Affective and enjoyment responses to a high-intensity interval exercise with elastic resistance

Respuestas afectivas y de disfrute a un ejercicio interválico de alta intensidad con resistencia elástica

Authors

Lenice Brum Nunes [1]
Leticia Nascimento Santos Neves [1]
Victor Hugo Gasparini Neto [1]
Carla Zimerer [1]
Lorena Flores Duarte [1]
Eduardo Matta Mello Portugal [2]
Richard Diego Leite [1]
Luciana Carletti [1]

[1] Federal University of Espirito Santo (Brasil)
[2] Federak University of Rio de Janeiro (Brasil)

Corresponding author:
Lenice Brum Nunes
Lenicenunes09@gmail.com

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Abstract

Introduction: Positive affective and enjoyment responses have been linked to longer-term adherence to exercise. Exercise intensity influences affective responses and enjoyment, but it is still unclear whether a new type of high-intensity exercise consisting of running with elastic resistance fixed in a belt can evoke positive or negative psychophysiological responses.
Objective: This study compared affective, enjoyment, and physiological responses between high-intensity interval training on a treadmill (HIIT) and high-intensity interval training with elastic resistance (EL-HIIT).
Methodology: Eighteen healthy adults (8 men and 10 women; 26.6 ± 3.9 years) participated in randomized HIIT and EL-HIIT sessions. Each session consisted of 10 × 1-minute intervals at ~85-90% $\dot{V}O_{2max}$ with 1-minute passive recovery intervals. Affective responses were assessed before, during (at the end of each effort), and 10 minutes after each session, while enjoyment responses were assessed post-session. A two-way ANOVA was used to compare responses before, during, and after each session, and a paired t-test for post-session differences.
Results: The EL-HIIT session elicited less positive affective responses during the session compared to HIIT ($p < 0.05$). Ten minutes after EL-HIIT, the affective response was more positive, and both sessions exhibited a high level of enjoyment.
Discussion: EL-HIIT and HIIT provided similar positive affective, enjoyment, self-efficacy, and future intention. The results are similar to those of studies that applied HIIT protocols.
Conclusions: Although AR declined during the session, neither protocol resulted in a negative psychological response. EL-HIIT and HIIT provided similar positive affective, enjoyment, self-efficacy, and future intention responses after exercise.

Keywords

Affective responses; enjoyment; exercise; high-intensity interval training; psychological responses.

Resumen

Introducción: Las respuestas afectivas y de disfrute positivas se han vinculado con la adherencia al ejercicio a largo plazo. La intensidad del ejercicio influye en las respuestas afectivas y el disfrute, pero aún no está claro si un nuevo tipo de ejercicio de alta intensidad, consistente en correr con resistencia elástica fijada en una cinta, puede generar respuestas psicofisiológicas positivas o negativas.
Objetivo: Este estudio comparó las respuestas afectivas, de disfrute y fisiológicas entre el entrenamiento a intervalos de alta intensidad en cinta de correr (HIIT) y el entrenamiento a intervalos de alta intensidad con resistencia elástica (EL-HIIT).
Metodología: Dieciocho adultos sanos (8 hombres y 10 mujeres; 26,6 ± 3,9 años) participaron en sesiones aleatorizadas de HIIT y EL-HIIT. Cada sesión consistió en 10 intervalos de 1 minuto al ~85-90 % del $VO_{2máx}$ con intervalos de recuperación pasiva de 1 minuto. Las respuestas afectivas se evaluaron antes, durante (al final de cada esfuerzo) y 10 minutos después de cada sesión, mientras que las respuestas de disfrute se evaluaron después de la sesión. Se utilizó un ANOVA de dos vías para comparar las respuestas antes, durante y después de cada sesión, y una prueba t pareada para las diferencias posteriores a la sesión.
Resultados: La sesión de EL-HIIT generó menos respuestas afectivas positivas durante la sesión en comparación con el HIIT ($p < 0,05$). Diez minutos después del EL-HIIT, la respuesta afectiva fue más positiva y ambas sesiones mostraron un alto nivel de disfrute.
Discusión: El EL-HIIT y el HIIT proporcionaron resultados similares en afectividad positiva, disfrute, autoeficacia e intención de futuro. Los resultados son similares a los de estudios que aplicaron protocolos de HIIT.
Conclusiones: Aunque la RA disminuyó durante la sesión, ninguno de los protocolos resultó en una respuesta psicológica negativa. El EL-HIIT y el HIIT proporcionaron resultados similares en afectividad positiva, disfrute, autoeficacia e intención de futuro después del ejercicio.

Palabras clave

Respuestas afectivas; disfrute; entrenamiento interválico de alta intensidad; ejercicio; respuestas psicológicas.

Introduction

Recently, there has been growing interest in investigating the psychological responses elicited by physical exercise. When exercise generates positive affective and enjoyment responses, individuals are more likely to engage in future exercise sessions. (Brand & Ekkekakis, 2018; Williams et al., 2008). However, exercise intensity influences affective responses (AR) and enjoyment.

According to the dual-mode theory, certain factors prevalent at high intensities (i.e., above the second lactate and ventilatory threshold), such as metabolic acidosis, pain, and fatigue, may promote negative AR. Conversely, AR tends to be predominantly positive at low intensities, below the first ventilatory threshold. Furthermore, at moderate intensities, situated between the ventilatory thresholds, there is considerable interindividual variability, with some individuals reporting positive AR while others experience negative. At this intensity, cognitive factors, such as self-efficacy defined as an individual's confidence in their ability to complete a task or demand appear to exert a more substantial influence on determining AR (Ekkekakis, 2003; Ekkekakis et al., 2011)

The intermittent nature of high-intensity interval training (HIIT) elicits distinct AR compared to continuous high-intensity exercise. (Niven et al., 2018). For example, the variation between high-intensity and low-intensity or rest recovery can alleviate feelings of monotony, while the brief duration of high-intensity effort may enhance the tolerability of HIIT. Consequently, this phenomenon may foster positive affective and enjoyment responses (Bartlett et al., 2011; Reljic et al., 2019; Thum et al., 2017).

HIIT is characterized by repeated high-intensity efforts and recovery at active low-intensity or passive rest periods. The literature also presents it as an effective alternative for promoting adherence to a regular physical exercise program (Reljic et al., 2019) , as it improves cardiorespiratory fitness (V̇O2max) and metabolic health. Additionally, a HIIT session is typically shorter than a moderate-intensity continuous training (MICT) session, which may further enhance adherence among individuals who cite a lack of time as a reason for not exercising regularly (Buchheit & Laursen, 2013; Gibala et al., 2014; Way et al., 2020)

Studies examining AR and enjoyment in traditional HIIT protocols (e.g., treadmill and cycle ergometer) have shown a decline in positive AR during the session, followed by a return to positive values post-session, along with elevated levels of enjoyment (Niven et al., 2021; Tavares et al., 2021). Therefore, while HIIT may be potentially unfavorable for AR due to its high intensity, nonetheless the opportunity for recovery between exercise sets may help mitigate monotony and enhance self-efficacy when individuals perceive themselves as capable of performing at high intensity (Bartlett et al., 2011; Dunston & Taylor, 2023).

