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Effects of music on psychophysiological responses during high intensity interval training using body weight exercises

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ABSTRACT

The use of music in exercise sessions is considered an interesting strategy as it facilitates, through motivation, an improvement in physical performance, as well as a reduction in the subjective perception of effort and an improvement in mood. Such factors are important for the maintenance of physical exercise programs, however, considering high intensity interval training, the effects of music remain inconclusive. Thus, the objective of this study was to evaluate the influence of music during high intensity interval training sessions using body weight (HIIT-B) on the physiological parameters and mood state of adults. Methods: 11 CrossFit male practitioners were randomly submitted to three sessions of HIIT-B under the following experimental conditions: preference music (PM), non-preference music (nPM) and without music (WM). The HIIT-B protocol consisted of 20 sets of 30 s of stimulus using maximal intensities followed by 30 s of passive recovery. The following exercises were used: jumping jacks, burpee, mountain climber and squat jumping. The following parameters were analyzed: heart rate (HR), lactate (La), total amount of movements (TAM), affective response (AR), rating of perceived exertion (RPE), recovery (RPR) and mood states. Results: although an increase ($p< 0.05$) of HR, RPE and La, reduction of RPR was found after performing the HIIT session, no differences were found between the three conditions to these parameters. The nPM condition promoted lower ($p< 0.001$) TAM compared to the WM and PM conditions, which also differed from each other. However, for AR, a music effect was found among the protocols ($p< 0.0001$), indicating that the PM session promoted an increase in pleasure, unlike WM and nPM session which provided pleasure reduction and displeasure respectively. The WM session did not promote any changes. There were no main effects on time for depression and anger, which were different for vigor, fatigue, mental confusion, tension and mood disturbance. Additionally, differences were found after session to tension ($p = 0.0229$), vigor ($p = 0.0424$) and fatigue ($p = 0.0400$) for PM condition, vigor ($p = 0.0424$), fatigue ($p = 0.0400$) mental confusion ($p = 0.0302$) and mood disturbance ($p = 0.0129$) for nPM and vigor ($p = 0.0363$) and fatigue ($p = 0.0468$) to WM conditions. Conclusion: Listening to preferred music during an 'all out' HIIT-B session increases exercise performance and elicits more positive affective responses in recreationally active adult males, despite similar HR, blood lactate, RPE and fatigue compared to nonpreferred music or no-music.

1. Introduction

The performance of HIIT using body weight (HIIT-B) can be considered a promising strategy for improving physical fitness in healthy adults [30], as well as providing enjoyment. Benefits observed are similar to HIIT workouts using an ergometer [38]. Interventions

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using HIIT demonstrated that the strategy was chronically effective in providing improving aerobic capacity [12,30,39] and neuromuscular outcomes [12,33]. In addition, it is possible to consider advantages of HIIT-B as easy applicability, easy access, low cost, no need for materials for practice and utilization of large spaces.

Studies have shown that throughout the HIIT-B session there are changes in physiological responses such as increased oxygen consumption [19,20], heart rate [28], lactate [28,37] and psychophysiological changes such as increased in rating of perceived exertion [13,31,40], decreased perception of recovery [11,28], increased feelings of fatigue [11] and decreased perception of pleasure [11].

In order to improve performance during exercise, the use of music has proven to be an effective strategy [2-5,17,25,34,36,41]. Through motivation, music facilitates an improvement in physical performance, as well as a reduction of the subjective perception of effort and improvement of mood [7,40,41] considered important for maintenance in exercise programs. Additionally, the influence of music can increase arousal and neural activity resulting in improved performance during exercise [7,9]. Thus, the influence of music during exercise results in psychophysiological responses such as increased motivation and effort, leading to improved performance [5,25], which can also be mediated through improved mood, enjoyment of exercise, and increased sense of power [7,40,41].

Considering HIIT, the effects of music still remain inconclusive mainly due to its intermittent and high intensity nature. JONES et al. [22] demonstrated that music did not influence affective response during sessions, series and recovery periods. However, listening to music continuously promoted greater pleasure following the sessions. MEHTA et al. [31] demonstrated that music promoted a positive effect on pleasure, affection and perceived exertion without changing the mood compared to sessions without music and may somehow facilitate adherence to HIIT programs. KARLOVIC et al. [24] analyzed the effect of music timing during recovery intervals during HIIT sessions with longer times being slow (90–100 bpm) and fast (140–160 bpm). Interestingly, both musical conditions (slow or fast) resulted in less reduction in heart rate, indicating less recovery but greater perception of well-being compared to the no-music condition. This suggests that listening to music in the resting phases during HIIT sessions can improve well-being and influences reductions in heart rate.

