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Not All Forms of Exercise Lead to Positive Affect: A Comparative Monitoring Between an Imposed and Self-Adjusted Prescription in Runners, a Cross-Sectional Randomized Controlled Study

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Abstract: Objective: To evaluate the affective responses to running with imposed velocity or self-selected time trials in runners, as well as the effects on volume load (VL) and training impulse (TRIMP). Anxiety was also determined. We establish the level of association between the dependent variables. Methods: Three visits were carried out. 1st visit consisted of a maximum running effort test (VO_2Max). 2nd and 3rd visits, participants were divided between the time limit (T_{Lim}) or time trial 1000m running at self-selected intensity (T_{1000}). Participant responded to felt arousal, feeling and anxiety SUDS scale, before, during and after T_{Lim} and T_{1000}. Results: T_{Lim} vs. T_{1000} ($p<0.001$), V_{Peak} x V_{1000} ($p=0.013$), showed differences, but did not influence VL_{TLim} vs. VL_{1000} (3181.34 ± 872.22 vs. 3570.60 ± 323.3; $p=0.062$). TRIMP showed no differences ($p=0.068$). Arousal did not differ between the pre-exercise ($p=0.772$) and post-exercise ($p=0.083$) groups, but was different during ($p=0.035$). There were differences between groups in the pre-exercise ($p=0.012$), during ($p<0.001$) and post-exercise ($p<0.001$) for feeling and anxiety scores. The correlation between TRIMP and affective scores showed association for T_{Lim} ($r=0.46$; $p=0.043$). Conclusion: The self-selected exercise generated positive affective responses, but the same did not occur for the imposed T_{Lim}. VL and TRIMP presented equality. There was association TRIMP and T_{Lim} feeling scale. T_{Lim} significantly increased anxiety scores.

Keywords: affective responses; affect; anxiety; high intensity exercise

1. Introduction

The literature presents evidence that intensities characterized as vigorous or close to VO_2Max stand out for promoting rapid physiological adaptations and in a shorter time of exposure to exercise [1–4]. Workouts popularly known as high-intensity interval training (HIIT) [1–4], have become an interesting alternative that counteracts one of the barriers related to adherence to regular training programs, in this case, the time spent in each session. Thus, reverberating in an improvement in the time/efficiency relationship [5].

However, at the same time as this exercise mode appears to be efficient on the physiological aspect [6–8], in exaggerated doses or incompatible with the training status [9], appear to provide negative affective responses [10,11], which could encourage evasion. On the other hand, self-selection of workloads, according to the practitioner's preference, seems to be an interesting alternative [9,12–

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14]. Since self-regulation of the magnitude of the external load is based on interoceptive and cognitive interactions, supported by previous experiences, such a condition would enable an increase in self-efficacy [15] and the achievement of a positive affective valence, without the need for fixed patterns of intensities or elaborate prescriptions.

The meta-analysis produced by Oliveira, Deslandes and Santos [16] presents the idea that self-selected exercise vs. imposed prescription influence affective responses differently, and the "equal intensity" condition would demonstrate better affective responses in the self-selected exercise condition, based on the premise of greater autonomy [16]. The authors also point out that intensities above the ventilatory threshold seem to induce worse responses regarding affect. Based on this understanding, the "Dual Model" Theory seems to be the foundation for understanding such responses [16]. Additionally, it is worth noting that negative affective responses seem to reverberate in anxiety symptoms [17].

Numerous studies have observed the behavior of affective responses to self-selected and imposed work intensities [8,13,18,19], in athletes [20,21], sedentary [15,22–24] and overweight/obese individuals [25]. However, there are no known studies that have investigated affective and anxiety responses in middle-aged people who practice recreational physical exercise, as well as in the face of stimuli with a maximum time trial characteristic, i.e., an open task. In this case, adherence is not the heart of the matter, but the understanding of the nature of the stimulus, as well as the possible deleterious psychophysiological effects, such as on anxiety levels. Furthermore, the volume load (VL) and training impulse (TRIMP) responses to a self-selected protocol are apparently unknown. Thus, we do not know whether, in the "let it run freely" condition, VL and the TRIMP impulse performed for the self-selected protocol could be significantly attenuated compared to the imposed programming, since these are practitioners not engaged in high performance.

Therefore, the aim of the present study was to investigate the affective responses to running stimuli with imposed and self-selected velocity (time trial characteristics) by middle-aged recreational runners, as well as the effects on aerobic performance variables (VL and TRIMP). Secondarily, as a means of observing possible stressful conditions of exercise, anxiety responses were also determined. Finally, as a tertiary outcome, the level of association between VO_2Max and anxiety scores, as well as between TRIMP and the post-exercise feeling scale, was investigated. Our primary hypothesis (H_1) is based on the construct that self-selected speed stimuli will enable ideal adjustments of effort regulation, consequently, better affective responses, in addition to equal results on aerobic performance parameters. As a secondary hypothesis (H_2), a significant reduction in anxiety levels will be observed for the self-selected intensity condition, to the detriment of the imposed prescription. Finally, as a final hypothesis (H_3), higher VO_2Max levels will represent greater variations in anxiety scores, and higher TRIMP levels will be related to the feeling scale scores.

2. Materials and Methods

Experimental Approach

This study followed the assumptions described in the STROBE-Statement guideline for randomized controlled cross-sectional study designs. The research was carried out throughout the period of 2022, and had a total duration of four months, following Resolution 466/2012 of the National Health Council, as well as being approved by the institutional research ethics committee no. (#1.220.339). All participants obtained the necessary information about the study and had their questions answered. Those who met the inclusion criteria and agreed to participate in the experiment were presented with an understanding of the possible risks inherent to the exercise, for later signing the free and informed consent form (ICF).

