relationships ($p < 0.05$; $-0.20 \geq r \leq 0.37$; small to moderate) were shown between CR10-RPE and $HR_{baseline}$, HR_{mean}, $\%HR_{peak}$, time $\geq$ 70% HR_{peak}, time $\geq$ 90% HR_{peak}, HR_{end}, $RMSSD_{end}$, $R\text{-}R_{baseline}$, and $R\text{-}R_{end}$. Significant relationships ($p < 0.05$; $-0.33 \geq r \leq 0.63$; moderate to large) were revealed between $\%HR_{peak}$ and $HR_{baseline}$, HR_{mean}, time $\geq$ 70% HR_{peak}, time $\geq$ 90% HR_{peak}, HR_{end}, $\Delta HRR_{end\text{-}60s\ end}$, $\Delta HRR_{end\text{-}120s\ end}$, $RMSSD_{end}$, $R\text{-}R_{baseline}$, and $R\text{-}R_{end}$. Significant associations ($p < 0.05$; $-0.28 \geq r \leq 0.67$; small to large) were detected between $RMSSD_{end}$ and

Table 1
Baseline clinical data reported through mean ± standard deviation [limits of the 95% confidence intervals of the mean].

Parameter	Overall ($n = 17$)	Males ($n = 11$)	Females ($n = 6$)
HR_{peak} ($beat{\cdot}min^{-1}$)	190.4 ± 11.0 [184.8 to 196.1]	194.0 ± 11.2 [186.4 to 201.5]	183.9 ± 7.5 [176.0 to 191.9]
Body mass (kg)	69.8 ± 12.1 [63.7 to 76.1]	74.3 ± 9.0 [68.2 to 80.3]	61.6 ± 13.6 [47.3 to 76.0]
BMI ($kg{\cdot}m^{-2}$)	24.0 ± 1.8 [23.1 to 25.0]	24.3 ± 1.6 [23.2 to 25.4]	23.1 ± 2.3 [21.2 to 26.0]
Muscle mass (%)	34.9 ± 8.1 [30.7 to 39.1]	39.7 ± 3.6 [37.3 to 42.2]	26.1 ± 6.1 [19.6 to 32.5]
Body fat (%)	24.2 ± 8.1 [20.0 to 28.4]	19.6 ± 5.3 [16.1 to 23.2]	32.6 ± 5.2 [27.1 to 38.2]
Visceral fat (%)	5.8 ± 1.6 [5.0 to 6.7]	6.4 ± 1.6 [5.3 to 7.5]	4.8 ± 0.9 [3.8 to 5.8]
WHR	0.78 ± 0.04 [0.75 to 0.80]	0.80 ± 0.03 [0.78 to 0.83]	0.73 ± 0.03 [0.69 to 0.77]
MBP (mmHg)	91.5 ± 5.3 [88.8 to 94.3]	91.6 ± 5.2 [88.1 to 95.2]	91.3 ± 6.0 [85.0 to 97.6]
$\dot{V}O_{2max}$ (mL·$kg^{-1}{\cdot}min^{-1}$)	54.2 ± 7.6 [50.3 to 58.2]	59.0 ± 4.2 [56.1 to 61.9]	45.5 ± 3.3 [42.0 to 49.0]

Mean ± SD [95% interval limits]. HR_{peak}: heart rate peak; BMI: body mass index; WHR: waist/hip ratio; MPB: Mean blood pressure; $\dot{V}O_{2max}$: maximum oxygen consumption.

Table 2
Physiological and psychological training data reported through mean ± standard deviation [limits of the 95% confidence intervals of the mean].