Despite investigations [2-5,17,25,34,36,41] into music and exercise, information referring to HIIT sessions, still remains inconclusive. Furthermore, it is unclear whether the type of music (preferred vs. non-preferred) might differently modulate physiological and, mainly, psychological responses during HIIT-B sessions. Therefore, the aim of this study was to evaluate the effect of preferred and non-preferred music on physiological and psychological responses during a HIIT-B session. Even if the influence of music in HIIT sessions on psychophysiological parameters such as pleasure and mood are influenced by music, the existence of inconsistencies in knowledge about the effects of music during HIIT sessions are still inconsistent. This study aimed to evaluate the influence of music in HIIT-B sessions on parameters of psychophysiological responses in of healthy adults.

2. Methods

2.1. Study design

This study was designed to investigate the effects of preferred and non-preferred music on physiological and psychological responses during HIIT-B sessions in physically active adult men. All participants underwent three sessions of HIIT-B (preferred music, non-preferred music, no music) at random with an interval of 7 days between sessions. All participants were instructed to abstain from physical exercise for 48 h before all procedures and from consumption of caffeine and alcohol for 24 h before the session. In addition, the subjects were instructed to maintain their usual meals for the 24 h prior to the interventions and to arrive at the laboratory well-fed in the afternoon. The study was approved by the Human Research Ethics Committee of the Federal University of Espírito Santo (CAAE: 41375120.6.0000.5542/2021).

2.2. Participants

Participants were recruited through advertisements placed on the internet through social media. A total of 20 apparently healthy adults were interested in participating in the study. The study included: men aged between 20 and 30 years; healthy, physically active (over 150 min of physical activity per week) assessed by the IPAQ questionnaire as previously published by our group [27]. The following were excluded from the study: individuals with joint and/or musculoskeletal disorder in the dominant lower limb that prevents performance exercise protocols; smokers; individuals with cardiovascular and metabolic alterations; individuals who have been using buffer substances or creatine as supplements, as well as those who do not agree with the terms informed consent. All subjects completed informed consent forms prior to data collection.

The minimum sample size was estimated to be 12 participants when considering analysis of G Power software (v. 3.1.9.4), for a power of (1 - beta) of 0.95 and alpha = 0.05, however considering attrition we decided to work with 20 individuals considering a 60% increase in the total sample. After selecting the subjects, 9 individuals were excluded from the study for presenting indicators related to the exclusion criteria. Thus, 11 healthy male individuals (26.64 ± 2.15 years old) and practitioners of CrossFit modality for at least one year were evaluated. All eligible individuals underwent three randomized HIIT-B sessions with a 48-hour interval between each session: preference music session (PM, HIIT-B session influenced by preference music or music perceived as pleasant indicated by each subject); non-preference music session (nPM, HIIT-B session influenced by un preference music or music perceived as unpleasant indicated by each subject) and without music (WM, HIIT-B session without music).

The characteristics of the subjects are described in Table 1. Briefly, all participants underwent a height assessment using a Cardiomed stadiometer (WCS model). Body mass was assessed using a calibrated Filizola electronic scale (Personal Line Model 150). Body mass index (BMI) was calculated according to the equation BMI= weight/height^2 and body composition assessed by skinfold thickness.

2.3. Procedures

The HIIT-B protocol consisted of a warm-up of 5 min without interruption with one minute of stationary running, followed by 30 s using the following exercises: jumping jacks, burpee, mountain climber and squat jumping, ending with another minute of stationary running and one minute of walking at an intensity between 4 and 5 as recorded on the Borg scale (score 0–10). After warming up, the session started, consisting of 20 sets (five sets for each exercise) of 30 s of stimulus and 30 s of passive recovery between sets performed using "all-out" intensity monitored using the Borg scale adapted from (0–10). The following exercises were used: jumping jacks, burpee, mountain climber and squat jumping as previously published [26–29].