New proposals for applying HIIT using methods other than traditional ergometers are emerging in the literature. HIIT protocols incorporating aerobic and muscle-strengthening stimuli (e.g., bodyweight HIIT and functional training) have gained popularity. These protocols can be performed with minimal space and do not require specialized equipment (Ballesta-García et al., 2019; Zovico et al., 2024). Furthermore, different HIIT modalities compared to traditional treadmill-based HIIT, can induce varying levels of physiological stress, even at similar relative intensities, due to movement characteristics that increase muscular demands, such as enhanced recruitment and contraction patterns (Bellissimo et al., 2022; Neves et al., 2023).

In the high-intensity interval exercise with elastic resistance (EL-HIIT), participants wear a hip-enforced belt attached to an elastic tube, performing high-intensity forward and backward runs. This approach utilizes elastic resistance that can increase muscular activation and cardiorespiratory demand, providing a portable, cost-effective, and accessible HIIT option for public fitness settings (Gasparini-Neto et al., 2022; Neves et al., 2023). Neves et al., 2023 demonstrated, that performing EL-HIIT requires significant cardiorespiratory effort and muscular strength, particularly in the lower limbs, which may further enhance the intensity of the exercise compared to HIIT on the treadmill.

Furthermore, the EL-HIIT has the potential to be applied in practical contexts and real-world settings due to its applicability and relevance across diverse populations, providing functional and accessible solutions (Gasparini-Neto et al., 2021; Le Scouarnec et al., 2022). However, despite its practical utility in exercise programs, the impact of EL-HIIT on AR and enjoyment, which are crucial for exercise adherence and long-term maintenance, remains unclear. This modality may elicit distinct physiological and perceptual responses due to differences in movement patterns and the additional elastic resistance during tethered running (Bogdanis et al., 2021). It is important to advance the understanding of the psychological and physiological parameters altered during an EL-HIIT session, so we aim to compare them to traditional treadmill-based HIIT and to determine whether this new modality can favorably influence affective and enjoyment responses. We hypothesize that EL-HIIT and HIIT will significantly increase enjoyment while reducing affective responses during the session, which is typical of HIIT protocols. Although EL-HIIT represents a novel exercise approach, incorporating innovative exercise modalities may enhance enjoyment and positively influence long-term adherence (Lakicevic et al., 2020).

Method

Participants

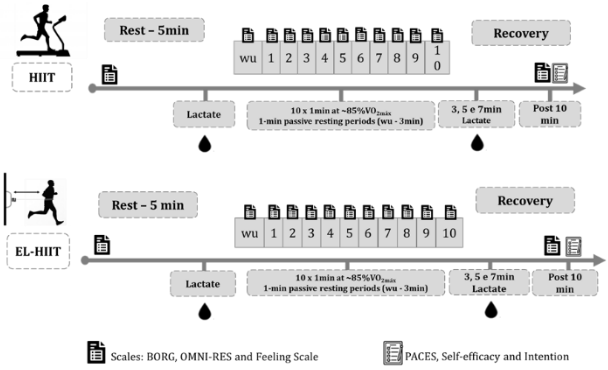
Eighteen healthy adults (8 men and 10 women) with mean age, body mass index (BMI), and maximum oxygen consumption ($\dot{V}O2max$) of 26.6 ± 3.9 years, 22.5 ± 2.5 kg/m^2, and 42.91 ± 6.0 ml·kg^{-1}·min^{-1}, respectively, participated in the study. The sample size was used to determine a relevant effect on the primary outcome variable (AR), and evidence from previous studies was utilized. (Martinez et al., 2015), it was determined a priori using a statistical power of 80%, suggesting 18 participants (two-way ANOVA; effect size: moderate, alpha error: 5%; software G*Power 3.1). The following inclusion criteria were adopted: male and female sex, body mass index (≥ 18 and ≤ 25 kg·m−2), age between 18 and 35 years, and physically independent adults (engaging in physical activity for ≥ 150 min per week). Exclusion criteria included cardiopulmonary or metabolic diseases, medical contraindications that could impede participation in tests or protocols, dietary supplements or anabolic steroids, and suspected respiratory tract infections (e.g., COVID-19). BMI was calculated using a digital anthropometric scale with a stadiometer (Marte Científica, L200, São Paulo) by assessing body mass and height.

Procedure

A cross-sectional randomized study was conducted with the approval of the Human Research Ethics Committee of the Federal University of Espírito Santo (CAAE: 09109319.2.0000.5542). The study adhered to the principles outlined in the Declaration of Helsinki. All participants were informed of the potential risks and benefits, provided written informed consent, and were familiarized with the experimental procedures before the study.

Four visits were conducted at the Exercise Physiology Laboratory (LAFEX/UFES), with a minimum interval of seven days between each visit. During the first visit, participants were familiarized with the psychological and anthropometric measurements. Subsequently, a cardiopulmonary treadmill test was administered to determine the exercise session's intensity, corresponding to 85-90% of $\dot{V}O2max$. The second visit involved further familiarization with psychological measurements and an incremental test using elastic resistance to prescribe the session at a stage corresponding to 85-90% $\dot{V}O2max$. The exercise sessions were conducted during the third and fourth visits, with the order of sessions randomized.

Figure 1. Experimental design of the sessions



HIIT: high-intensity interval training on a treadmill; EL-HIIT: high-intensity interval training with Elastic Resistance; Lactate: blood lactate concentration; wu: warm-up.