Parameter	Overall ($n = 68$)
FS	2.6 ± 1.8 [2.1 to 3.0]
CR10-RPE	4.7 ± 2.0 [4.2 to 5.2]
$HR_{baseline}$ ($beat{\cdot}min^{-1}$)	64.6 ± 10.8 [61.9 to 67.3]
HR_{mean} ($beat{\cdot}min^{-1}$)	160.3 ± 12.8 [157.1 to 163.5]
$\%HR_{peak}$	83.3 ± 4.7 [82.3 to 84.7]
time ≥ 70% HR_{peak} (s)	84.0 ± 85.3 [62.8 to 105.1]
time ≥ 80% HR_{peak} (s)	170.7 ± 93.2 [147.6 to 193.8]
time ≥ 90% HR_{peak} (s)	48.9 ± 88.6 [26.9 to 70.8]
HR_{end} ($beat{\cdot}min^{-1}$)	168.6 ± 12.8 [165.4 to 171.7]
$\Delta HRR_{end\text{-}60s\ end}$ ($beat{\cdot}min^{-1}$)	48.3 ± 12.3 [45.2 to 51.3]
$\Delta HRR_{end\text{-}120s\ end}$ ($beat{\cdot}min^{-1}$)	68.2 ± 11.4 [65.3 to 71.0]
$RMSSD_{baseline}$ (ms)	44.4 ± 21.1 [39.1 to 46.6]
$RMSSD_{end}$ (ms)	12.0 ± 10.3 [9.4 to 14.6]
$R\text{-}R_{baseline}$ (ms)	946.7 ± 149.6 [909.6 to 983.8]
$R\text{-}R_{end}$ (ms)	443.8 ± 64.2 [427.9 to 459.7]

Mean ± *SD* [95% interval limits]. FS: feeling scale; CR10-RPE: rating of perceived exertion category ratio 10 scale; $HR_{baseline:}$ heart rate baseline; HR_{mean}: heart rate mean; $\%HR_{peak}$: percentage of heart rate peak; time ≥ 70% HR_{peak}: time between 70% and 80% of the heart rate peak; time ≥ 80% HR_{peak}: time between 80% and 90% of the heart rate peak; time ≥ 90% HR_{peak}: time between 90% and 100% of the heart rate peak; HR_{end}: heart rate at the end of exercise; $\Delta HRR_{end\text{-}60s\ end}$: change between the heart rate at the end and after 60 s of recovery; $\Delta HRR_{end\text{-}120s\ end}$: change between the heart rate at the end and after 120 s of recovery; $RMSSD_{baseline}$: the root mean square of successive differences between R–R intervals at baseline; $RMSSD_{end}$: the root mean square of successive differences between R–R intervals at end; $R\text{-}R_{baseline}$: interval between two successive R waves at baseline; $R\text{-}R_{end}$: interval between two successive R waves at end.

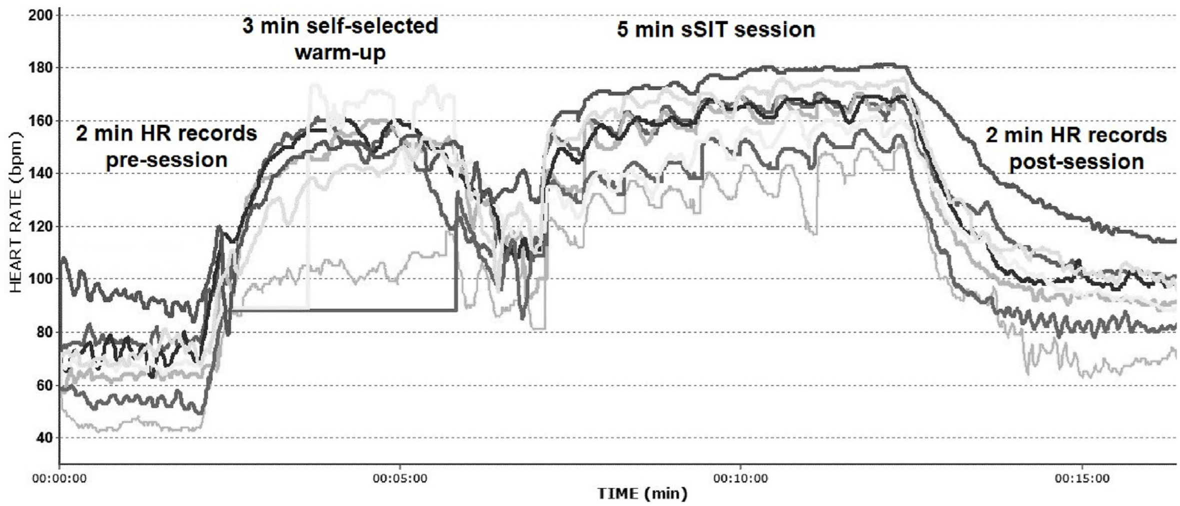

Fig. 2. Descriptive image of original records representing individual HR data across sSIT. HR: heart rate; sSIT: short sprint interval training.

