How to cite: Fidalgo A, Pilon R, Matos-Santos L, Oliveira A, Baladán R, Medeiros R et al. Heart rate and training volume responses in High-Intensity Interval Resistance Training with different intervals between stimuli. Rev Bras Fisiol Exerc 2021;20(5):532-541. doi: 10.33233/rbfex.v20i5.4897

RBFEx
ISSN Online: 2675-1372

Revista Brasileira de Fisiologia do Exercício

Original article

Heart rate and training volume responses in High-Intensity Interval Resistance Training with different intervals between stimuli

Frequência cardíaca e volume de treinamento no High-Intensity Interval Resistance Training com diferentes intervalos entre estímulos

Andressa Fidalgo[1], Rui Pilon[1], Lenifran Matos-Santos[1], Adriano Oliveira[2], Rodrigo Baladán[2], Rodrigo Medeiros[2], Paulo Farinatti[1], Walace Monteiro[1,2]

1. Universidade do Estado do Rio de Janeiro, Rio de Janeiro, RJ, Brazil
2. Universidade Salgado de Oliveira, Rio de Janeiro, RJ, Brazil

ABSTRACT

Introduction: Among the prescription variables of the High Intensity Interval Resistance Training (HIRT), the rest interval between stimuli stands out. The self-selected interval (SS) is an interesting rest interval strategy between stimuli that has not yet been investigated in HIRT sessions. **Objective:** The study compared the heart rate (HR) and training volume responses in HIRT sessions applied with fixed and SS intervals between stimuli. **Methods:** The sample consisted of 12 trained men, who underwent three HIRT sessions in randomized order, with different rest intervals between stimuli (10 s, 30 s, and SS). **Results:** HR responses did not differ by applying the different intervals ($P > 0.05$), and the same did not occur with the training volume, which was higher in the session with SS interval ($P < 0.05$). **Conclusion:** HR responses in HIRT sessions were similar in all investigated rest interval strategies. Due to efficiency and practicality, SS intervals may be applied to control the exercise intensity in HIRT sessions. However, when the purpose of the session falls on a greater training volume, 30 s intervals should be applied.

Keywords: high-intensity interval training; heart rate; exercise.

RESUMO

Introdução: Dentre as variáveis de prescrição do *High Intensity Interval Resistance Training* (HIRT), destaca-se o intervalo entre estímulos. Uma interessante estratégia de intervalo entre estímulos que ainda não foi investigada na aplicação do HIRT diz respeito ao intervalo autosselecionado (AS). **Objetivo:** O estudo comparou as respostas da frequência cardíaca (FC) e do volume de treinamento em sessões de HIRT aplicadas com intervalos entre estímulos fixos e AS. **Métodos:** A amostra foi composta por 12 homens treinados, que foram submetidos a três sessões de HIRT, aplicadas em ordem randomizada, com diferentes intervalos entre estímulos (10 s, 30 s, e AS). **Resultados:** As respostas de FC não se diferenciaram mediante a aplicação dos diferentes intervalos ($P > 0,05$), o mesmo não ocorrendo com o volume de treinamento, que foi superior na sessão com intervalo AS ($P < 0,05$). **Conclusão:** As respostas de FC nas sessões de HIRT foram similares em todas as estratégias de intervalo entre estímulos investigadas. Devido à eficiência e praticidade, intervalos AS podem ser aplicados para controlar a intensidade do esforço em sessões de HIRT. Todavia, quando o objetivo da sessão recair em um maior volume de treinamento, intervalos de 30 s devem ser aplicados.

Palavras-chave: treinamento intervalado de alta intensidade; frequência cardíaca; exercício físico.

Received: August 26, 2021; Accepted: October 22, 2021.