Cardiopulmonary exercise test (CPx)

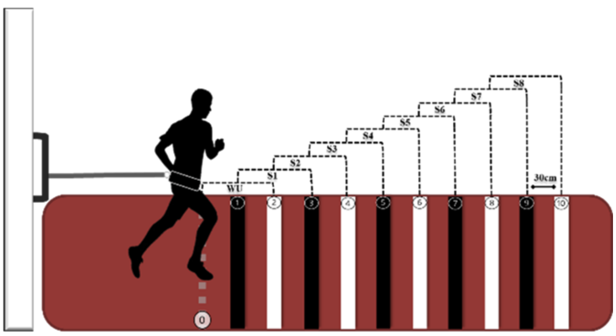
The test was conducted on a motorized treadmill (Inbra Sports Super ATL, Porto Alegre, Brazil). A warm-up was performed at 4 km/h for 3 minutes, maintained at a 1% incline. A ramp protocol was used, where the speed increased by 1 km/h every minute until exhaustion, targeting a duration between 6 and 12 minutes. Ventilatory variables were measured using a metabolic gas analyzer (Cortex Metamax 3B, Germany) with breath-by-breath data collection, and analyzed using the Metasoft™ software. To confirm that the test reached maximal effort, at least three of the following criteria were required: a) exhaustion; b) attainment of a maximum heart rate (HR) of at least 90% of the age-predicted maximum (220-age); c) a respiratory exchange ratio of 1.05 or greater; d) a plateau or peak in oxygen consumption (V̇O2max). The Metasoft™ software was used to calculate the relative V̇O2max, with the average of the final 30 seconds of the test considered for analysis.

Cardiopulmonary exercise test with elastic resistance (CPxEL)

The cardiopulmonary exercise test with elastic desistance (CPxEL) was conducted on a rubber mat marked with 11 lines, each 5 cm thick and spaced 30 cm apart, covering an area of 4.50 meters in length and 1.00 meters in width. The lines were painted in alternating colors (white and black) to designate different test stages, ranging from 1 to 8, as described by (Gasparini-Neto et al., 2022). Participants wore an adjustable belt with a reinforced clasp, to which a 2-meter silver elastic tube (TheraBand®, Akron, OH, USA) was securely attached. The test protocol required participants to perform alternating forward and backward steps while resisting the elastic tension, maintaining a continuous back-and-forth movement pattern. For more can be accessed at https://doi.org/10.52082/jssm.2022.426.

Following a 3-minute warm-up, the protocol consisted of increments of one stage per minute. Participants were instructed to synchronize their movements with a regulated cadence set by a metronome (Cell Phone Application – CifraClub®). The metronome was set at 180 beats per minute (bpm) during the warm-up and increased to 200 bpm for the subsequent test stages. The CPxEL was performed until the participants reached volitional exhaustion. The same standardized procedures and maximal test criteria were applied in consistency with CPx.

Figure 2. Cardiopulmonary exercise test with elastic resistance.



Cardiopulmonary exercise test with elastic resistance. The movement consisted of rhythmic movements (200 bpm) back and forth until maximum exhaustion. The test contained 8 stages, and the warm-up was performed between line 0 and line 2.

HIIT and EL-HIIT sessions

The HIIT session started with a 3-minute warm-up at 4 km·h−1. This was followed by 10 intervals of 1 min of work at a velocity corresponding to 85-90% of V̇O2max (as determined in the cardiopulmonary exercise test), each followed by 1 min of passive rest. The total time exercise was 23 min.

The EL-HIIT session started with a 3-minute warm-up with a cadence of 180 bpm. This was followed by 10 intervals of 1 min of work at a stage corresponding to 85-90% of V̇O2max (as determined in the CPxEL test), each followed by 1 min of passive rest, with a cadence of 200 bpm during the work intervals. The total time exercise was 23 min. The protocol used in the present study was applied in previous studies (Duarte et al., 2023; Gillen et al., 2013; Neves et al., 2023).

Measurements

Heart rate, V̇O2max, and peak blood lactate concentration

Heart rate was continuously monitored during the sessions using the POLAR T31 coded™ heart rate sensor (Polar Electro Oy, Kempele, Finland). V̇O2 was also continuously monitored and evaluated using Metasoft™ software. The average of the last 10 seconds of each interval was calculated to determine the intensity achieved during the sessions, expressed as a percentage of %HRmax and %V̇O2max.

To characterize the metabolic stimulus induced by the protocol, the blood lactate concentration at rest and the peak lactate were evaluated, considered the highest value of the measurements at 3-, 5- and 7-minutes post-exercise. Blood samples (50 μL) were collected from the earlobe and analyzed using an electroenzymatic method (YSI 2300 STAT; Yellow Springs Inc., Yellow Springs, OH, USA).

Affective Responses (AR)

AR was assessed using the feeling scale (FS). The FS is an 11-point scale ranging from -5 ("very bad") to +5 ("very good"), which assesses the feeling of pleasure/displeasure provided by physical exercise. The volunteers replied, “How are you feeling now?" (Hardy; Rejeski J. W, 1989). The FS was administered at three time points: before exercise (baseline), immediately after each bout, due to the short duration of HIIT, and 10 min post-exercise.

Rating Perceived Effort

The Borg Scale (CR-10) was applied to measure the rating of perceived effort at the central level. The scale ranges from 0 (rest) to 10 (maximum effort). The OMNI-RES EB scale was adapted for elastic resistance with Thera-Band® (Thera Band®, Akron, OH, USA) for the peripheral effort, the scale ranges from 0 (extremely easy) to 10 (maximum effort). Both scales were applied at warm-up, immediately after each bout, and 10 min post-exercise of the sessions (Colado et al., 2014; Foster et al., 2001).

Enjoyment, self-efficacy, and future intention to exercise

The original 18-item Physical Activity Enjoyment Scale (PACES) was used to assess enjoyment 10 minutes after the exercise sessions. Participants rated their feelings about the physical activity performed using a 7-point bipolar rating scale, where higher PACES scores indicate greater enjoyment (Mullen et al., 2011).

Self-efficacy and future intention to exercise were assessed 10 min after the sessions. Self-efficacy and future exercise intentions were also evaluated 10 minutes after the sessions. Self-efficacy was measured using a single-item scale adapted from the McAuley Exercise Self-Efficacy Scale (Mcauley et al., 1993). Participants were asked, “How confident do you feel performing this exercise session?” with response options ranging from 0% (not at all confident) to 100% (extremely confident). To assess future exercise intentions, participants indicated their intent using a single-item scale with the question: “What is your intention to participate in this type of exercise session in the future?” The response options ranged from 0% (no intention) to 100% (strong intention) (Focht et al., 2007).

Data analysis

The Shapiro-Wilk test, and to evaluate by histogram, kurtosis, and asymmetry (-1 and 1) was applied to test normality. Data with normal distribution was represented by mean ± standard deviation. The median and interquartile range were used to show data that did not present a normal distribution (MED[IQR]) was applied to ensure the robustness of the analysis and minimize the risk of biased conclusions due to non-normal distributions or unequal variances. The paired t-test was used to compare the differences between HIIT vs. EL-HIIT on physiological parameters (HR, %HRmax, V̇O2, %V̇O2max, and blood lactate concentration) and enjoyment. Two-way ANOVA for repeated measures and Tukey post hoc (moments x protocols) were used to analyze AR, BORG-CR10, and OMNI-RES EB. For non-parametric variables, self-efficacy, and intention between the two protocols, the Wilcoxon test was used to compare measures. This test was applied to ensure the robustness of the analysis and minimize the risk of biased conclusions due to non-normal distributions or unequal variances. Cohen's d-effect size (ES) was calculated and classified as trivial (0–0.19), small (0.20–0.49), moderate (0.50–0.79), and large (≥ 0.8) to determine the magnitude of differences. Analyses were conducted using GraphPad Prism 8.0.1 software.