Table 3
Correlation coefficients between feeling scale and baseline clinical data ($n = 17$).

Parameter	FS ρ (p-value)
HR_{peak} (beat·min^{-1})	0.22 (0.37)
Body mass (kg)	0.22 (0.38)
BMI (kg·m^{-2})	−0.82 (0.75)
Muscle mass (%)	0.62 (0.007)[a]
Body fat (%)	−0.67 (0.003)[a]
Visceral fat (%)	−0.05 (0.83)
WHR	0.078 (0.76)
MBP (mmHg)	−0.30 (0.24)
$\dot{V}O_{2max}$ (ml·kg^{-1}·min^{-1})	0.15 (0.55)

FS: feeling scale; HR_{peak}: heart rate peak; BMI: body mass index; WHR: waist/hip ratio; MPB: Mean blood pressure; $\dot{V}O_{2max}$: maximum oxygen consumption.
[a] Correlation is significant at the 0.01 level.

$HR_{baseline}$, HR_{mean}, time ≥ 70% HR_{peak}, time ≥ 90% HR_{peak}, HR_{end}, $\Delta HRR_{end\text{-}60s\ end}$, $\Delta HRR_{end\text{-}120s\ end}$, $RMSSD_{baseline}$, $R\text{-}R_{baseline}$, and $R\text{-}R_{end}$ (Table 4).

3.5. Correlation between feeling scale with exercise task self-efficacy and intentions

No significant correlations were detected between *FS* and exercise task self-efficacy and intentions ($\rho \leq 0.30$; $p > 0.05$).

3.5.1. Multiple regression

While regression analyses identify the joint effects of the predictor variables on the predicted variable (i.e. *FS*), the regression model was significant ($F_{3,61} = 5.57$; $p = 0.002$); however, only three variables significantly entered the generated regression model: $\Delta HRR_{end\text{-}120s\ end}$ ($p = 0.002$; $VIF = 2.58$), time ≥ 90% HR_{peak} ($p = 0.001$; $VIF = 1.26$), and $RMSSD_{end}$ ($p = 0.025$; $VIF = 2.23$). The R^2 adjusted was 0.177 (Durbin–Watson = 1.82). The regression model is:

$$FS = (-0.44 * \text{time} \geq 90\%\ HR_{peak}\ [s]) + (0.57 * \Delta HRR_{end-120s\ end}\ [beat \cdot min^{-1}]) + (0.38 * RMSSD_{end}\ [ms])$$

The % contribution to *FS* were, respectively, $\Delta HRR_{end\text{-}120s\ end}$ = 40.8%; time ≥ 90% HR_{peak} = 31.6%; and $RMSSD_{end}$ = 27.6%. Fig. 4 demonstrates the explained variance of $\Delta HRR_{end\text{-}120s}$, time ≥ 90% HR_{peak}, and $RMSSD_{end}$ in *FS* ($n = 68$).

4. Discussion

This study investigated the physiological and psychological predictors of the affective valence response to real-world based sSIT sessions in moderately active university students. First, results demonstrated a positive affective valence after the four sessions; thus, the physical stimulus was well tolerated. Second, time ≥ 90% HR_{peak}, $\Delta HRR_{end\text{-}120s\ end}$, and $RMSSD_{end}$, but not the psychological responses recorded, significantly predicted affective valence. These findings suggest that HR-based measures of internal training load, particularly those related to in-task stress (time ≥ 90% HR_{peak}) and post-task recovery ($\Delta HRR_{end\text{-}120s\ end}$, and $RMSSD_{end}$), may predict feelings of pleasure-displeasure during real-world sSIT sessions.