Correspondence: Walace Monteiro, UERJ, Laboratório de Atividade Física e Promoção da Saúde (LABSAU), Instituto de Educação Física e Desportos, Rua São Francisco Xavier, 524, sala 8121F Maracanã 20550-900 Rio de Janeiro, RJ, Brazil. walacemonteiro@uol.com.br

Rev Bras Fisiol Exerc 2021;20(5):532-541

Introduction

High-Intensity Interval Resistance Training (HIRT) consists of an interval training modality, conducted with resistance exercises. In HIRT, the exercises are performed at all out intensity and organized in a circuit format, whose objective is to maintain a high intensity of effort throughout the session. Among the advantages of applying HIRT, the simultaneous improvement of cardiorespiratory fitness and muscle strength stands out [1,2]. However, depending on the way in which the methodological variables of training prescription are combined in the HIRT, the time at high intensity may be negatively affected [3]. Among these variables, the interval between stimuli influences in several aspects, including the accumulation of metabolites and fatigue, causing early interruption of sessions [4,5] if not properly applied. Although some studies have investigated acute responses to exertion in HIRT sessions, they did not focus on the manipulation of intervals between stimuli and their effect on indicators of effort intensity and performance, such as heart rate (HR) and volume of training [6,7].

An interesting recovery strategy between stimuli that has been investigated concerns the adoption of self-selected recovery intervals (SS) by practitioners. In this form of interval, individuals rest as long as they deem necessary to execute the consecutive stimulus. Schoenmakers & Reed [8] investigated the acute physiological responses to exertion by applying SS intervals in interval training, and found that this interval strategy was effective in controlling the intensity of exertion. However, the application of SS intervals was investigated in a running protocol, which involves a single motor gesture. On the other hand, HIRT circuits are conducted with different exercises, implying different motor gestures, which are performed in different orders. In addition, they involve exercises with different sizes of muscle groups and exercise loads. Therefore, the results of studies involving cyclical activities such as running and cycling cannot be extrapolated to HIRT circuits. Unfortunately, the literature is still scarce regarding the application of SS intervals in HIRT, and it is not known to what extent this strategy of interval between stimuli is efficient in controlling the intensity of effort in this type of circuit.

Another aspect to be highlighted in the HIRT sessions refers to the training volume responses. When thinking about designing conditioning programs aimed at improving muscle strength, training volume responses can provide important information. As far as we are concerned, little is known about the behavior of the training volume in HIRT sessions [9]. In addition, about the application of different interval strategies between stimuli in HIRT, some still remain unresponsive. Therefore, the elucidation of these issues can be important in the design of HIRT sessions. Therefore, the aim of the present study was to compare heart rate and training volume responses in HIRT sessions performed with intervals between fixed and SS stimuli.

Methods

Subjects

This is a quasi-experimental study, whose sample consisted of 12 men, aged 27.1 ± 3.9, height 179.7 ± 6.6 cm, body mass 84.6 ± 9.0 kg and peak oxygen consumption (VO_{2peak}) of 56.6 ± 7.5 $ml.kg.^{-1}min^{-1}$, practitioners of high intensity mixed circuits, for at least six months. The limiting factors to the practice of physical exercises were identified through the application of a structured questionnaire by the researchers. Thus, the following study exclusion criteria were adopted: a) existence of musculoskeletal problems that could limit performing exercises in circuits, as well as on a treadmill; b) existence of cardiovascular diseases that could interfere with the acquisition of cardiorespiratory variables; c) use of medications that interfere with cardiorespiratory responses to exercise. Before starting the experiment, the individuals signed an informed consent form and the project was approved by the institutional ethics committee (CAEE: 08275619.6.0000.5289).