Results

Physiological parameters

In the comparative analysis of physiological parameters between HIIT on the treadmill and EL-HIIT, higher values were observed for heart rate (HR), percentage of maximum heart rate (%HRmax), oxygen consumption ($\dot{V}O2$), percentage of maximum oxygen consumption (%$\dot{V}O2max$), and blood lactate concentration ($mmol \cdot L^{-1}$) in the EL-HIIT condition. Specifically, the mean differences were 15 bpm, 7.7%, 3.6 $ml \cdot kg^{-1} \cdot min^{-1}$, 14.4%, and 2.7 $mmol \cdot L^{-1}$, respectively, higher for EL-HIIT. (Table 1)

Table 1. Physiological parameters of HIIT and EL-HIIT

Parameters	HIIT	EL-HIIT	ES	p
HR (bpm)	160 ± 13	175 ± 14*	1.07^{L}	< 0.001
$\%HR_{max}$	84.30 ± 5.81	92.03 ± 5.95*	1.35^{L}	< 0.001
$\dot{V}O_2$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	34.11 ± 1.17	37.67 ± 1.09*	0.87^{L}	< 0.001
$\%\dot{V}O_{2max}$	80.01 ± 7.36	91.45 ± 6.49*	2.14^{L}	< 0.001
Blood lactate ($mmol \cdot L^{-1}$)	3.48 ± 0.99	6.22 ± 2.88*	1.30^{L}	< 0.001

Mean ± standard deviation; HIIT: high-intensity interval training; EL-HIIT: high-intensity interval training with elastic resistance; HR: heart rate; $\%HR_{max}$: percentual of maximum heart rate; $\dot{V}O_2$: oxygen consumption; $\%\dot{V}O_{2max}$: percentual of maximum oxygen consumption; ES: effect size; L: large effect; *Difference between HIIT and EL-HIIT.

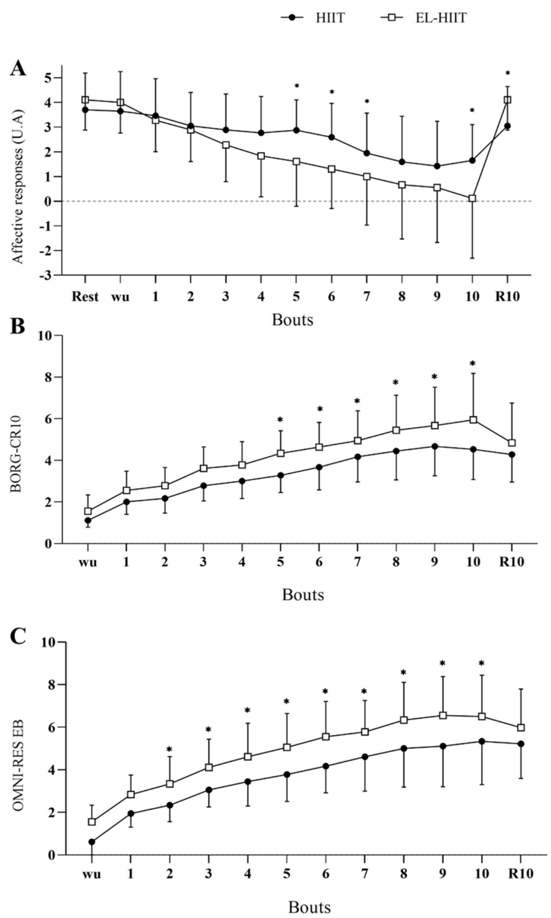
AR, BORG CR-10 e OMNI-RES EB

There was a significant interaction between time points and protocols for affective response (AR) [F(12. 204) = 8.253; $p < 0.05$]. Additionally, a significant effect of time was observed for both HIIT and EL-HIIT [F(12. 204) = 23.00; $p < 0.05$], although no significant effect was found between the two protocols [F(1. 17) = 2.208; $p > 0.05$]. Post-hoc analyses revealed that AR during the EL-HIIT session was less positive compared to HIIT at effort intervals 5, 6, 7, and 10. However, AR 10 minutes post-exercise was more positive for EL-HIIT (Figure 2). For HIIT, AR at rest was more positive than during several moments of the session and immediately after, with significant differences at intervals 7, 8, 9, and 10, but no significant difference was observed 10 minutes post-exercise. In contrast, for EL-HIIT, AR at rest was more positive than at effort intervals 2, 3, 4, 5, 6, 7, 8, 9, and 10, with no difference observed 10 minutes post-exercise ($p < 0.05$).

Furthermore, for the BORG CR-10 scale, there was no significant interaction between protocols [F(11. 187) = 1.280; $p > 0.05$]. However, there was a significant main effect of both protocols [F(1. 17) = 10.48; $p < 0.05$] and time points [F(11. 187) = 59.01; $p < 0.05$]. Post-hoc analysis revealed that BORG CR-10 values were higher for EL-HIIT compared to HIIT during effort intervals 5, 6, 7, 8, 9, and 10 (Figure 3).

For OMNI-RES EB values, there was no interaction between protocols and time points [F(11. 187) = 0.6116; $p > 0.05$]. However, there was a significant main effect for both protocols [F(1, 17) = 11.42; $p < 0.05$] and time points [F(11. 187) = 104; $p < 0.05$]. OMNI-RES EB values were higher for EL-HIIT compared to HIIT at time points 2, 3, 4, 5, 6, 7, 8, 9, and 10. No significant difference was observed between HIIT and EL-HIIT 10 minutes post-exercise (Figure 3).

Figure 3. Comparison of AR, BORG CR-10, and OMNI-RES EB between EL-HIIT and HIIT.



Mean ± standard deviation; A: Mean values of affective response; B: Mean values of subjective perception of effort BORG-CR10; C: Mean values of subjective perception of effort OMNI-RES EB; wu: warm-up; R10: Recovery 10 min later; * Significant difference between to HIIT.