Burgomaster et al.[66] demonstrated significant improvements in muscle oxidative capacity and cycling performance in young adults after six Wingate-based SIT sessions over a 2-week period. These results were confirmed by other scientists in the last two decades.[10] However, concerns have been raised about the potential translation of SIT to real-world scenarios, especially because of the long (~30 s) "all out" efforts which result in extreme fatigue.[67] In fact, this regimen elicits significant declines in affective valence and are perceived as "bad",[18] and promotes higher stress and tension than MICT in young adults.[68]

Recent studies demonstrated that sSIT protocols involving fewer "all out" sprints with a shorter duration than the traditional Wingate-based SIT protocol, similarly improves cardiometabolic health and fitness in several populations (i.e. "same gain with less pain").[11,17] These shorter sprints elicit a lower blood lactate concentration,[20,25] neuromuscular fatigue,[25,69] and a more positive affective valence[18,22] compared to Wingate-based SIT, which makes this approach more feasible for non-athletic populations. Also, sSIT did not show greater displeasure post-exercise versus MICT and vigorous intensity continuous training.[59] Furthermore, a recent meta-analysis[19] showed that, although affective valence decreases with each additional "all out" sprint, shorter duration SIT regimens (5–6 s) have a lower decrease in affective valence compared to 30 s sprints (0.20 vs. 0.84 units/sprint). Data from this meta-analysis