Table 1
Sample characteristics.

Parameters	Mean ± SD	CV
Body mass (kg)	84.15 ± 6.37	7.56%
Height (m)	1.78 ± 0.05	2.98%
BMI (kg/m^2)	26.37 ± 1.37	5.22%
Fat body (%)	14.48 ± 2.23	15.44%
Fat mass (kg)	12.25 ± 2.42	19.76%
Fat free mass (kg)	71.90 ± 4.81	6.69%
Crossfit practice (years)	3.77 ± 1.36	36.23%

Values expressed in mean ± standard deviation. CV: coefficient of variation.

The experimental conditions PM, nPM or WM were chosen at random by drawing lots on the day of the session. The selection of songs (10 songs for each condition) for the PM and nPM conditions was performed prior to the start of data collection, regardless of the order of the condition to be started, through the participant's own indication. It was considered that PM songs in which the subjects considered motivating and pleasurable to perform the exercise practice, while nPM were demotivating and unpleasant songs for performing the exercise practice. The subjects performed the HIIT-B session individually to avoid the variability of music style.

2.4. Evaluated parameters

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2.5. Lactate concentration

The assessment of blood lactate concentration was evaluated before and immediately after the HIIT-B sessions. Blood samples were taken from the tip of a sterilized finger using a sterile lancet. The first drop of blood was discarded, and free flowing blood was collected in glass capillary tubes. All blood samples for lactate analysis were evaluated using the Accutrend® equipment (Roche - Basel, Switzerland) previously calibrated according to previous publications [28,37].

2.6. Heart rate

Heart rate (HR) was continuously assessed at rest for 10 min, immediately after each series (total of 20 measurements) and at the end of the session using a Polar frequency meter (Model S810). To avoid any complications during collections, all subjects were instructed to check the equipment already positioned on the chest for 10 min. Absolute (HRmax) and relative (%HRmax) maximum heart rates were estimated using equations by TANAKA et al. [42].

2.7. Perceptions of effort and recovery

Rating of perceived exertion (RPE) was assessed using the BORG scale as previously described [11,26,28,37]. The instrument consisted of a scale graduated from 0 to 10 with verbal anchors considering 0 little intense and 10 very intense. The rating of perceived recovery (RPR) was assessed using the recovery scale [31]. The RPR scale is graded from 0 to 10 and has verbal anchors related to the perception of recovery, 0 being not recovered and 10 completely recovered, thus, the closer to the value 10, the greater the individual's perception of recovery. The RPE was evaluated immediately after the performance of the series, whereas the RPR was evaluated with 10″ at the end of the recovery period.

2.8. Training load

To assess training load, the procedures used by Foster et al. [13] were employed. Briefly, the training load was evaluated by multiplying the total session time by the value of the exercise intensity of the session given from the RPE scale graded from zero to 10 points. To ensure that the information obtained from the RPE referred to the exercise as a whole, the participant was asked to answer the question, "How was your training session?" 30 min after the end of the session.

2.9. Affective response

The feeling scale was used to assess the affective response before and 15 min after the session to evaluate the affective response (AR). The instrument is an 11-point bipolar scale ranging from +5 to −5, commonly used to measure affective response (pleasure/discontent) during exercise. This scale has the following verbal anchors: −5 = very bad; −3 = bad; −1 = pretty bad; 0 = neutral; +1 pretty good; +3 = good; and +5 = very good, already used in other study [16]. Subjects received standard instructions on the use of the instrument in the preliminary guidelines and immediately before the beginning of the exercise. The scale was presented to the volunteers, and they chose a "descriptor/number" that represents their feeling at that moment.

2.10. Mood states

Mood states were assessed by applying the Brunel Mood Scale – BRUMS before and 15 min after the session with the following question "How do you feel now?". Briefly, the instrument has 24 items arranged into six mood subscales, tension (T), depression (D), anger (A), vigor (V), fatigue (F) and mental confusion (MC). For each adjective, participants indicate whether they have experienced such feelings on a 5-point Likert Scale (i.e. 0= not at all, 1 = a little, 2= moderately, 3= quite a bit, and 4= extremely). Factors T, D, R, F and MC are considered negative mood factors, with V being considered the positive factor. The total mood disturbance (TMD) was calculated by the sum of the negative factors minus the positive factor (TMD= $(T + D + A + F$+MC) – V) and adding a constant of 100 to prevent negative numbers being a global measure of mood disturbance according to previously publication [23].