A total of three visits were conducted with each volunteer, with a minimum and maximum interval of 48 and 72 hours, respectively, carried out in a gym. The first visit consisted of a maximum progressive effort test to estimate VO_2Max, performed on a treadmill (Technogym® Run Now 700). In the second visit, the volunteers were randomized, through a simple draw, between the time limit until exhaustion (T_{Lim}) or time trial procedures of 1000 m of running at self-selected intensity (T_{1000}). All volunteers performed the procedures in a closed environment, with 12 treadmills available, free from influences from the rest of the gym and with a controlled temperature between 20 and 21º. The participants performed the tests on alternate days and at the same time of day (8:00 AM to 10:00 AM). For the two experimental visits, each volunteer responded to three scales (felt arousal scale, feeling scale and SUDS anxiety scale) before, during and after an open and closed task test (T_{Lim} and T_{1000}). In addition, the International Physical Activity Questionnaire (IPAQ) short version was applied to confirm the level of physical activity [26]. The results section presents Flowchart 1, referring to the processes of call, exclusion and inclusion for the study.

Sample

Twenty volunteers, 10 women and 10 men, physically active (physical activity level >150 minutes per week) and familiar with regular recreational running practice, were recruited to participate in the study through a public call via digital media, in a high standard gym located in the west zone of Rio de Janeiro. The calls were made during the period from June 2022 to October 2022. Participants who regularly ran at least 3 times a week and freely accepted the testing conditions, fulfilling all testing requirements, were included. Volunteers with diagnosed chronic non-communicable diseases, who used ergogenic substances, or who had osteomyoarticular injuries, as well as a history of smoking, were excluded. The characteristics of the participants are described in Table 1. For the sample calculation, an ANOVA for repeated measures was considered, establishing, input of effect size=0,40, alfa α=0,05; Power (1-β err prob) = 0,80, number of groups =2; Number of measurements= 3; Corr among rep measures=0; designating a sample size of 19 participants (G*Power, Version 3.1.9.4).

Table 1. Sample Characteristics.

Sample characteristics	Experimental group (Mean ± SD)
Age (years)	43.3 ± 4.2
Body mass (kg)	68.3 ± 9.5
Stature (cm)	170.5 ± 8.3
Training experience (years)	5.4 ± 4.3

Procedures

Body Morphology

The anthropometric assessment consisted of measuring body mass using an digital scale and height measured using a standard wall-mounted stadiometer (Sanny, Brazil).

Progressive Maximal Exercise Test

The subjects started walking on the treadmill at 5.0 km·h^{-1} at 0% slope for two minutes. From this initial stage, increments of 1.0 km·h^{-1} (approx. 1 MET) were administered every two minutes, aiming at achieving maximum performance and effort until voluntary exhaustion. Maximum oxygen consumption was estimated according to the equation proposed by the American College of Sports Medicine (ACSM), and shown in Board 1. Heart rate responses (Polar® monitor model RS800), as well as perceived exertion - RPE (Borg 0-10), were monitored and recorded every minute until exhaustion. The presence of signs or symptoms mentioned by the participants, or maximum voluntary exhaustion itself, was used as a criterion for completing the test.

Board 1. VO_2Max estimation equation.

$$VO_2Max = (0,2 \text{ x velocity x slope}) + 3,5$$

Where:

VO_2Max - maximum oxygen consumption in mL·kg^{1}·min^{1};

Velocity – m·min^{-1}
Slope – centesimal unit

Time to Exhaustion Protocol (T_{Lim})

A 5-minute warm-up was performed in a self-selected intensity. Participants underwent a T_{Lim} test on a treadmill without imposing an incline. After 5 min, participants moved off the treadmill, where for a period of one minute the treadmill was adjusted to peak of velocity (V_{Peak}). Participants were continuously encouraged to sustain the intensity for as long as possible. The test aimed to determine the maximum achievable duration at the intensity associated with VO_2Max (100%) or V_{Peak}. The values collected in minutes were converted to seconds for later analysis. RPE was monitored at 60-s intervals and 15 min after the end of the session (session RPE).

1000m Time Trial Protocol (T_{1000})

After a 5-min warm-up at self-selected intensity, participants took a one-minute rest. During the rest, the intensity was adjusted to 8 km·h^{-1}, and then, participants entered the treadmill. After entering, participants were free to increase or decrease their working velocity in order to complete the 1000m as quickly as possible. RPE was monitored at 60-s intervals and 15 min after the end of the session (session RPE).

Subjective Measurement Instruments

Body arousal and feeling scales were applied at three times: pre-exercise, during (between 2 and 2 min 30 sec) and 5 min after exercise. The SUDS anxiety scale was applied before and 5 min after exercise sessions. The perceived exertion (RPE Borg 0-10) was applied after 15 min of the exercise session.

Felt arousal scale: the level of body arousal was analyzed in a self-perceived way during the experimental conditions: pre and post-physical exercise performed. It is a Likert scale, which varies linearly from 1 = slightly activated, to 6 = very activated, with intermediate values.

Feeling scale: the dimensions of affective responses are determined by the level of positive, neutral, or bad sensation provided by aerobic exercise, being distributed on a bipolar ordinal scale, ranging from zero (0) as a neutral position; +1 = reasonably good to +5 = very good; -1 = reasonably bad, up to -5 = very bad.

Rating of perceived exertion (RPE): the adapted linear RPE scale (0 to 10) as produced and described by Borg was used, where "0" refers to the perception of 'extremely light' effort, reaching "total fatigue" 10. For the self-selected sessions, participants were induced and motivated to obtain the maximum global effort index.

SUDS anxiety scale: each participant described how he or she feels at the moment according to his or her perceived mental state, scoring on a linear scale between: 0- absolutely no anxiety; and 10- extremely anxious.