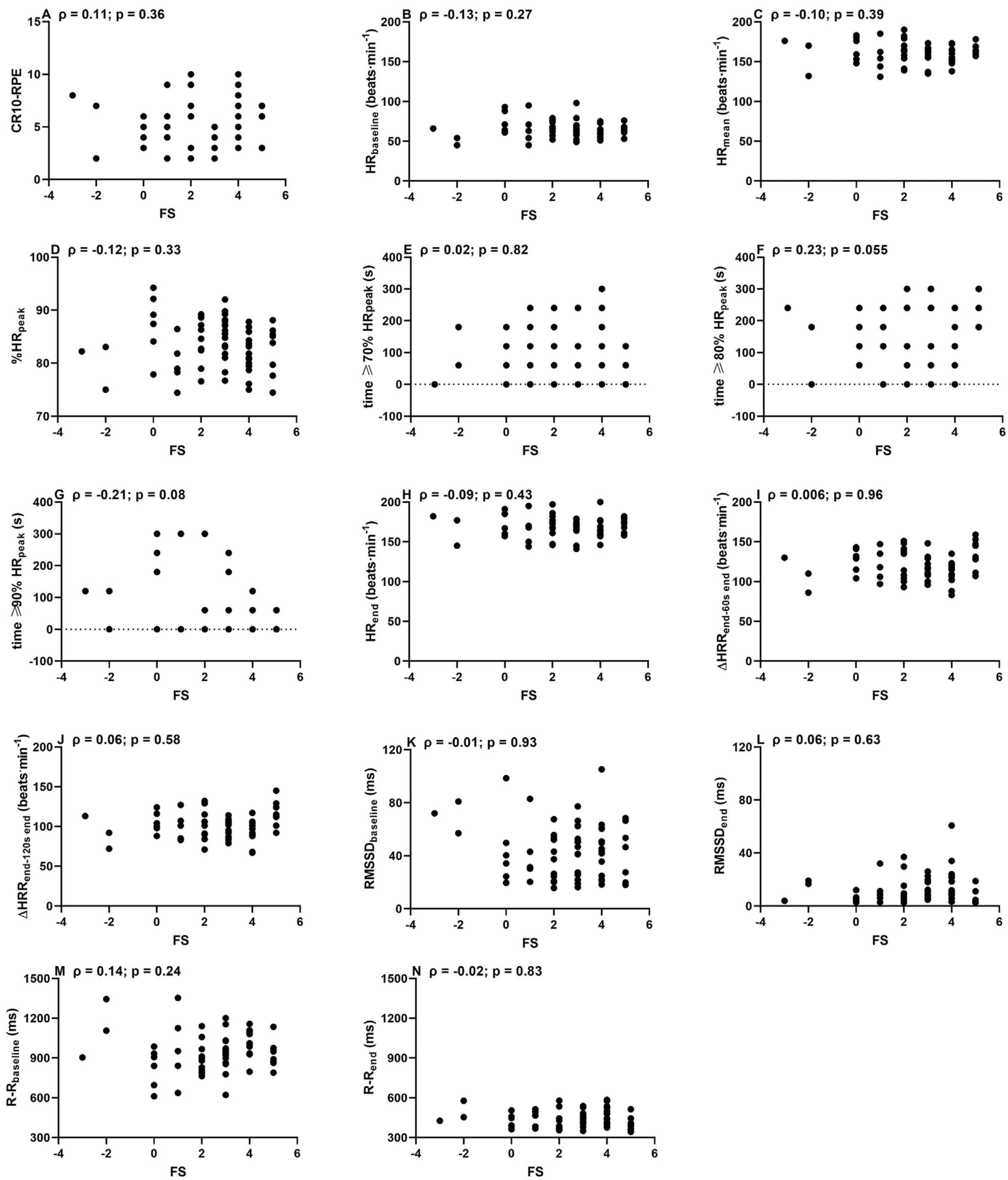

Fig. 3. Correlation coefficients between the *FS* and training data ($n = 68$, four training sessions for each individual). *FS*: feeling scale; CR10-RPE: rating of perceived exertion category ratio 10 scale; $HR_{baseline}$: heart rate at baseline; HR_{mean}: heart rate mean; $\%HR_{peak}$: percentage of heart rate peak; time $\geq$ 70% HR_{peak}: time between 70% and 80% of the heart rate peak; time $\geq$ 80% HR_{peak}: time between 80% and 90% of the heart rate peak; time $\geq$ 90% HR_{peak}: time between 90% and 100% of the heart rate peak; HR_{end}: heart rate at the end of exercise; $\Delta HRR_{end\text{-}60s\ end}$: change between the heart rate at the end and after 60 s of recovery; $\Delta HRR_{end\text{-}120s\ end}$: change between the heart rate at the end and after 120 s of recovery; $RMSSD_{baseline}$: the root mean square of successive differences between R–R intervals at baseline; $RMSSD_{end}$: the root mean square of successive differences between R–R intervals at end; $R\text{-}R_{baseline}$: interval between two successive R waves at baseline; $R\text{-}R_{end}$: interval between two successive R waves at end.

also suggest that positive affective valence can be expected for ≤ 10 "all out" sprints of 5–6 s, which our data exhibit (10 × 4 s, 30 s of recovery).[19] Indeed, our participants reported a *FS* value equal to "good" (*FS* = [2.6 ± 1.8] units) simultaneously with a moderate to hard internal load (CR10-RPE = [4.7 ± 2.0] units; $\%HR_{peak}$ = 83.3% ± 4.7%) across four sessions (Table 2). Likewise, after the completion of sSIT sessions, we do not report any events such as; faints, respiratory events, nausea, light-headedness, and vomiting.

In addition, our results demonstrated a faster $\Delta HRR_{end\text{-}60s\ end}$ vs. other studies using real-world based running SIT ([48.3 ± 12.3] beat·min^{-1}), which may be due to the fewer bouts completed ([27 ± 9] beat·min^{-1})[27] or the shorter duration of each bout ([33.2 ± 8.5] beat·min^{-1}).[70] Heart rate recovery is commonly used as a simple index of cardiac parasympathetic reactivation after exercise, representing a global marker of disturbances to homeostasis.[71] Thus, a greater training load elicits slower HRR and autonomic restoration.[72] Our low-volume sSIT

Table 4
Correlation coefficients with *p*-value between all the training data ($n = 68$, four training sessions for each individual).