Data collection

The experiment consisted of five visits to the Physical Activity and Health Promotion Laboratory (*LABSAU – State University of Rio de Janeiro*), with an interval of 48 to 72 hours between each visit. Each participant underwent three experimental sessions, always in the morning, with visits scheduled according to availability. On the first day, the subjects underwent a clinical examination, performed by a cardiologist. Also on that day, anthropometric measurements of body mass and height were taken. To measure body mass, a Filizola® mechanical scale (*São Paulo, Brazil*) was used. Height was measured using an aluminum stadiometer attached to the same scale. For that, the individuals were instructed to adopt an orthostatic, with feet together and head oriented in the Frankfurt plane, after maximum inspiration. In addition, the individuals performed a standard anamnesis developed at the LABSAU–UERJ, in order to identify the physical activities performed, as well as possible limiting factors to the of exercise practice. For those who were selected, a cardiopulmonary exercise test (CPET) was subsequently performed. On the second day, the subjects were familiarized with the HIRT circuit. After simple randomization, usinga spreadsheet from the software Microsoft Excel, from the third to the fifth day, three HIRT sessions were applied to each subject, with different recovery intervals between stimuli.

Cardiopulmonary exercise test

The test was performed on a treadmill using a ramp protocol based on the maximum oxygen consumption values (VO_{2max}) estimated by the Matthews *et al.* questionnaire [10] From these values, the initial and final speeds of the protocol were calculated, using the equation proposed by the American College Sports Medicine (ACSM) [11]. The protocol was programmed to last between eight and 12 minutes [12]. Before starting the test, the subjects remained monitored until the respiratory quotient and VO_2 assumed values of approximately 0.75 to 0.85 and 3.5 $ml.kg^{-1}.min^{-1}$, respectively [13]. Individuals were encouraged to perform maximum effort during CPET, and the highest VO_{2peak} was recorded at the end of the test. The protocol was performed with the VO2000 gas analyzer (*Medical Graphics, Saint Paul, United States*), the data monitored continuously and archived every 20 seconds. Polar heart rate monitor (*RS-800, Kempele, Finland*) was used to obtain HR measurements. The test was considered maximum when the subject reached at least three of the five criteria [14]: a) maximum voluntary exhaustion, b) grade 9 or 10 on the Borg CR-10 scale; c) obtaining at least 90% of the maximum HR (HR_{max}) predicted for the age or presence of a HR plateau by increasing the speed at the end of the test; d) VO_2 plateau with increased velocity at the end of the test, e) respiratory quotient ≥ 1.10.

Familiarization session

The familiarization session was carried out 48 hours after the application of the CPET, with the objective of accustoming the subjects to the exercise circuit, as well as to select the load in the different exercises. For this purpose, the volunteers performed two rounds through the circuit, adopting one of the strategies of intervals between sets used in the study (20 s of peak stimulus, alternating with 30 s of recovery). As the loads in the different exercises were self-selected, if any individual judged that the value selected for conducting the exercises in the adaptation was not adequate, it could be adjusted for conducting the experimental sessions.

Exercise session

All individuals in the sample were underwent to three experimental sessions. Initially, the individuals performed a warm-up consisting of one round through the circuit, with the load chosen in the familiarization session. After warming up, individuals were given one minute to position themselves in the place where the exercises were conducted. The HIRT sessions were performed in a circuit form, consisting of the following exercises order: 1) Thruster; 2) Swing; 3) Unilateral Snatch 4) Mountain Climber. The load in the exercises was applied using a kettlebell (Swing exercise) and dumbbells (Thruster and unilateral Snatch exercise). The choice of load was self-selected for each exercise, by each participant, depending on their experience with the exercises and use of equipment. In all sessions, four rounds per exercise were performed, lasting 20 s at peak stimuli. In all rounds, participants were verbally encouraged to complete as many repetitions as possible in the exercises. The HR was monitored during the sessions and the number of repetitions was accounted for later calculation of the training volume. The training volume corresponded to the number of repetitions performed in all exercises within the different rounds of the circuit, which was obtained by filming the HIRT sessions.

The duration of resting intervals was different in each session, namely: 10 s, 30 s and SS. The SS interval, was determined individually, in which each volunteer rested as long as they deemed necessary to perform the next exercise. Despite this interval strategy being individual, an evaluator registered the the duration adopted by each individual to analyze the profile adopted by the subjects throughout the session. Furthermore, subjects were not aware that the intervals between stimuli would be registered.