PACES, Self-efficacy, and Future intention to exercise

There was no significant difference in PACES values between HIIT (106.2 ± 14.1) and EL-HIIT (107.2 ± 15.1) (p = 0.61; ES = 0.07 - trivial). The median self-efficacy score was 100 - extremely confident (95% CI: 90-100), and the IQR was 100-100 for the HIIT group. And for EL-HIIT the median also presented values of 100 (95% CI: 60-100), and the IQR was 100-100 (Z = 1.069; p= 0.50). Furthermore, no significant difference was found in future exercise intention (n = 12) between HIIT which presented a median of 97.5 (95% CI: 50-100%) and IQR of 72.5-100. EL-HIIT presented median values of 100 (95% CI: 50-100%) and IQR 76-100 (Z = -0.314; p= 0.84). Thus, in both protocols, participants reported values indicating a strong intention to exercise.

Discussion

This study compared the psychological and physiological responses between EL-HIIT and traditional treadmill-based HIIT, using a 1:1 work-to-rest ratio, in healthy adults. Our primary finding revealed that the EL-HIIT exhibited a more significant decrease in AR between the middle and the end of the session. The main findings suggest that although AR declined during the session, neither protocol resulted in a negative psychological response. Additionally, the intensity values (%HRmax, %V̇O2max, blood lactate, BORG CR-10, OMNI-RES EB) observed during EL-HIIT were higher than those in treadmill HIIT. As previously reported in studies, both modalities exhibit cardiorespiratory responses characteristic of HIIT. However, their distinct characteristics contribute to particular physiological outcomes (Duarte et al., 2023; Neves et al., 2023). Furthermore, EL-HIIT produced acute positive psychological responses post-exercise (AR, enjoyment, self-efficacy, and future intention) similar to those of treadmill HIIT. Our hypothesis that both protocols would show a decline in AR during exercise, followed by a return to baseline values post-session, was confirmed. Additionally, the hypothesis that EL-HIIT and treadmill HIIT would elicit high levels of enjoyment was also supported.

It is well-established that exercise intensity modulates AR (Marques et al., 2020; Oliveira et al., 2018), which may explain the slightly greater decline in AR during EL-HIIT compared to treadmill HIIT. In the present study, both protocols were prescribed at similar intensity and volume levels, based on comparable submaximal parameter values obtained from cardiopulmonary exercise testing. Despite this, our data show EL-HIIT elicited a higher intensity response across all measured parameters, both subjective and objective, compared to treadmill HIIT. BOGDANIS et al., 2021 compared a similar prescription of a session of HIIT, realized in two modalities (treadmill and cycle ergometer) using a protocol 10x 1min (work): 1min (rest) and similar relative intensities, and found physiological and perceptual responses different for both modalities of HIIT. However, there is no significant difference in AR and enjoyment (Bogdanis et al., 2021). Our results partially agree as both treadmill HIIT and EL-HIIT demonstrated high levels of enjoyment, with no significant differences observed between the two modalities. This finding may explain a slightly greater decline found in EL-HIIT, according to the dual model theory, at higher intensities, the interoceptive pathway becomes predominant (e.g., increased heart rate, respiratory rate, metabolic acidosis, pain, and fatigue), which can lead to negative AR during exercise (Ekkekakis, 2003; Ekkekakis et al., 2011). Studies have shown an intensity-dependent relationship between AR and intensity during HIIT, with higher intensities causing a greater decline in AR (Jones et al., 2020; Olney et al., 2018). Despite this, both HIIT and EL-HIIT showed a decline in positive AR during the session, corroborating several studies that evaluated AR during traditional HIIT (Niven et al., 2021; Tavares et al., 2021). These results can be attributed to the fact that high-intensity exercise (continuous or interval) can be an exacerbated stressor.

However, recovery periods in interval exercise can mitigate sensations of discomfort and pain compared to continuous exercise (Bartlett et al., 2011; Tavares et al., 2021). Additionally, the frequent alternation between efforts and recovery intervals in HIIT helps maintain a relatively positive AR by reducing monotony and enhancing the sense of accomplishment, as was observed in our study (Poon et al., 2018). The present study adopted a 1:1 work-to-rest ratio, and it is suggested that using a ratio of ≥ 1:1 and efforts lasting ≤ 120 seconds in HIIT can help sustain a positive AR throughout the session, despite the natural decline in AR, and using passive recovery may be reduced a sensation of effort and tolerance to HIIT (Oliveira et al., 2018; Sánchez-Otero et al., 2022).

Regarding the AR measured 10 minutes after both EL-HIIT and HIIT, it was found to be positive and equal to the AR assessed at rest for both protocols. However, EL-HIIT demonstrated a more positive AR 10 minutes post-exercise than HIIT. This result was anticipated, as AR often exhibits a rebound effect after exercise, with values equal to or even more positive than those measured before the session (Ekkekakis, 2003; Ekkekakis et al., 2011). The rebound effect following high-intensity exercise can be attributed to the restoration of homeostasis, which leads to a return of AR to more positive values (Solomon & Corbit, 1974). Additionally, the elevated expression of neuromodulators, such as dopamine and serotonin, may account for the improvements in psychological responses observed after exercise (Portugal et al., 2013).

The higher AR measured during the exercise seems to be related to the habit of physical activity. Previous studies have shown that increases in positive AR or decreases in negative AR during physical activity (e.g., incremental exercise, free-living physical activity, and MICT) are associated with adopting higher levels of habitual physical activity (Liao et al., 2017; Rhodes & Kates, 2015; Williams et al., 2008). However, this finding was not confirmed in some studies on HIIT (Ivanova et al., 2022; Stork et al., 2018, 2023), which requires investment in more studies to clarify this point.

On the other hand, examining the AR experienced after HIIT could offer valuable insights for enhancing exercise adherence (Santos et al., 2021). Psychological measures taken post-exercise in the context of HIIT may serve as more effective predictors of continued engagement with this modality (Stork et al., 2017). For instance, several studies have reported positive AR and enjoyment following various forms of HIIT conducted over periods ranging from 2 to 12 weeks, accompanied by high rates of training adherence (Heinrich et al., 2014; Li et al., 2022; Silva et al., 2023). Consequently, EL-HIIT has been shown to promote positive AR and enjoyment after exercise, which may enhance the likelihood of adherence to these modalities. Thus, even a single session of EL-HIIT may contribute to the formation of a positive memory trace and influence future decisions to engage in this form of exercise (Brand & Ekkekakis, 2018; Ekkekakis et al., 2011).

In addition, the relationship between the acute post-exercise affective response and adherence may be linked to an increase in self-efficacy following task completion. Self-efficacy reflects the belief that one can successfully perform a task and is an important predictor of maintaining exercise behavior (Bandura, 1977; Fletcher & Banasik, 2001). In the present study, the two protocols presented similar self-efficacy values and were close to "totally confident" in performing the exercise. Furthermore, there was no difference between EL-HIIT and traditional HIIT in future intention to exercise, and both sessions presented a "strong intention". Jung et al. (2014) present similar results, reporting high values of self-efficacy and a great intention to engage in HIIT in the future (Jung et al., 2014). However, the authors have compared the psychological responses induced by HIIT with those caused by moderate and vigorous continuous exercise using only one type of exercise (cycle ergometer).