Parameter	$HR_{baseline}$ (beats·min^{-1})	HR_{mean} (beats·min^{-1})	% HR_{peak}	time ≥ 70% HR_{peak} (s)	time ≥ 80% HR_{peak} (s)	time ≥ 90% HR_{peak} (s)	HR_{end} (beats·min^{-1})	$\Delta HRR_{end\text{-}60s\ end}$ (beats·min^{-1})	$\Delta HRR_{end\text{-}120s\ end}$ (beats·min^{-1})	$RMSSD_{baseline}$ (ms)	$RMSSD_{end}$ (ms)	$R\text{-}R_{baseline}$ (ms)	$R\text{-}R_{end}$ (ms)
CR10-RPE	−0.28	−0.26	−0.32	0.24	−0.09	−0.20	−0.26	−0.18	−0.11	0.085	0.37	0.31	0.29
	0.023	0.030	0.008	0.014	0.31	0.046	0.035	0.13	0.36	0.50	0.002	0.012	0.018
$HR_{baseline}$ (beat·min^{-1})		0.55	0.56	−0.33	0.15	0.29	0.55	0.59	0.50	−0.54	−0.45	−0.96	−0.60
		< 0.001	< 0.001	< 0.001	0.09	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
HR_{mean} (beat·min^{-1})			0.63	−0.76	0.22	0.63	0.94	0.69	0.71	0.02	−0.42	−0.61	−0.69
			< 0.001	< 0.001	0.015	< 0.001	< 0.001	< 0.001	< 0.001	0.85	< 0.001	< 0.001	< 0.001
$\%HR_{peak}$				−0.48	0.11	0.43	0.58	0.45	0.43	−0.06	−0.33	−0.57	−0.44
				< 0.001	0.19	< 0.001	< 0.001	< 0.001	< 0.001	0.61	0.006	< 0.001	< 0.001
time ≥ 70% HR_{peak} (s)					−0.41	−0.55	−0.67	−0.67	−0.55	−0.55	0.43	0.32	0.50
					< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
time ≥ 80% HR_{peak} (s)						−0.24	0.14	0.20	0.17	−0.05	−0.16	−0.15	−0.10
						0.018	0.12	0.03	0.059	0.57	0.81	0.089	0.27
time ≥ 90% HR_{peak} (s)							0.61	0.36	0.40	−0.04	−0.28	−0.29	−0.38
							< 0.001	< 0.001	< 0.001	0.65	0.004	0.003	< 0.001
HR_{end} (beat·min^{-1})								0.71	0.69	−0.04	−0.45	−0.60	−0.75
								< 0.001	< 0.001	0.71	< 0.001	< 0.001	<0.001
$\Delta HRR_{end\text{-}60s\ end}$ (beat·min^{-1})									0.92	−0.31	−0.69	−0.61	−0.92
									< 0.001	0.01	< 0.001	< 0.001	< 0.001
$\Delta HRR_{end\text{-}120s\ end}$ (beat·min^{-1})										−0.21	−0.74	−0.53	−0.82
										0.09	< 0.001	< 0.001	< 0.001
$RMSSD_{baseline}$ (ms)											0.28	0.55	0.33
											0.021	< 0.001	0.007
$RMSSD_{end}$ (ms)												0.48	0.67
												< 0.001	< 0.001
$R\text{-}R_{baseline}$ (ms)													0.63
													< 0.001

CR10-RPE: rating of perceived exertion category ratio 10 scale; $HR_{baseline}$: heart rate baseline; HR_{mean}: heart rate mean; $\%HR_{peak}$: percentage of heart rate peak; time ≥ 70% HR_{peak}: time between 70% and 80% of the heart rate peak; time ≥ 80% HR_{peak}: time between 80% and 90% of the heart rate peak; time ≥ 90% HR_{peak}: time between 90% and 100% of the heart rate peak; HR_{end}: heart rate at the end of exercise; $\Delta HRR_{end\text{-}60s\ end}$: change between the heart rate at the end and after 60 s of recovery; $\Delta HRR_{end\text{-}120s\ end}$: change between the heart rate at the end and after 120 s of recovery; $RMSSD_{baseline}$: the root mean square of successive differences between R–R intervals at baseline; $RMSSD_{end}$: the root mean square of successive differences between R–R intervals at end; $R\text{-}R_{baseline}$: interval between two successive R waves at baseline; $R\text{-}R_{end}$: interval between two successive R waves at end. For time ≥ 70% HR_{peak}, time ≥ 80% HR_{peak}, and time ≥ 90% HR_{peak} the correlation coefficient is Kendall's τ b.

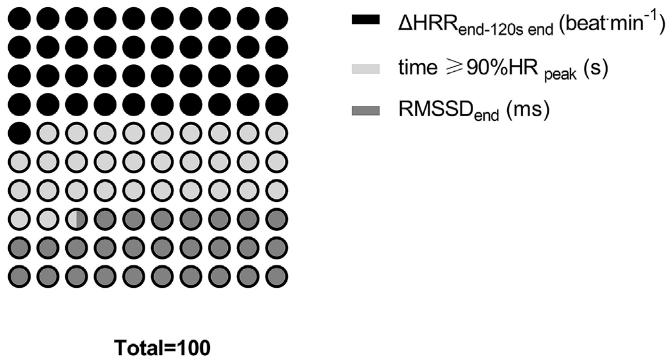

Fig. 4. Percent participation of the variables identified in the regression analysis. $\Delta HRR_{end\text{-}120s\ end} = 40.8\%$; time $\geq$ 90% HR_{peak} = 31.6%; and $RMSSD_{end}$ = 27.6% on the total FS ($n = 68$, four training sessions for each individual). Time $\geq$ 90% HR_{peak}: time between 90% and 100% of the heart rate peak; $\Delta HRR_{end\text{-}120s\ end}$: change between the heart rate at the end and after 120 s of recovery; $RMSSD_{end}$: the root mean square of successive differences between R–R intervals at end.