2.11. Performance during the session

The total amount of movements in each series was monitored and quantified for each series in accordance with previous publications [28, 37] and used as a performance parameter. In this study, a higher total number of movements performed reflects a higher performance in the HIIT-B session.

2.12. Statistical analysis

For analysis of data normality, the Shapiro-Wilks test was used. The differences between the SM, PM and nPM conditions were analyzed by analysis of variance with repeated measures followed by Tukey's post-hoc test. Analysis of variance with repeated measures with two factors: time (before and after) and condition (time*condition) with the Bonferroni post hoc test used to verify the effects on the studied variables over time. The mean of the difference and the 95% confidence interval (95% CI) were calculated to confirm the differences. Analyses were performed using GraphPad Prism software (v. 6.01; GraphPad software, USA) with a significance level of $p<0.05$ with data presented as mean ± standard deviation.

3. Results

As outlined in Table 2 a main effect for time was found for HR ($F = 1415$; $p<0.0001$), La ($F = 713.1$; $p<0.0001$) and AR ($F = 15.59$; $p = 0.0004$) without a significant interaction of HR ($F = 0.0521$; $p = 0.9492$) and La ($F = 0.5956$; $p = 0.5576$), however, significant interaction ($F = 20.60$; $p< 0.0001$) was found for AR. Additionally, reduction ($p = 0.0107$) of feeling scale parameter was noted after the WM session, however, curiously, the PM session promoted positive pleasure ($p = 0.0375$), differently to nPM that promoted a negative feeling ($p <0.0001$) after the training session. Additionally, no significant differences were found between conditions in pre versus post interventions.

No significant difference was found in absolute and relative HR (HR %) between sessions, however, the PM condition promoted a greater number of movements compared to the WM and nPM conditions which also differed from each other (Table 3). No difference was found in RPE and training load between exercise sessions.

In Fig. 1, it is possible to observe the data related to HR, RPE and RPR along the sets and their respective areas under the curve. The data show that the values of HR, RPE and RPR in all session were similar in all experimental condition (WM, nPM or PM). The evaluation of area under the curve indicate no difference between the values of HR (WM: 3127 ±

Table 2
Physiological and affective response before and after HIIT-B session.

Parameters	Before	After	MD	95% CI	ANOVA Time p	Interaction F	p
HR (bpm)							
WM	78.18 ± 11.32	169.56 ± 7.06*	−91.38	−102.1 to −80.71	< 0.0001	0.0521	= 0.9492
nPM	79.00 ± 10.83	171.38 ± 10.59*	−92.38	−103.1 to −81.71	< 0.0001		
PM	74.27 ± 7.76	164.73 ± 15.74*	−90.46	−101.1 to −79.79	< 0.0001		
Lactate (mmol.L^{-1})							
WM	1.14 ± 0.25	14.35 ± 2.72*	−13.21	−15.51 to −10.91	< 0.0001	0.5956	= 0.5576
nPM	1.17 ± 0.26	15.43 ± 3.32*	−14.26	−16.56 to −11.97	< 0.0001		
PM	1.06 ± 0.14	15.60 ± 2.92*	−14.54	−16.83 to −12.24	< 0.0001		
Affective response							
WM	2.63 ± 0.50	0.54 ± 2.06*,‡	2.09	0.44 to 3.73	= 0.0094	20.60	< 0.0001
nPM	2.45 ± 0.93	−1.63 ± 2.24*	4.09	2.44 to 5.73	< 0.0001		
PM	2.27 ± 0.64	4.00 ± 0.44*,†,‡	−1.72	−3.37 to −0.08	= 0.0375		

Values expressed in mean ± standard deviation of WM (without music), nPM (non preference music) and PM (preference music) conditions. MD: mean difference. CI: confidence interval. HR: heart rate.
* $p<0.05$ vs before.
† $p<0.05$ vs WM.
‡ $p<0.05$ vs nPM.

Table 3
Training parameters of HIIT-B on different experimental conditions.