Calculation of Volume Load and Training Impulse (TRIMP)

The volume load (VL) was calculated based on the product of the total work achieved for T_{Lim} or T_{1000} performed in both tests by the average velocity. To calculate the TRIMP, as suggested by Banister and adapted by Foster, the VL measurement was used, multiplied by the RPE of the session [27,28].

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Randomization Process

Participants, after eligibility and written informed consent, were randomly assigned to experimental assessments of T_{Lim} and T_{1000} time trial. The randomization sequence was computer generated (www.randomizer.org) and allocated by a third member of the research group, keeping it blind until the time of the experiment.

Data Analysis and Processing

To avoid possible biases in the analysis, the data were collected by a researcher associated with the project and the research group (P.A and E.P.) and analyzed by a third researcher (group leader A.S). The researcher responsible for data analysis remained blind throughout the data collection process. The names of all participants remained confidential, being excluded from the technical file and replaced by numbers.

Statistical Analysis

A descriptive analysis of the data was performed and presented as mean ± standard deviation (SD), 95% confidence interval (CI95%), median, and maximum and minimum values. Data normality was tested using the Shapiro-Wilk test. If normality was present ($p > 0.05$), data were expressed as mean ± standard deviation. If normality was violated ($p < 0.05$), data were expressed as median and maximum and minimum values. Given that the aerobic performance variables (T_{Lim}, T_{1000}, V_{Peak}, V_{1000}) presented normality, the Student's t-test for paired samples was used. In addition, a Wilcoxon test was used to compare the scores of the arousal, feeling, and anxiety scales. As pairwise comparisons, that is, to investigate the effect of time, the Friedman test was performed. A correlation test associated the VO_2Max variable with differences in anxiety level scores, as well as TRIMP and feeling scores. Delta % (Δ%) was also calculated for the anxiety score variables. All analyses were performed using SPSS 20.0 for Windows® software (Chicago, USA), with a statistical significance of $p \leq 0.05$ adopted.

3. Results

Flowchart 1 presents the entry, inclusion and exclusion criteria for the sample participants. After Shapiro-Wilk distribution analysis, normality was observed for the variables VO_2Max ($p = 0.170$), V_{Peak} ($p = 0.167$), T_{Lim} ($p = 0.242$), T_{1000} ($p = 0.072$), V_{1000} ($p = 0.200$) and VL ($p = 0.359$). However, the same was not observed for perception of exertion (RPE: $p < 0.001$), therefore being treated in a non-parametric manner. The general results regarding the conditioning of the participants in this study are presented in Table 2.

Table 2. Aerobic performance responses to the imposed T_{Lim} and self-selected T_{1000} experimental protocol.

		Imposed			Self Selected		
	VO_2Max	T_{Lim}	V_{Peak}		T_{1000}	V_{1000}	
	($mL \cdot kg^{-1} \cdot min^{-1}$)	(seg)	($km \cdot h^{-1}$)	(%)	(seg)	($km \cdot h^{-1}$)	(%)
Mean	51.1	220.7	14.3	100.0	284.8	12.9	90.0
SD	5.7	43.8	1.7	0.0	35.1	1.7	6.4

Subtitle: T_{Lim} = time limit until exhaustion; V_{1000} = Average velocity for 1000m; SD = standard deviation.

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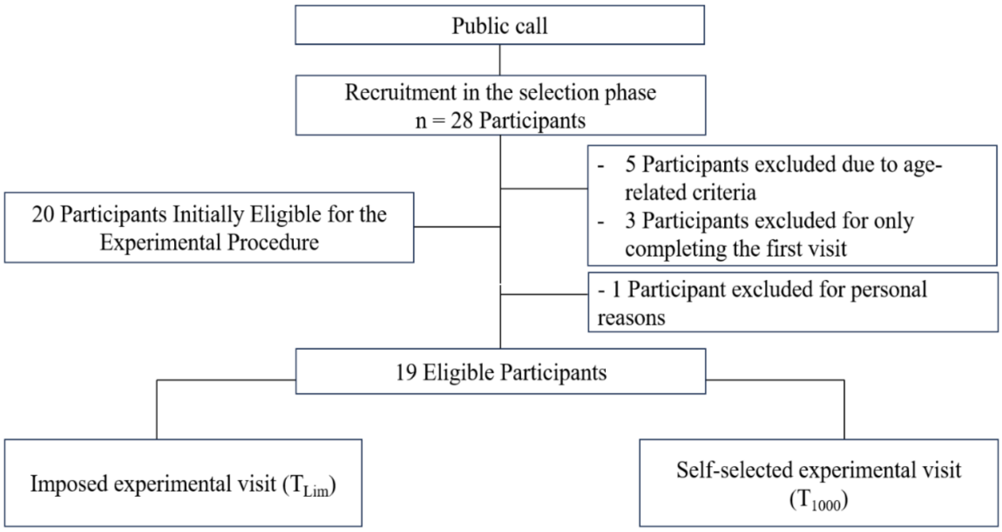

Flowchart 1. Entry, inclusion and exclusion criteria for sample participants.

3.1. Primary Outcomes

Significant differences were observed between T_{Lim} and T_{1000} ($p < 0.001$) and V_{Peak} and V_{1000} ($p = 0.013$). However, there were no significant differences regarding VL_{TLim} and VL_{1000} (3181.34 ± 872.22 vs. 3570.60 ± 323.3; p = 0.062), suggesting equality of work performed. Likewise, RPE_{TLim} and RPE_{1000} (Median = 10.0; CI95% = 9.8 - 10.0 vs. Median = 10.0; CI95% = 9.3 - 9.9, respectively for T_{Lim} and T_{1000}) were analyzed through the nonparametric Mann-Whitney test, in which no significant difference was observed (Mann-Whitney U = 141.50; p = 0.072). Similarly, for the TRIMP between the T_{Lim} and T_{1000} sessions, no significant difference was evidenced (Mann-Whitney U = 118.000; p = 0.068). Figure 1 shows the comparison of the TRIMP between experimental protocols.