protocol elicited positive affective valence and moderate physiological stress; thus, may be feasible in real-world scenarios for physically active young adults. In fact, this real-world based sSIT improved endurance capacity[24] in university students, showing its efficacy despite a reduced exercise volume. Overall, this evidence confirms that low-volume sSIT was a well-tolerated interval training approach, which could improve compliance with PA recommendations; specifically, for vigorous PA which is practically null in young adult populations.[4] As well, our protocol was applied with affordable tools; that is, HR monitors (any smartwatch can measure) and perception scales, using basketball court that could be on any university campus, making it easier to implement and reproducibility.

Due to the association between affective valence and exercise participation throughout long-term interval training interventions,[8] it seems important to identify its potential physiological and psychological predictors along exercise such as SIT and sSIT.

In general, our results show no significant correlations between participants' baseline clinical characteristics and *FS*. Although, a significant negative relationship was found between body fat and *FS* ($r = -0.67$; $p = 0.003$; large) (Table 3). This outcome means that individuals who had greater adiposity elicited a higher level of displeasure throughout the sSIT sessions. According to our knowledge, this is the first study that detects associations between body composition and affective valence during interval training. Nevertheless, our results should be taken with caution since we did not use the gold standard for measuring body composition such as DEXA. Additionally, no significant correlations were revealed between participants' physical and psychological responses during sSIT, or cardiac autonomic indices post-sSIT and affective valence (Table 4, Fig. 3). More recently, it was showed significant correlations between affective valence and PA level ($r = 0.34$ to 0.37) as well as exercise RPE ($r = -0.61$ to -0.82), and RPE in the recovery periods ($r = -0.35$ to -0.69) in all moments (beginning: 1–3 intervals; middle: 4–7 intervals; end: 8–10 intervals), and $\%HR_{peak}$ ($r = -0.27$) at the end of a low-volume HIIT session (10 × 60 s at 90% of maximal treadmill velocity) in young men.[30] Currently, it was detected in healthy young men a very high level of correlation between the FS response and RPE in 3 types of interval training approaches (10 × 1 min at 90% peak power/1 min at 50% peak power; 10 × 1 min at 100% peak power/1 min at 40% peak power; 10 × 1 min at 110% peak power/1 min at 30% peak power [$r > 0.8$]).[73] These data coincide with the observations of Ramalho Oliveira et al.[32] who demonstrated that the greatest predictor of the affective valence was RPE ($R^2 = 0.68$; $p = 0.01$). Furthermore, in 71 young adults, it was exhibited a significant correlation between changes in affective valence and blood lactate concentration ($r = -0.21$; $p = 0.03$), change in RPE ($r = -0.59$; $p < 0.001$), and enjoyment ($r = 0.25$; $p = 0.03$), yet there was no association with baseline $\dot{V}O_{2max}$ ($r = 0.11$; $p = 0.16$).[29] Also, Bradley et al.[60] proposed that the exercise tolerance may condition the pleasure/displeasure dichotomy along sSIT, yet our data show that cardiorespiratory fitness is not associated with this response (Table 3). Similarly, it was demonstrated analogous *FS* responses to 2 × 20 s sprints in adults with below average versus above average $\dot{V}O_{2max}$.[20] Additionally, when we analyze another "all-out" modality with short bouts, for example; performed with body weight (i.e. high-intensity functional training), cardiorespiratory fitness did not influence affective valence.[74]