Parameters	WM	nPM	PM	F	p
HR (bpm)	166.60 ± 7.36	169.40 ± 8.45	170.60 ± 9.29	0.6654	= 0.5215
HR_{max} (%)	87.97 ± 3.90	89.45 ± 4.20	90.08 ± 4.56	0.7191	= 0.4954
TAM (reps)	649.10 ± 41.88†	591.50 ± 64.47	705.30 ± 46.32*,†	13.25	< 0.0001
RPE (0–10)	8.45 ± 0.93	8.09 ± 1.44	8.72 ± 1.19	0.7676	= 0.4730
Training load	169.10 ± 18.68	161.80 ± 28.92	174.50 ± 23.82	0.7676	= 0.4730

Values expressed in mean ± standard deviation of WM (without music), nPM (non preference music) and PM (preference music) conditions. HR: heart rate (HR). TAM: total amount of movements. RPE: rating of perceived exertion of session.
* $p<0.05$ vs WM.
† $p<0.05$ vs nPM.

180; nPM: 3117 ± 189; PM: 3113 ± 196; $F = 0.07248$; $p = 0.4927$), RPE (WM: 150 ± 27; nPM: 152 ± 18; PM: 156 ± 25; $F = 0.8639$; $p = 0.4318$) and RPR (WM: 79 ± 24; nPM: 83 ± 18; PM: 79 ± 23; $F = 1.040$; $p = 0.3659$) between exercise sessions regardless of the experimental conditions.

Table 4 describes the values related to the mood state parameters. There were no main effect on time for depression ($F = 1.050$; $p = 0.3136$) and anger ($F = 0.0409$ $p = 0.8409$), however, main effect for time were found for vigor ($F = 20.62$; $p< 0.0001$), fatigue ($F = 20.31$; $p< 0.0001$), mental confusion ($F = 15.68$; $p = 0.0004$), tension ($F = 17.38$; $p = 0.0002$) and mood disturbance ($F = 21.42$; $p< 0.0001$) after the completion of the sessions. No interactions were found in any mood parameters. Additionally, differences were found after session to tension ($p = 0.0229$), vigor ($p = 0.0424$) and fatigue ($p = 0.0400$) for PM condition, vigor ($p = 0.0424$), fatigue ($p = 0.0400$) mental confusion ($p = 0.0302$) and mood disturbance ($p = 0.0129$) for nPM and vigor ($p = 0.0363$) and fatigue ($p = 0.0468$) to WM conditions. No significant differences were found between conditions in pre versus post interventions.

4. Discussion

This study investigated the effects of music preference (preferred music. nonpreferred music, and non-music) on exercise performance, physiological and psychological responses during HIIT-B in recreationally active adult males. The main findings indicate that despite the similar physiological (HR and blood lactate) and psychological responses among the conditions, individuals showed a better performance (total number of movements) and reported a positive affective response with preferred music when compared to nonpreferred music and no-music.

The physiological and psychological responses related to HR, blood lactate, and RPE imposed on the individuals were similar to previous studies that used HIIT-B [28,29,37]. This indicates that HIIT-B is a simple, low-cost, time-efficient, and a feasible exercise approach to elicit a high interval load (> 85% of HRmax; RPE > 8; blood lactate > 14 mmol/l) in adults, which explains its effects in improving neuromuscular and cardiorespiratory parameters [12]. Regarding the effects of music preference on exercise performance during this highly demanding training method, our findings indicated that the preferred music increased performance during the HIIT-B compared to non-preferred music and no-music

According to previously studies [2,4,5,43] the mechanisms postulated to explain the effect of music on physical performance are related to psychological, physiological and psychophysiological factors. There are indications in the literature [2,4,5,43] that music can promote systemic physiological changes during exercise, which are related to neural activation with concomitant increases in brain activity in the region of the motor cortex with increased autonomic response. Collectively, these changes can promote an increase in the speed of cognitive processing and movement organization when listening to music during exercise. This results in improved performance [8] and metabolic response, such as increased oxygen consumption, energy expenditure, and changes in lactate concentrations [5]. Another important point worthy of consideration is that the neurological changes influenced by music can also promote peripheral changes in addition to the activation of the autonomic and somatic nervous system [5]. Jia et al. [21] demonstrated that the use of music during cycling was associated with the prevention of decreased heart rate variability after exercise, indicating a preservation of parasympathetic stimulation after physical stress. However, the type of music can affect HR responses differently. Yamamoto et al. [44] demonstrated that relaxing music can reduce norepinephrine levels while fast-paced music increases epinephrine levels with exercise influencing HR considerably.