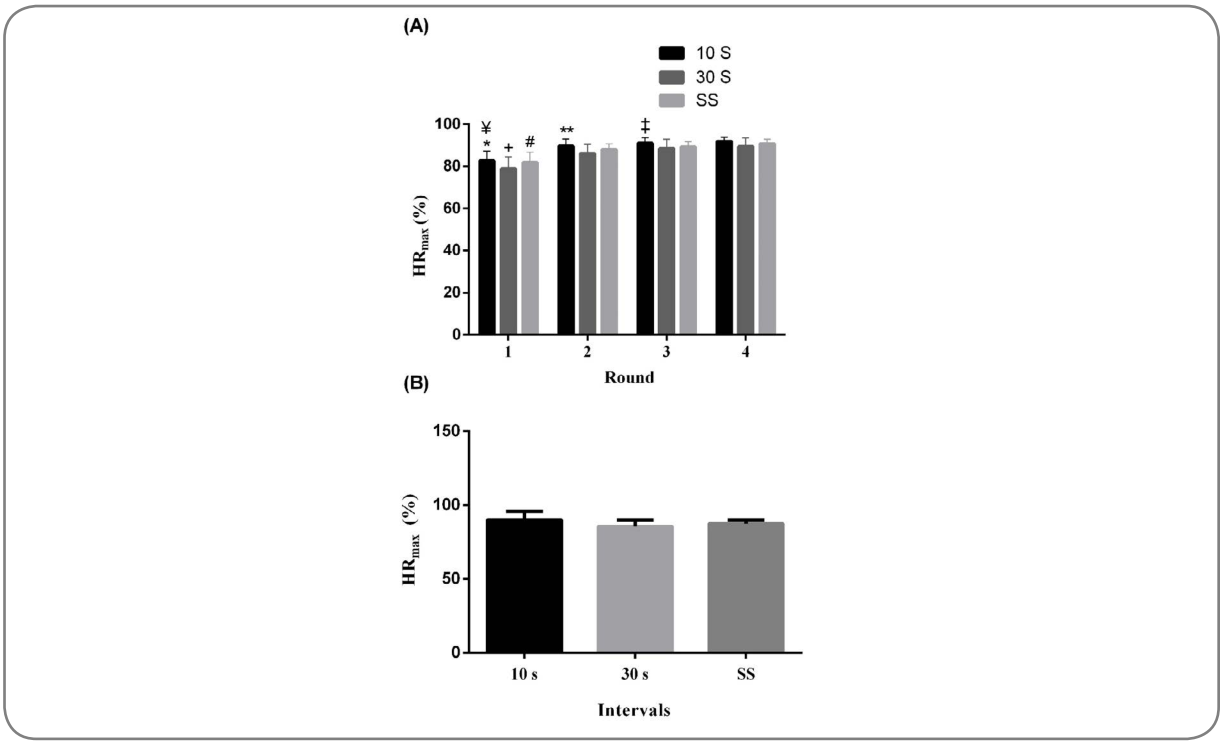
Statistical analysis

To perform the sample calculation, effect size and statistical power, the *G*Power software*, version 3.1.9.6, was used. (*Universitat Düsseldorf, Düsseldorf, Germany*). Significance and statistical power of 0.05 and 0.80 were respectively established. The data normality was initially tested using the Shapiro-Wilk test. To compare the duration of the session with SS interval with each fixed interval strategy, a paired Student's t test was used. Subsequently, the comparison of HR_{max} responses and training volume in the different rounds was performed using two-way ANOVA (interval strategy versus rounds), followed by Bonferroni's post-hoc test, in order to detect where differences between the experiments were found. To compare the mean values of HR and training volume obtained in the HIRT sessions, as well as the mean values of training volume obtained in the different exercises, one-way ANOVA was used, followed by Bonferroni's post-hoc test, applied to reveal where the differences between the experiments were found. Data were analyzed using the SPSS version 20 statistical package (*IBM, New York, United States*) and illustrated by *GraphPad Prism*, version 6.01 (*GraphPad Software, San Diego, California*).