On the other hand, da Silva et al.[28] observed that changes in HRV using two different power-domain parameters (i.e. low-frequency $r = -0.34$; $p < 0.05$ and low-frequency/high-frequency ratio $r = -0.33$; $p < 0.05$) were related to displeasure at intensities in the severe domain. Our results show that $RMSSD_{end}$ ($R^2 = 27.6\%$; $p = 0.025$) and $\Delta HRR_{end\text{-}120s\ end}$ ($R^2 = 40.8\%$; $p = 0.002$) were significant in-task predictors of affective valence (Fig. 4). Therefore, our results indicate that when vagal reactivation was affected, the affective valence decreases. This response is potentially associated with a greater contribution of anaerobic metabolism,[75] especially during the second min of recovery.[76,77] In fact, we noted a significant negative correlation between $RMSSD_{end}$ and HR_{mean}, $\%HR_{peak}$, time ≥ 70% HR_{peak}, time ≥ 90% HR_{peak}, and HR_{end} ($r \geq -0.28$; $p > 0.05$). Previously, it was discovered a negative correlation between time spent above the respiratory compensation point ($r = -0.59$) and affective valence in inactive overweight men.[78] Moreover, our results show that another significant predictor of FS response is time ≥ 90% HR_{peak} ($R^2 = 31.6\%$; $p = 0.001$) (Fig. 4). Overall HR-based measures of stress and recovery during and post-exercise can predict affective valence in response to sSIT. Nevertheless, it seems that the predictors of affective valence may vary according to the specific interval training regimen used.

From a practical perspective, our study demonstrated that "all out" running-based sSIT may be a feasible exercise approach to elicit positive affective valence in physically active university students to prevent the risk to develop cardiometabolic disease with aging. This point may be important for this population given that only 30% comply with PA recommendations,[3] and more time-efficiency exercise strategies in real-world contexts are necessary.[34,79] In addition, based on individuals' time spent ≥ 90% HR_{peak}, $\Delta HRR_{end\text{-}120s\ end}$, and $RMSSD_{end}$, which are easily accessible using most HR monitors, it seems possible to predict the affective valence responses to sSIT. Thus, these variables would allow individual adjustments to be made for the next sSIT session, as decreasing the number of bouts and/or increasing the recovery time between each bout therefore manipulating affective responses.

This study has some limitations. First, we recruited 17 moderately active adults, although the sample size was estimated, future works should recruit a larger number of participants due to possible smaller effect sizes than estimated for this work. Our findings do not apply to less active individuals or clinical populations. Nevertheless, present evidence suggested that obese peoples experienced equal or greater pleasure and enjoyment across interval training regarding to MICT.[80] Upcoming studies should investigate the psychological effects of sSIT compared to interval training or MICT regimens in these clusters. Second, the impact of the menstrual cycle was not controlled. Third, given that we assessed affective valence immediately post-exercise, we do not rule out the occurrence of "affective rebounding"[26]; however, this seems unlikely since recent studies with sSIT observed the lowest value immediately post-session.[18,21–23,25,59,60] Fourth, post-exercise HRV was evaluated during a vagal reactivation phase. Future studies should evaluate HRV after 2–3 min of recovery[76] to capture vagal modulations during a stationary state. Likewise, future studies should include lactate measurements, which would allow identifying the influence of anaerobic metabolism on affective valence. Fifth, whether self-selected versus fixed recovery intervals during sSIT optimize psychological responses are unclear. Current evidence proposed that self-selected recovery have the same affective valence[81] but greater enjoyment and autonomy versus fixed recovery across interval training modalities[81,82]; without affecting acute mechanical and cardiorespiratory responses.[81,82] Sixth, subsequent studies should investigate the impact of increasing or decreasing load along sSIT.[83] Finally, previous findings show that RPE-based exercise prescription can improve maximal aerobic power.[84] However, the long-term effects of *FS*-based exercise programs have not yet been investigated, which would be appropriate to analyze in upcoming studies.

5. Conclusion

Our findings suggest that HR-based measures of in-task stress (time $\geq$ 90% HR_{peak}) and post-task recovery ($\Delta HRR_{end\text{-}120s\ end}$, and $RMSSD_{end}$) are related to affective valence in real-world based low-volume sSIT sessions in physically active young adults.

Ethical approval statement

(1) Informed consent from each participant was collected; (2) the study was reviewed and received approval to implement by the Ethics Committee of Instituto Superior de Educación Física, Universidad de la República, Uruguay (2/2020 and date of final approval November 4, 2020); and (3) the study was implemented in accordance with the Declaration of Helsinki.

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CRediT authorship contribution statement

Stefano Benítez-Flores: Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Flávio A. de S. Castro:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation. **Eduardo Caldas Costa:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis. **Daniel Boullosa:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis. **Todd A. Astorino:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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