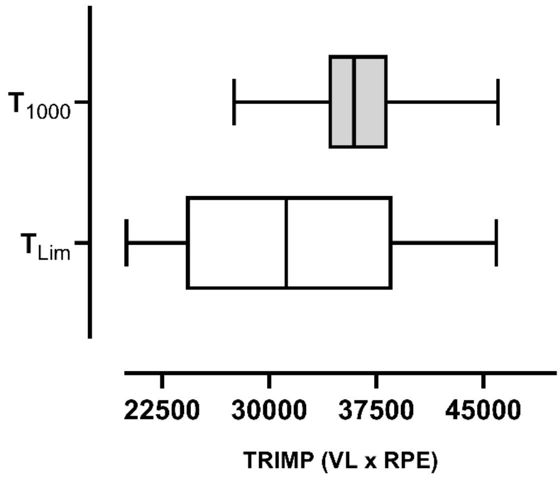

Figure 1. Comparison of TRIMP between experimental protocols.

Regarding the comparison between the types of treatment (T_{Lim} vs. T_{1000}) for the arousal variable pre-exercise (Z = -0.284; p = 0.776), during (Z = -2.111; p = 0.035) and post-exercise (Z = -1.732; p = 0.083), differences were observed only during the experimental procedures. The Friedman test was used for comparison in the time factor, with a significant difference being observed for both T_{Lim} and T_{1000} (p = 0.001; p = 0.001, respectively), both increasing significantly after intervention. Figure 2 shows the differences between groups and moments for the activation scale.

For the feeling scale, the Wilcoxon test showed significant differences between groups for the pre-exercise (Z = -2.501; p = 0.012), during (Z = -3.739; p < 0.001) and post-exercise (Z = -3.532; p <

0.001) conditions. The Friedman test was used to compare the time factor in the feeling scale, showing differences for both interventions (p = 0.015; p < 0.001, respectively for T_{Lim} and T_{1000}). For the T_{Lim} intervention, there was a significant reduction, while for T_{1000}, there was a significant increase in affective valence. Figure 3 shows the differences between groups and moments for the feeling scale.

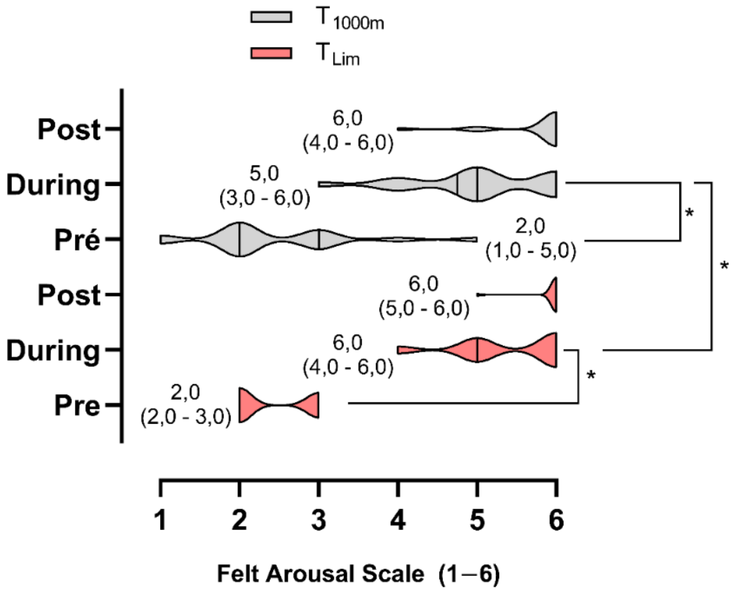

Figure 2. Differences between groups and moments for felt arousal scale.

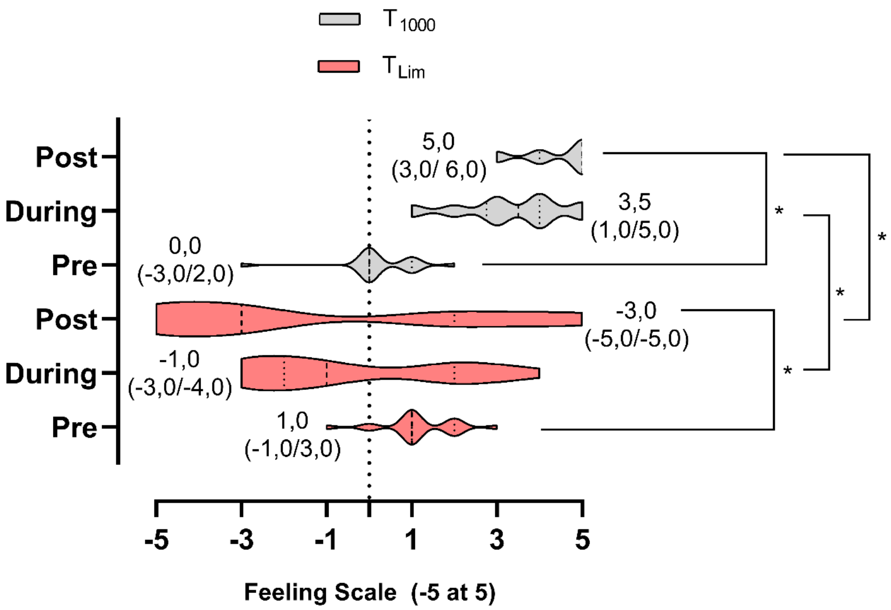

Figure 3. Differences between groups and moments for the feeling scale in the face of both interventions.