Our study compared the psychological and physiological responses of two types of HIIT (elastic resistance and treadmill), which involve different muscle contractions. In addition, EL-HIIT combines cardiorespiratory and muscle strength efforts, capable of inducing some responses that are beneficial to health (Gasparini-Neto et al., 2022; Neves et al., 2023). Furthermore, EL-HIIT produced positive affective responses, greater future exercise intention, and self-efficacy similar to those observed with treadmill-based HIIT.

EL-HIIT provides significant practical advantages, including it is adaptability to diverse contexts, environments, and populations. It is accessibility, requiring minimal equipment and space, makes it versatile for various settings. These characteristics facilitate its integration into real-world exercise programs but also enhance its potential to promote long-term adherence. However, investigating the relationship between affective responses and exercise adherence was not within the scope of this study. Nonetheless, our findings contribute to the scientific literature by presenting the AR associated with a new HIIT modality and comparing them to traditional treadmill HIIT.

Our study has some limitations: administering multiple measures and scales during brief high-intensity exercise sessions (HIIT 1:1) may have increased mental stress. Despite this, affective responses (AR) were assessed both during and after the sessions, offering a comprehensive view of the psychological impacts of the protocols. Additionally, measuring AR at the end of intervals during different types of HIIT is recommended by current evidence (Ekkekakis et al., 2023). To capture the "recovery" of AR, thereby providing a complete picture of AR behavior throughout the entire session. In addition, gas analysis during sessions may reduce the ecological validity of the study, however, percentage values of heart rate and subjective perception of effort are presented, which facilitates its application in more practical contexts. Future studies should explore long-term adherence and evaluate EL-HIIT in diverse populations, offering greater insights and supporting its broader application in exercise programs.

Conclusions

Both EL-HIIT and traditional HIIT present acute physiological responses compatible with high-intensity training. The affective responses decrease during exercise for both protocols. However, after the exercise, the EL-HIIT and traditional HIIT provoke similar positive affective, enjoyment, self-efficacy, and future intention to exercise responses.

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References

Ballesta-García, I., Martínez-González-moro, I., Rubio-Arias, J., & Carrasco-Poyatos, M. (2019). High-intensity interval circuit training versus moderate-intensity continuous training on functional ability and body mass index in middle-aged and older women: A randomized controlled trial. International Journal of Environmental Research and Public Health, 16(21). https://doi.org/10.3390/ijerph16214205

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. Psychological Review, 84(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Bartlett, J. D., Close, G. L., Maclaren, D. P. M., Gregson, W., Drust, B., & Morton, J. P. (2011). High-intensity interval running is perceived to be more enjoyable than moderate-intensity continuous exercise: Implications for exercise adherence. Journal of Sports Sciences, 29(6), 547–553. https://doi.org/10.1080/02640414.2010.545427

Bellissimo, G. F., Ducharme, J., Mang, Z., Millender, D., Smith, J., Stork, M. J., Little, J. P., Deyhle, M. R., Gibson, A. L., de Castro Magalhaes, F., & Amorim, F. (2022). The acute physiological and perceptual responses between bodyweight and treadmill running high-intensity interval exercises. Frontiers in Physiology, 13. https://doi.org/10.3389/fphys.2022.824154

Bogdanis, G. C., Mallios, V. J., Katsikas, C., Fouseki, T., Holman, I., Smith, C., & Astorino, T. A. (2021). Effects of exercise structure and modality on physiological and perceptual responses to exercise. Journal of Strength and Conditioning Research. https://journals.lww.com/nsca-jscr

Brand, R., & Ekkekakis, P. (2018). Affective–reflective theory of physical inactivity and exercise: foundations and preliminary evidence. German Journal of Exercise and Sport Research, 48(1), 48–58. https://doi.org/10.1007/s12662-017-0477-9

Buchheit, M., & Laursen, P. B. (2013). High-intensity interval training, solutions to the programming puzzle: Part I: Cardiopulmonary emphasis. In Sports Medicine (Vol. 43, Issue 5, pp. 313–338). https://doi.org/10.1007/s40279-013-0029-x

Colado, J. C., Garcia-Masso, X., Triplett, N. T., Calatayud, J., Flandez, J., Behm, D., & Rogers, M. E. (2014). Construct and concurrent validation of a new resistance intensity scale for exercise with thera-band® elastic bands. Journal of Sports Science and Medicine, 13, 758–766. http://www.jssm.org

Duarte, L. F., Gasparini-Neto, V. H., Neves, L. N. S., Nunes, L. B., Leite, R. D., de Sousa, N. M. F., & Carletti, L. (2023). A cardiopulmonary exercise testing for prescribing high-intensity interval training sessions with elastic resistance. International Journal of Environmental Research and Public Health, 20(23), 7097. https://doi.org/10.3390/ijerph20237097

Dunston, E. R., & Taylor, K. (2023). Psychological and physiological responses across six weeks of HIIT and mict in previously inactive, young adults. International Journal of Exercise Science, 16(5), 756–769. http://www.intjexersci.com

Ekkekakis, P. (2003). Pleasure and displeasure from the body: Perspectives from exercise. Cognition And Emotion, 17(2), 213–239. https://doi.org/10.1080/02699930244000282

Ekkekakis, P., Hartman, M. E., & Ladwig, M. A. (2023). A methodological checklist for studies of pleasure and enjoyment responses to high-intensity interval training: Part II. Intensity, timing of assessments, data modeling, and interpretation. Journal of Sport and Exercise Psychology, 45(2), 92–109. https://doi.org/10.1123/JSEP.2022-0029

Ekkekakis, P., Parfitt, G., & Petruzzello, S. J. (2011). The pleasure and displeasure people feel when they exercise at different intensities decennial update and progress towards a tripartite rationale for exercise intensity prescription. Sports Medice, 41(8), 641–671. https://doi.org/doi:10.2165/11590680-000000000-00000.

Fletcher, J. S., & Banasik, J. L. (2001). Exercise self-efficacy. Clinical Excellence for Nurse Practitioners, 5(3). https://doi.org/10.1054/xc.2001.24203

Focht, B. C., Knapp, D. J., Gavin, T. P., Raedeke, T. D., & Hickner, R. C. (2007). Affective and self-efficacy responses to acute aerobic exercise in sedentary older and younger adults. Journal of Aging and Physical Activity, 15(2), 123–138. https://doi.org/10.1123/japa.15.2.123

Foster, C., Florhaug, J. A., Franklin, J., Gottschall, L., Hrovatin, L. A., Parker, S., Doleshal, P., & Dodge, C. (2001). A new approach to monitoring exercise training. Journal of Strength and Conditioning Research, 15(1), 109–115.