In the present study, the use of music did not influence the relative and absolute HR response during exercise. One hypothesis for this corresponds to the high intensity levels indicated when performing experimentally. Because the intensity of exercise was indicated as all out or maximal, it was expected that music would not exert influence under these conditions in which maximum effort had already been postulated.

Despite the positive effects of HIIT-B in inducing health- and fitness-

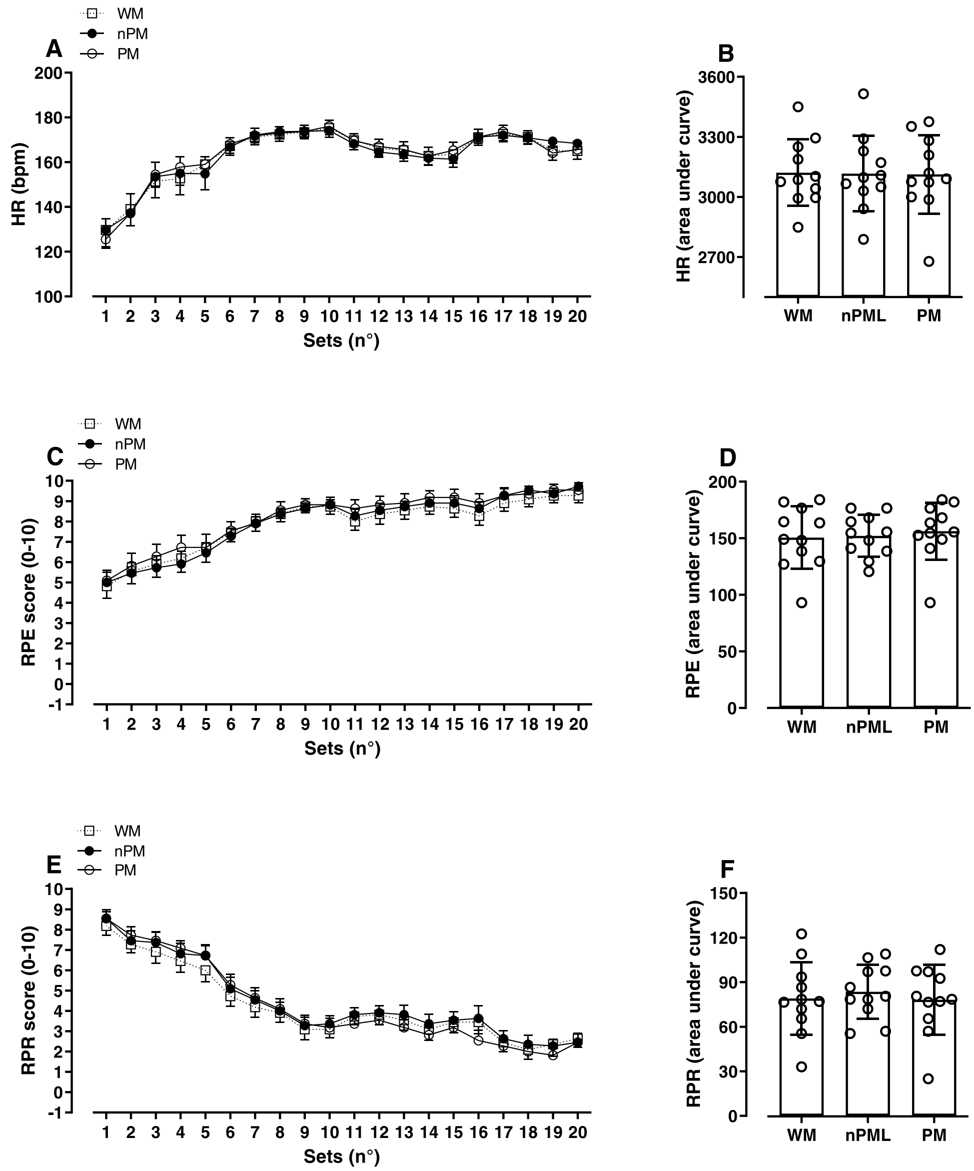

Fig. 1. Values expressed in mean ± standard deviation of WM (without music), nPM (non preference music) and PM (preference music) conditions. Panel A: heart rate (HR). Panel B: area under curve of HR. Panel C: rating of perceived exertion (RPE). Panel D: area under curve of RPE. Panel E: rating of perceived recovery (RPR). Panel F: area under curve of RPR.