3.2. Secondary Outcome

After determining the differences between the pre and post conditions for anxiety scores, the Wilcoxon analysis showed no differences between groups between the pre conditions (Z = -1.515; p = 0.130), however, it demonstrated differences between groups for the post conditions (Z = -3.485; p < 0.001). For the time factor, differences were observed for T_{Lim} (Z = -2750; p = 0.006) and T_{1000} (Z = -3.501; p < 0.001). Table 3 presents the pre- and post-intervention anxiety response values. Figure 4 presents the individual anxiety responses for both experimental protocols.

Table 3. Pre and post exercise anxiety scores in the face of T_{Lim} intervention and T_{1000} time trial.

	T_{Lim}				T_{1000}			
	Pre	Post	Dif	Δ %	Pre	Post	Dif	Δ %
Mean	3.9	4.8	0.9	23%	4.3	2.7	1.6	-37%
SD	0.9	1.3			1.6	1.4		

Subtitle: Δ% = Percentage variation from pre- and post-exercise moments for the anxiety scale; Diff = differences between pre- and post-exercise conditions.

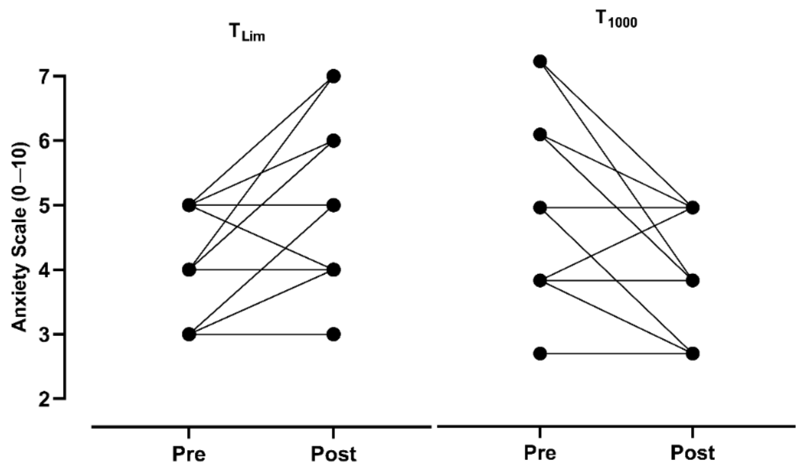

Figure 4. Individual variability of anxiety responses to experimental protocols.

3.3. Tertiary Outcome

Spearman's correlation showed no association between VO_2Max values and the percentage variation in anxiety scores (r = 0.125; p = 0.610; r = 0.122; p = 0.631), suggesting that anxiety variations were independent of a low or high level of VO_2Max. However, Pearson's correlation (normality observed only for TRIMP derived from T_{Lim}) between the TRIMP performance measure and the final scores of the affective scale showed a significant and positive association for the T_{Lim} experiment (r = 0.46; p = 0.043), suggesting that the greater the training impact achieved, the better the affective scores. The correlation between TRIMP and the sensation scale for the self-selected experiment was not significant (p = 0.190). Figure 5 shows the correlation performed. The affective domains are presented graphically based on the circumplex model represented in Figure 6. The Circumplex Model was structured in two dimensions using the feeling and felt arousal scales, represented in a Cartesian parameter.

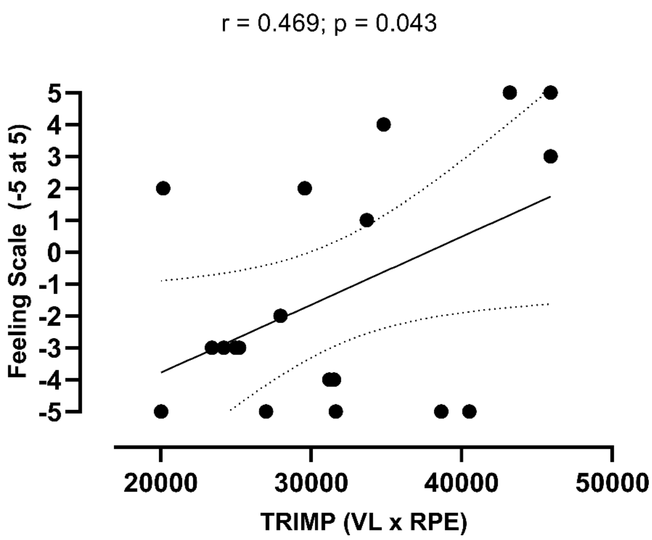

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Figure 5. Correlation between TRIMP and affective responses for the imposed T_{Lim} experiment.

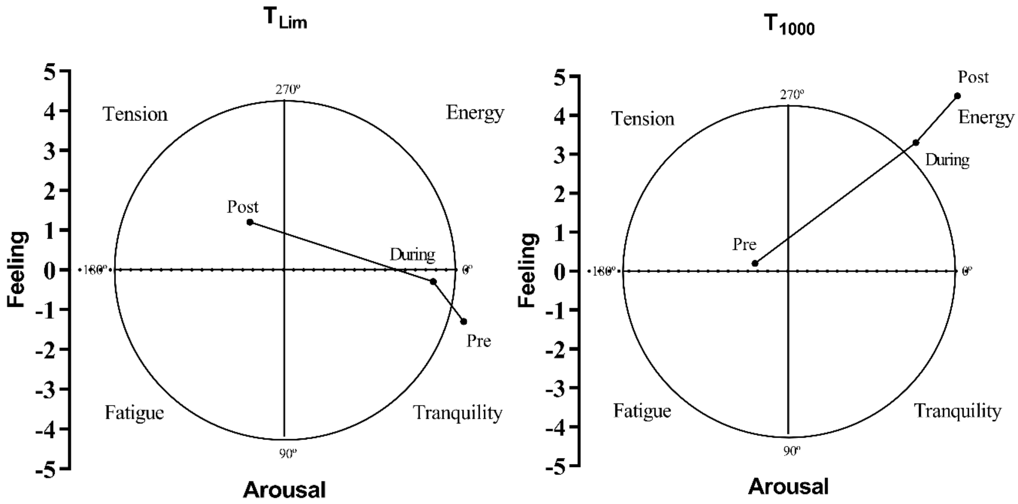

Figure 6. Circumplex Model of Affect.