Gasparini-Neto, V. H., Caldas, L. C., de Lira, C. A. B., Carletti, L., Leite, R. D., Nikolaidis, P. T., Knechtle, B., & Vancini, R. L. (2021). Profile of blood pressure and glycemic responses after interval exercise in

older women attending (in) a public health physical activity program. Journal of Bodywork and Movement Therapies, 25, 119–125. https://doi.org/10.1016/j.jbmt.2020.10.011
Gasparini-Neto, V. H., Neves, L. N. S., Kalva-Filho, C. A., Schwingel, P. A., Leite, R. D., & Carletti, L. (2022). Cardiopulmonary exercise testing with elastic resistance: a new reproducible proposal for determination of ventilatory thresholds and maximum oxygen consumption. Journal of Sports Science and Medicine, 21(3), 426–434. https://doi.org/10.52082/jssm.2022.426
Gibala, M. J., Gillen, J. B., & Percival, M. E. (2014). Physiological and health-related adaptations to low-volume interval training: influences of nutrition and sex. In Sports Medicine (Vol. 44, pp. 127–137). Springer International Publishing. https://doi.org/10.1007/s40279-014-0259-6
Gillen, J. B., Percival, M. E., Ludzki, A., Tarnopolsky, M. A., & Gibala, Martin. J. (2013). Interval training in the fed or fasted state improves body composition and muscle oxidative capacity in overweight women. Obesity, 21(11), 2249–2255. https://doi.org/10.1002/oby.20379
Hardy J., C., & Rejeski J. W. (1989). Not What, But How One Feels: The measurement of affect during exercise. Journal of Sport & Exercise Psychology, 11, 304–317. https://doi.org/10.1123/jsep.11.3.304
Heinrich, K. M., Patel, P. M., O'Neal, J. L., & Heinrich, B. S. (2014). High-intensity compared to moderate-intensity training for exercise initiation, enjoyment, adherence, and intentions: An intervention study. BMC Public Health, 14(1). https://doi.org/10.1186/1471-2458-14-789
Ivanova, E., Sadikaj, G., Bourne, J. E., Beauchamp, M., Little, J. P., & Jung, M. E. (2022). A pilot study on in-task affect predicting free-living adherence to HIIT and MICT. Research Quarterly for Exercise and Sport, 93(2), 291–300. https://doi.org/10.1080/02701367.2020.1828562
Jones, L., Stork, M. J., & Oliver, L. S. (2020). Affective responses to high-intensity interval training with continuous and respite music. Journal of Sports Sciences, 38(24), 2803–2810. https://doi.org/10.1080/02640414.2020.1801324
Jung, M. E., Bourne, J. E., & Little, J. P. (2014). Where does HIT fit? An examination of the affective response to high-intensity intervals in comparison to continuous moderate- and continuous vigorous-intensity exercise in the exercise intensity-affect continuum. Plos One, 9(12), e114541. https://doi.org/10.1371/journal.pone.0114541
Lakicevic, N., Gentile, A., Mehrabi, S., Cassar, S., Parker, K., Roklicer, R., Bianco, A., & Drid, P. (2020). Make fitness fun: could novelty be the key determinant for physical activity adherence? Frontiers in Psychology, 11. https://doi.org/10.3389/fpsyg.2020.577522
Le Scouarnec, J., Samozino, P., Andrieu, B., Thubin, T., Morin, J. B., & Favier, F. B. (2022). Effects of repeated sprint training with progressive elastic resistance on sprint performance and anterior-posterior force production in elite young soccer players. Journal of Strength and Conditioning Research, 36(6), 1675–1681. https://doi.org/10.1519/JSC.0000000000004242
Li, F., Kong, Z., Zhu, X., Chow, B. C., Zhang, D., Liang, W., Shang, B., Liu, Y., & Zhang, H. (2022). High-intensity interval training elicits more enjoyment and positive affective valence than moderate-intensity training over a 12-week intervention in overweight young women. Journal of Exercise Science and Fitness, 20(3), 249–255. https://doi.org/10.1016/j.jesf.2022.05.001
Liao, Y., Chou, C. P., Huh, J., Leventhal, A., & Dunton, G. (2017). Associations of affective responses during free-living physical activity and future physical activity levels: an ecological momentary assessment study. International Journal of Behavioral Medicine, 24(4), 513–519. https://doi.org/10.1007/s12529-016-9626-z
Marques, M., Alves, E., Henrique, N., & Franchini, E. (2020). Positive affective and enjoyment responses to four high-intensity interval exercise protocols. Perceptual and Motor Skills, 127(4), 742–765. https://doi.org/10.1177/0031512520918748
Martinez, N., Kilpatrick, M. W., Salomon, K., Jung, M. E., & Little, J. P. (2015). Affective and enjoyment responses to high-intensity interval training in overweight-to-obese and insufficiently active adults. Journal of Sport and Exercise Psychology, 37(2), 138–149. https://doi.org/10.1123/jsep.2014-0212
Mcauley, E., Lox, C., & Duncan, T. E. (1993). Long-term maintenance of exercise, self-efficacy, and physiological change in older adults. In Journal of Gerontology: Psychological Sciences, 48, (4). https://doi.org/10.1093/geronj/48.4.p218
Mullen, S. P., Olson, E. A., Phillips, S. M., Szabo, A. N., Wójcicki, T. R., Mailey, E. L., Gothe, N. P., Fanning, J. T., Kramer, A. F., & McAuley, E. (2011). Measuring enjoyment of physical activity in older adults: Invariance of the physical activity enjoyment scale (paces) across groups and time. International