related changes [12,33], previous studies have shown that the nature of effort, which occurs in the HIIT-B in the present study, may elicit aversive psychological responses. These include a reduction in the feeling of pleasure during HIIT-B [11] and after HIITs sessions based on a treadmill [14–16]. This is concerning given that these responses may promote negative exercise experiences, which may impact on exercise adherence [18,45]. In this context, the use of preferred music during HIIT-body work with `all out` efforts might favor a better performance in addition to more positive affective responses, which seems to promote a more favorable exercise experience.

Our findings showed that the PM condition induced an increment of positive affective response to the exercise session. This indicated that exercise sessions performed with music chosen by subjects may be less aversive or unpleasant compared with WM and nPM regardless of whether physiological stress is similar. To our knowledge, this is the first study to report this result. Although it has been shown that affective response during HIIT is more negative when the HR and perceived exertion are especially higher in the end of the exercise session [14–16] and at a time when a metabolic imbalance is present [35] the positive affective valence found in the PM condition needs further investigation.

However, according to the circumplex mode, the dissimilar in task response between HIIT and moderate intensity exercise could be hypothetically postulated. The affective feelings crossed from active pleasure (i.e. enthusiastic. elated) to active displeasure (distressed. upset) in HIIT, while the affective feelings during moderate intensity continuous exercise changed from deactivated pleasure (serene, peaceful) to pleasure (satisfied). This suggests that the contribution of anaerobic metabolism during HIIT sessions might intensify the afferent interoceptive signals from the body to the brain areas related to the generation of the affective response (ie prefrontal cortex and subcortical areas). This response may be less stimulated or inhibited after exercise sessions. More studies are needed to clarify this suggestion.

Psychological responses can influence exercise performance because it is related to well-being, cognitive, emotional and behavioral domains, which can impact on performance during exercise [1]. Less tension, depression, anger and greater vigor have been associated with better athletic performance [6]. Such information partially corroborates the data found in the present study, showing that the PM and WM conditions

Table 4
Mood parameters before and after HIIT-B session.

Parameters	Before	After	MD	95% CI	ANOVA Time p	Interaction F	p
Tension							
WM	2.09 ± 1.64	0.63 ± 0.67	1.45	−0.07 to 2.98	= 0.0659	0.2036	= 0.8169
nPM	2.54 ± 2.06	1.36 ± 1.20	1.18	−0.34 to 2.71	= 0.1692		
PM	2.00 ± 1.73	0.27 ± 0.46*	1.72	0.19 to 3.25	= 0.0229		
Depression							
WM	0.81 ± 0.87	1.00 ± 0.77	−0.18	−1.61 to 1.24	> 0.9999	0.3733	= 0.6916
nPM	0.72 ± 0.78	1.45 ± 1.91	−0.72	−2.15 to 0.70	= 0.6197		
PM	0.72 ± 0.90	0.81 ± 1.66	−0.09	−1.51 to 1.33	> 0.9999		
Anger							
WM	0.63 ± 0.67	0.45 ± 0.82	0.18	−0.47 to 0.83	= 0.8662	0.5328	= 0.5924
nPM	0.54 ± 0.68	0.72 ± 0.64	−0.18	−0.83 to 0.47	= 0.8662		
PM	0.54 ± 0.52	0.45 ± 0.52	0.09	−0.56 to 0.74	= 0.9799		
Vigor							
WM	9.54 ± 1.96	5.90 ± 3.61*	3.63	0.18 to 7.08	= 0.0363	0.0014	= 0.9985
nPM	9.00 ± 1.26	5.45 ± 4.36*	3.54	0.09 to 6.99	= 0.0424		
PM	9.09 ± 2.62	5.54 ± 2.50*	3.54	0.09 to 6.99	= 0.0424		
Fatigue							
WM	3.00 ± 2.28	6.45 ± 2.38*	−3.45	−6.87 to −0.03	= 0.0468	0.0015	= 0.9985
nPM	3.27 ± 1.34	6.81 ± 4.40*	−3.54	−6.96 to −0.12	=0.0400		
PM	3.26 ± 1.96	6.90 ± 3.93*	−3.54	−6.96 to −0.12	= 0.0400		
Mental confusion							
WM	0.27 ± 0.46	1.09 ± 1.04	−0.81	−1.82 to 0.18	= 0.1383	0.1568	= 0.8556
nPM	0.36 ± 0.50	1.45 ± 1.21*	−1.09	−2.09 to −0.08	= 0.0302		
PM	0.18 ± 0.60	1.00 ± 1.09	−0.81	−1.82 to 0.18	= 0.1383		
Mood disturbance							
WM	97.27 ± 3.77	103.72 ± 0.6.29	−6.45	−12.93 to 0.02	= 0.0511		
nPM	98.45 ± 3.35	106.36 ± 9.58*	−7.90	−14.39 to −1.42	= 0.0129	0.1313	= 0.8775
PM	97.72 ± 3.66	103.90 ± 6.30	−6.18	−12.66 to 0.29	= 0.0651		