3.4. Unintended Harm

Risks to health and physical integrity are inherent to physical exercise. Therefore, we monitored the effects of exercise sessions and the potential risks and harmful effects resulting from the exercise administered. For this purpose, in our study, no negative severe events resulting from the imposition of high-intensity load were observed. The sample showed potential adaptation regarding work in critical efforts. However, it is worth noting that the imposed exercise (T_{Lim}) induced significant discomfort and nausea during its practice, mainly in participants with lower capacity and tolerance. Since this format of running performance is not routine, the appearance of discomfort at high intensity is possible. Adequate guidance was provided to the participants and contact was maintained until the appropriate period.

4. Discussion

The aim of this study was to evaluate affective responses to running stimuli with imposed or self-selected velocity in a time trial format by middle-aged recreational runners. Secondarily, as a means of observing possible stressful conditions of exercise, anxiety responses were also determined during the session with imposed or self-selected loads. Finally, relationships between VO_2Max and anxiety, as well as TRIMP and sensation responses, were also established.

Firstly, our hypothesis H_1 proved to be true, since the 1000m time trial stimulus produced positive effects on affect. In principle, to our knowledge, this is the first study that investigated the nature of the time trial stimulus. For the most part, when the self-selection of intensity system is proposed, the literature establishes continuous patterns of intensity maintenance [29] or RPE fixed at a certain score [8]. Our findings establish that self-selected stimuli, even at their maximum demand, are an interesting form of aerobic exercise prescription, contributing to the optimization of training time (time-efficient strategy) and a faster development of cardiorespiratory skills.

In contrast, when we expose participants to rectangular stimuli at constant load, in the severe domain of exercise (100% of the velocity associated with VO_2Max), the physiological stress becomes exacerbated and constant for several minutes, quickly leading to exhaustion. The T_{Lim} observed in our study differed in its magnitude when compared to trained subjects (220.7 ± 43.8 vs. 404.0 ± 101 sec, respectively for our study and the study of Billat et al. [30], suggesting that participants, despite being regular in their running schedule, are far from a status classified as trained (i.e. the largest portion of the population that regularly practices exercise). Thus, our results seem to support the idea that the nature of this type of stimulus (under severe domain), even in the presence of participants engaged and experienced in the recreational activity of running, is not sustainable as a means of prescribing training.

The negative outcomes of affect observed in T_{Lim} (Pre: 1.16 ± 0.9 vs. Post: -1.32 ± 3.7), compared to self-selected intensity, can be explained based on the dual model theory, where cognitive and interoceptive factors define behavior. According to Acevedo & Ekkekakis [14,25], in this exercise domain, the disruption of homeostasis is severe, therefore, suffering a strong influence from peripheral metabolic signaling. However, both experimental conditions passed through the severe exercise domain (T_{Lim}: 100% vs. T_{1000}: 90%) and obtained different responses. In this particular case, we believe that cognitive factors predominated to the detriment of interoceptive mechanisms, reflecting inexperience with the nature of T_{Lim}. It appears that under these conditions, there is a significant decrease in prefrontal activity combined with increased activation of the amygdala, resulting in a type of emotional coping, which would explain the decline seen in affective valence [31].

When comparing the aerobic performance variables, we can observe that both experimental models presented significant differences (T_{Lim} vs. T_{1000} - $p < 0.001$; V_{Peak} x V_{1000} - $p = 0.013$). However, it is important to highlight that both T_{Lim} and T_{1000} passed through the same exercise domain, which confers, according to Hill, Poole & Smith [32], similar physiological instability effects between the tasks, and similar adaptive potentials [32], only differing in the time taken to reach VO_2Max and exhaustion [33,34]. It is worth highlighting that such divergence was presented with a compensation mechanism between the variables (time and velocity), which was reflected in equality in the results of VL and TRIMP, not differing between the experimental tasks.

TRIMP has been used to characterize exercise load during competitive time trial tasks and has been useful for controlling training load in long-term planning [27,28]. However, to date, it has not been used to attempt to observe possible associations with affective responses or the impact between training models. First, our study demonstrates that the self-selected protocol did not underestimate the impact of exercise, validating our initial hypothesis. The prescription in the maximum time trial model, therefore, can be designed and incorporated into training programs for adults already engaged in regular training programs. In addition, there was a significant and positive association between TRIMP and post-exercise sensation scores for the imposed T_{Lim} exercise model, suggesting that the greater the external load (100%) and the time achieved, the better the affective responses. This can be explained by the variability between participants and heterogeneity of performances, demonstrating that those who were most potentially adapted modulated the feeling, fatigue and exhaustion, even when faced with a high imposed load, in a differentiated way, when compared to those with a lower training status.

Verame et al. [35] present positive and similar psychoaffective responses to two protocol models and high intensity (ratio 1:2: RPE 17 vs. 1:0.5: RPE 16) in trained participants, which suggests facilitation on the part of trained participants in modulating positive responses, regardless of the stimulus configuration [35]. However, Rose & Parfitt [15] point out significant variability in affective responses to imposed (above the ventilatory threshold) and self-selected workload, such that sedentary participants transitioned positively to intensity above the ventilatory threshold, with no differences for the group of active women. Logically, the domain in which the exercise was performed is different from that suggested in our study (heavy vs. severe), which would explain the differences in our outcomes.