Journal of Behavioral Nutrition and Physical Activity, 8. https://doi.org/10.1186/1479-5868-8-103
Neves, L. N. S., Gasparini-Neto, V. H., Leite, R. D., & Carletti, L. (2023). Acute cardiopulmonary response of high-intensity interval training with elastic resistance vs. high-intensity interval training on a treadmill in healthy adults. International Journal of Environmental Research and Public Health, 20(12), 6061. https://doi.org/10.3390/ijerph20126061
Niven, A., Laird, Y., Saunders, D. H., & Phillips, S. M. (2021). A systematic review and meta-analysis of affective responses to acute high-intensity interval exercise compared with continuous moderate- and high-Intensity exercise. Health Psychology Review, 15(4), 540–573. https://doi.org/10.1080/17437199.2020.1728564
Niven, A., Thow, J., Holroyd, J., Turner, A. P., & Phillips, S. M. (2018). Comparison of affective responses during and after low volume high-intensity interval exercise, continuous moderate- and continuous high-intensity exercise in active, untrained, healthy males. Journal of Sports Sciences, 36(17), 1993–2001. https://doi.org/10.1080/02640414.2018.1430984
Oliveira, B. R. R., Santos, T. M., Kilpatrick, M., Pires, F. O., & Deslandes, A. C. (2018). Affective and enjoyment responses in high-intensity interval training and continuous training: A systematic review and meta-analysis. Plos One, 13(6). https://doi.org/10.1371/journal.pone.0197124
Olney, N., Wertz, T., Laporta, Z., Mora, A., Serbas, J., & Astorino, T. A. (2018). Comparison of acute physiological and psychological responses between moderate-intensity continuous exercise and three regimes of high-intensity interval training. Journal of Strength and Conditioning Research, 32(8), 2130–2138. https://doi.org/10.1519/jsc.0000000000002154
Poon, E. T. C., Sheridan, S., Chung, A. P. W., & Wong, S. H. S. (2018). Age-specific affective responses and self-efficacy to acute high-intensity interval training and continuous exercise in insufficiently active young and middle-aged men. Journal of Exercise Science and Fitness, 16(3), 106–111. https://doi.org/10.1016/j.jesf.2018.09.002
Portugal, E. M. M., Cevada, T., Sobral Monteiro-Junior, R., Teixeira Guimarães, T., Da Cruz Rubini, E., Lattari, E., Blois, C., & Camaz Deslandes, A. (2013). Neuroscience of exercise: From neurobiology mechanisms to mental health. Neuropsychobiology, 68(1), 1–14. https://doi.org/10.1159/000350946
Reljic, D., Lampe, D., Wolf, F., Zopf, Y., Herrmann, H. J., & Fischer, J. (2019). Prevalence and predictors of dropout from high-intensity interval training in sedentary individuals: A meta-analysis. In Scandinavian Journal of Medicine and Science in Sports, 29(9) p1288–1304. https://doi.org/10.1111/sms.13452
Rhodes, R. E., & Kates, A. (2015). Can the affective response to exercise predict future motives and physical activity behavior? a systematic review of published evidence. Annals of Behavioral Medicine, 49(5), 715–731. https://doi.org/10.1007/s12160-015-9704-5
Sánchez-Otero, T., Tuimil, J. L., Boullosa, D., Varela-Sanz, A., & Iglesias-Soler, E. (2022). Active vs. passive recovery during an aerobic interval training session in well-trained runners. European Journal of Applied Physiology, 122(5), 1281–1291. https://doi.org/10.1007/s00421-022-04926-2
Silva, M. O., Santos, T. M., Inoue, A., Santos, L. E. R., de Lima do Nascimento Anastácio, W., Lattari, E., & Oliveira, B. R. R. (2023). Is there a dose–response relationship between high-intensity interval exercise (HIIE) intensity and affective valence? Analysis of three HIIE sessions performed with different amplitudes. International Journal of Environmental Research and Public Health, 20(3). https://doi.org/10.3390/ijerph20032698
Solomon, R. L., & Corbit, J. D. (1974). An opponent-process theory of motivation: I. Temporal dynamics of affect. Psychological Review, 81(2), 119–145.
Stork, M. J., Banfield, L. E., Gibala, M. J., & Martin Ginis, K. A. (2017). A scoping review of the psychological responses to interval exercise: is interval exercise a viable alternative to traditional exercise? In Health Psychology Review 11(4), 324–344). https://doi.org/10.1080/17437199.2017.1326011
Stork, M. J., Gibala, M. J., & Martin Ginis, K. A. (2018). Psychological and Behavioral Responses to Interval and Continuous Exercise. Medicine and Science in Sports and Exercise, 50(10), 2110–2121. https://doi.org/10.1249/MSS.0000000000001671
Stork, M. J., Santos, A., Locke, S. R., Little, J. P., & Jung, M. E. (2023). Can in-task affect during interval and continuous exercise predict 12-month physical activity behavior? Findings from a randomized trial. International Journal of Behavioral Medicine. https://doi.org/10.1007/s12529-023-10224-8

Tavares, V. D. de O., Schuch, F. B., Tempest, G., Parfitt, G., Oliveira Neto, L., Galvão-Coelho, N. L., & Hackett, D. (2021). Exercisers' Affective and Enjoyment Responses: A Meta-Analytic and Meta-Regression Review. In Perceptual and Motor Skills 128 (5), 2211–2236. https://doi.org/10.1177/00315125211024212

Thum, J. S., Parsons, G., Whittle, T., & Astorino, T. A. (2017). High-intensity interval training elicits higher enjoyment than moderate intensity continuous exercise. Plos One, 12(1). https://doi.org/10.1371/journal.pone.0166299

Way, K. L., Sabag, A., Sultana, R. N., Baker, M. K., Keating, S. E., Lanting, S., Gerofi, J., Chuter, V. H., Caterson, I. D., Twigg, S. M., & Johnson, N. A. (2020). The effect of low-volume high-intensity interval training on cardiovascular health outcomes in type 2 diabetes: A randomised controlled trial. International Journal of Cardiology, 320, 148–154. https://doi.org/10.1016/j.ijcard.2020.06.019

Williams, D. M., Dunsiger, S., Ciccolo, J. T., Lewis, B. A., Albrecht, A. E., & Marcus, B. H. (2008). Acute affective response to a moderate-intensity exercise stimulus predicts physical activity participation 6 and 12 months later. Psychology of Sport and Exercise, 9(3), 231–245. https://doi.org/10.1016/j.psychsport.2007.04.002

Zovico, P. V. C., Leite, C. D. F. C., Rica, R. L., Barros, B. M., Machado, A. F., Morra, E. A., Evangelista, A. L., Leite, R. D., Barauna, V. G., & Bocalini, D. S. (2024). Acute and subacute psychophysiological responses in body weight HIIT sessions: a systematic review. *Retos, 60*, 1372–1381. https://doi.org/10.47197/retos.v60.106981

Authors' and translators' details:

Lenice Brum Nunes	lenicenunes09@gmail.com	Author/Translator
Leticia Nascimento Santo Neves	leticiansn@gmail.com	Author/Translator
Victor Hugo Gasparini Neto	victorgasparini@gmail.com	Author
Carla Zimerer	czimerer@gmail.com	Author
Lorena Flores Duarte	lorena.duarte@edu.cariacica.es.gov.br	Author
Eduardo da Matta Melo Portugal	portugalemm@eefd.ufrj.br	Author
Richard Diego Leite	rdleite@gmail.com	Author
Luciana Carletti	lucianacarletti@gmail.com	Author