Values expressed in mean ± standard deviation of WM (without music), nPM (non preference music) and PM (preference music) conditions. MD: mean difference. CI: confidence interval.
* $p<0.05$ vs before.

during HIIT-B were able to reduce the sensation of tension, as well as resulting in a greater number of movements performed during exercise when compared to the session using nPM. Furthermore, music preference can strongly influence mood and RPE [3]. Chtourou et al. [10] demonstrated that using music during warm-up increases performance in sprinters, resulting in better power and anaerobic performance. Furthermore, Biagini et al. [7] found interesting results indicating that self-selected music can increase vigor, speed and strength development during jumping in trained men.

Nakamura et al. [34] showed that RPE was significantly lower with the use of music during endurance exercise. Other types of exercises such as high-intensity repeated sprints and resistance exercises when performed with music showed a reduction in RPE [3,32]. In the present study, music had no effect on RPE in the HIIT-B session, regardless of whether the session used music that the subjects liked or disliked. All-out intensity exercise can be used as a mechanism for explanation, since these parameters are strongly correlated with HR during exercise.

The values referring to HR (% of the maximum), concentration of lactate, the RPE and RPR responses of all experimental conditions as well as the number of movements of the PM and nPM conditions agree with previous studies [28,37]. However, the greater number of movements found in the PM condition and the greater values in the perception of pleasure with concomitant non-alteration of the mood disorder can be considered as an effect of the music that subjects prefer during the session.

Choosing your favorite music or simply the one you like can mediate beneficial effects in response to exercise performance [2–5]. This corroborate the results of the present study, with an improvement in external load parameters (total number of movements) after performing the HIIT-B session with PM. It has been suggested that music preference influences exercise performance through motivation, lowers RPE and improves acute recovery and affective responses. The interactions between psychological and physiological mechanisms are responsible for the ergogenic effect [5]. Furthermore, preferred and non-preferred music can mediate performance through a single fact listed above or through multiple mechanisms that complement each other [2–5]. However, the mechanism by which music preferentially imposes greater benefits is still not well elucidated [2–5].

Some limitations in this study should be mentioned. This study was limited to CrossFit practitioners' individuals, the data collection was performed individually and used a limited sample; therefore, any generalization of the results should be interpreted with caution. The variety of HIIT programs and exercise regimens and therefore the results of this study cannot be suggested as similar to other forms of HIIT. Accurate measurement of maximal oxygen consumption and performing a maximal test are necessary to confirm HR variation. Considering that the results of the present study, we believe that further studies should be carried out to confirm our findings, as well as broaden the discussions considering different populations, levels of physical fitness, gender and training session design.

In conclusion, listening to preferred music during an 'all out' HIIT-B session increases exercise performance and elicits more positive affective responses in CrossFit adult males, despite similar HR, blood lactate, RPE and fatigue compared to nonpreferred music or no-music. In relation to practical applications, our findings support the message 'Turn on the preferred music to turn up the performance and affective responses during HIIT-B'.

Conflict of interest

The authors AFM and ALE declare conflict of interest for selling clinics and workshops associated with the topic of the manuscript. The other authors do not declared conflict of interest.

Data Availability

The data that has been used is confidential.

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