Finally, the circumplex model shows us that despite the high physiological demands in the self-selected time trial exercise model, such activation and feeling responses largely moved throughout the exercise in the upper right quadrant of the Cartesian plane, suggesting that the self-adjustment of intensities throughout the exercise reflected high levels of excitement and reward at its completion. Differently, the circumplex model for T_{Lim} moved under the upper left quadrant of tension, which would explain the results related to anxiety. We know that an exacerbation of the anxiety response is appropriate in the face of threatening conditions and reverberates in physiological changes, however, to a certain extent, it also negatively affects the performance result [36]. Although we did not observe a significant association between VO_2Max levels and anxiety scores in our study, refuting our

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hypothesis, we believe that such outcomes interfered individually with the participants in the T_{Lim} protocol, especially with regard to participants with lower training status, who generally have lower tolerance to high levels of effort and the ability to deal with threatening conditions.

In general terms, physical exercise is related to the reduction of anxiety levels in healthy people and in patients diagnosed with generalized anxiety disorders [37], panic [38] and depressives. This appears to occur at moderate intensities and even during maximum effort tests [39]. Despite this understanding, no study has specifically measured the potential effects of a T_{Lim} protocol on anxiety levels, which makes comparisons difficult. In our study, we observed a 23% increase in anxiety scores after T_{Lim}, which potentially had a negative impact on performance. Furthermore, it is clear to us, as observed in Figure 4, that participants exhibited significant variability in response to this stimulus model, which further suggests the dependence on intrinsic physiological factors not measured in our study.

5. Conclusions

In our primary outcome, the self-selected time trial exercise protocol was able to generate significant and positive affective responses, even when faced with an imposition of maximal effort. The same did not occur for the imposed T_{Lim}. The different results of the aerobic performance variables did not impact the VL and TRIMP, which were equal. However, the positive association between TRIMP and the scale of sensation in relation to T_{Lim} suggests that participants with greater performance potential tend to manifest positive affective responses. Finally, the T_{Lim} protocol generated a significantly stressful environment, resulting in higher post-exercise anxiety scores, which was also not associated with VO_2Max levels.

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References

1. Atakan MM, Li Y, Kosar SN, Turnagol HH, Yan X. Evidence-Based Effects of High-Intensity Interval Training on Exercise Capacity and Health: A Review with Historical Perspective. Int J Environ Res Public Health. 2021;18(13).10.3390/ijerph18137201
2. Gibala MJ, Little JP, Macdonald MJ, Hawley JA. Physiological adaptations to low-volume, high-intensity interval training in health and disease. J Physiol. 2012;590(5):1077-1084.10.1113/jphysiol.2011.224725
3. Ito S. High-intensity interval training for health benefits and care of cardiac diseases - The key to an efficient exercise protocol. World J Cardiol. 2019;11(7):171-188.10.4330/wjc.v11.i7.171
4. Weston KS, Wisloff U, Coombes JS. High-intensity interval training in patients with lifestyle-induced cardiometabolic disease: a systematic review and meta-analysis. Br J Sports Med. 2014;48(16):1227-1234.10.1136/bjsports-2013-092576
5. Salmon J, Owen N, Crawford D, Bauman A, Sallis JF. Physical activity and sedentary behavior: a population-based study of barriers, enjoyment, and preference. Health Psychol. 2003;22(2):178-188.10.1037//0278-6133.22.2.178
6. Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle: Part I: cardiopulmonary emphasis. Sports Med. 2013;43(5):313-338.10.1007/s40279-013-0029-x

7. Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle. Part II: anaerobic energy, neuromuscular load and practical applications. Sports Med. 2013;43(10):927-954.10.1007/s40279-013-0066-5
8. Kellogg E, Cantacessi C, McNamer O et al. Comparison of Psychological and Physiological Responses to Imposed vs. Self-selected High-Intensity Interval Training. J Strength Cond Res. 2019;33(11):2945-2952.10.1519/JSC.0000000000002528
9. Oliveira BRR, Santos TM, Kilpatrick M, Pires FO, Deslandes AC. Affective and enjoyment responses in high intensity interval training and continuous training: A systematic review and meta-analysis. PLoS One. 2018;13(6):e0197124.10.1371/journal.pone.0197124
10. Foster C, Farland CV, Guidotti F et al. The Effects of High Intensity Interval Training vs Steady State Training on Aerobic and Anaerobic Capacity. J Sports Sci Med. 2015;14(4):747-755
11. Oliveira BR, Slama FA, Deslandes AC, Furtado ES, Santos TM. Continuous and high-intensity interval training: which promotes higher pleasure? PLoS One. 2013;8(11):e79965.10.1371/journal.pone.0079965
12. Batista DR, Meneghel V, Ornelas F, Moreno MA, Lopes CR, Braz TV. Respostas fisiológicas e afetivas agudas em mulheres na pós menopausa durante exercício aeróbio prescrito e auto-selecionado. Cuadernos de Psicología del Deporte. 2019;19(1):28-38
13. Ekkekakis P. Let them roam free? Physiological and psychological evidence for the potential of self-selected exercise intensity in public health. Sports Med. 2009;39(10):857-888.10.2165/11315210-000000000-00000
14. Ekkekakis P, Lind E, Vazou S. Affective responses to increasing levels of exercise intensity in normal-weight, overweight, and obese middle-aged women. Obesity (Silver Spring). 2010;18(1):79-85.10.1038/oby.2009.204
15. Rose EA, Parfitt G. Exercise experience influences affective and motivational outcomes of prescribed and self-selected intensity exercise. Scand J Med Sci Sports. 2012;22(2):265-277.10.1111/j.1600-0838.2010.01161.x
16. Oliveira BR, Deslandes AC, Santos TM. Differences in exercise intensity seems to influence the affective responses in self-selected and imposed exercise: a meta-analysis. Front Psychol. 2015;61105.10.3389/fpsyg.2015.01105
17. Rutter LA, Ten Thij M, Lorenzo-Luaces L, Valdez D, Bollen J. Negative affect variability differs between anxiety and depression on social media. PLoS One. 2024;19(2):e0272107.10.1371/journal.pone.0272107
18. Oliveira GTA, Costa EC, Santos TM et al. Effect of High-Intensity Interval, Moderate-Intensity Continuous, and Self-Selected Intensity Training on Health and Affective Responses. Res Q Exerc Sport. 2024;95(1):31-46.10.1080/02701367.2022.2141674
19. Haile L, Goss FL, Andreacci JL, Nagle EF, Robertson RJ. Affective and metabolic responses to self-selected intensity cycle exercise in young men. Physiol Behav. 2019;2059-14.10.1016/j.physbeh.2019.02.012
20. Collins D, Hale B, Loomis J. Differences in Emotional Responsivity and Anger in Athletes and Nonathletes: Startle Reflex Modulation and Attributional Response. J Sport Exerc Psychol. 2017;17(2):171-184
21. Dias MR, Simao R, Machado GH et al. Relationship of different perceived exertion scales in walking or running with self-selected and imposed intensity. J Hum Kinet. 2014;43149-157.10.2478/hukin-2014-0100
22. Wardwell K, Focht C, Courtney Devries A, O'connell A, Buckworth J. Affective responses to self-selected and imposed walking in inactive women with high stress: a pilot study. J Sports Med Physical Fitness 2013;53(6):701-712
23. Parfitt G, Rose EA, Burgess WM. The psychological and physiological responses of sedentary individuals to prescribed and preferred intensity exercise. Br J Health Psychol. 2006;11(Pt 1):39-53.10.1348/135910705X43606
24. Oliveira A, Costa C, Santos T et al. Effect of High-Intensity Interval, Moderate-Intensity Continuous, and Self-Selected Intensity Training on Health and Affective Responses. Res Q Exerc Sport. 2024;95(1):31-46.10.1080/02701367.2022.2141674
25. Ekkekakis P, Lind E. Exercise does not feel the same when you are overweight: the impact of self-selected and imposed intensity on affect and exertion. Int J Obes (Lond). 2006;30(4):652-660.10.1038/sj.ijo.0803052
26. Matsudo S, Araújo T, Matsudo V et al. International Physical Activity Questionnaire (lPAQ): Study of Validaty and Reliability in Brazil. Revista Brasileira de Atividade Física & Saúde. 2001;6(2):1-14
27. Foster C, Florhaug JA, Franklin J et al. A new approach to monitoring exercise training. J Strength Cond Res. 2001;15(1):109-115
28. Banister EW, Carter JB, Zarkadas PC. Training theory and taper: validation in triathlon athletes. Eur J Appl Physiol Occup Physiol. 1999;79(2):182-191.10.1007/s004210050493
29. Oliveira, Deslandes AC, Nakamura FY, Viana BF, Santos TM. Self-selected or imposed exercise? A different approach for affective comparisons. J Sports Sci. 2015;33(8):777-785.10.1080/02640414.2014.968191
30. Billat V, Renoux JC, Pinoteau J, Petit B, Koralsztein JP. Reproducibility of running time to exhaustion at VO2max in subelite runners. Med Sci Sports Exerc. 1994;26(2):254-257.10.1249/00005768-199402000-00018
31. Acevedo E, Ekkekakis P. Psychobiology of Physical Activity (Human Kinetics Publishers, 2006).
32. MacInnis MJ, Gibala MJ. Physiological adaptations to interval training and the role of exercise intensity. J Physiol. 2017;595(9):2915-2930.10.1113/JP273196

 doi:10.20944/preprints202411.0326.v1

33. Hill DW, Poole DC, Smith JC. The relationship between power and the time to achieve .VO(2max). Med Sci Sports Exerc. 2002;34(4):709-714.10.1097/00005768-200204000-00023
34. Billat V, Renoux JC, Pinoteau J, Petit B, Koralsztein JP. Times to exhaustion at 90, 100 and 105% of velocity at VO2 max (maximal aerobic speed) and critical speed in elite long-distance runners. Arch Physiol Biochem. 1995;103(2):129-135.10.3109/13813459508996126
35. Verame A, Santana W, da Silva CA, Barbosa E, Figueira Júnior A. Physiological and Psychoaffective Responses of Adults Trained in Acute HIIT Protocols. Rev Bras Med Esporte. 2024;30(1):1-5
36. Ganasarajah S, Sundstrom Poromaa I, Thu WP et al. Objective measures of physical performance associated with depression and/or anxiety in midlife Singaporean women. Menopause. 2019;26(9):1045-1051.10.1097/GME.0000000000001355
37. Mochcovitch MD, Deslandes AC, Freire RC, Garcia RF, Nardi AE. The effects of regular physical activity on anxiety symptoms in healthy older adults: a systematic review. Braz J Psychiatry. 2016;38(3):255-261.10.1590/1516-4446-2015-1893
38. Machado S, Telles G, Magalhaes F et al. Can regular physical exercise be a treatment for panic disorder? A systematic review. Expert Rev Neurother. 2022;22(1):53-64.10.1080/14737175.2021.2005581
39. O'Connor PJ, Petruzzello SJ, Kubitz KA, Robinson TL. Anxiety responses to maximal exercise testing. Br J Sports Med. 1995;29(2):97-102.10.1136/bjsm.29.2.97