Results

Considering the four rounds through the circuit, the duration of the sessions was eight min (HIRT with an interval of 10 s between stimuli), 13.50 min (HIRT with an interval of 30 s between stimuli) and 9.16 min (HIRT with an interval of SS). The duration of the HIRT sessions showed difference between the session with SS interval and the session with 10 s interval ($P < 0.0001$), as well as between the session with SS interval and the session with 30 s interval ($P = 0 .01$).

Figure 1 illustrates the percentage of HR_{max} in the rounds of HIRT sessions with different intervals between stimuli (A), as well as the average percentage of HR_{max} in each session (B). When comparing the HR responses in the different rounds of the HIRT sessions, some differences were detected between sessions ($P < 0.05$). However, in relation to the mean HR values obtained in the HIRT sessions (B), no difference was detected between them ($P > 0.05$).

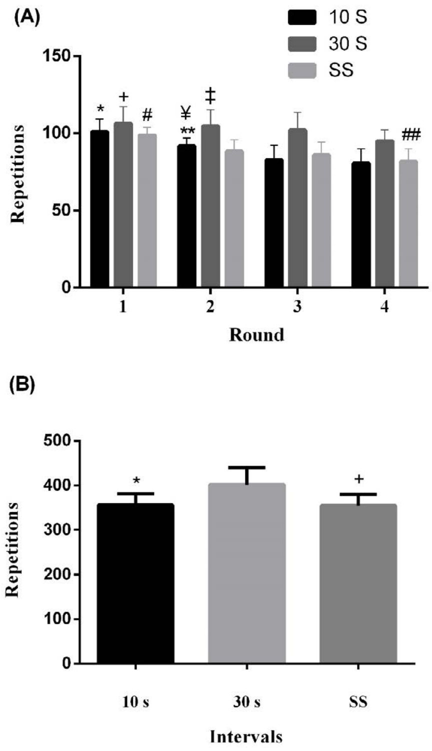


(A): * = difference between the first round of the session with 10 s interval in relation to the others (P <0.05); ** = difference in the second round of the session with 10 s interval in relation to the others (P < 0.05); + and # = difference between all rounds of the session with 30 s interval between stimuli and SS interval, respectively (P < 0.05); ¥ = difference in the first and second round between sessions with a 10 s interval and a 30 s interval (P = 0.05 and 0.02, respectively); ‡ = difference between sessions with 10 s interval and SS interval in the third round (P = 0.05)

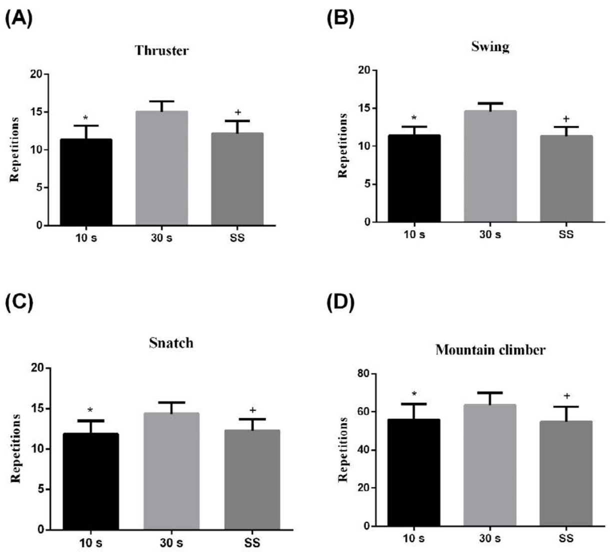
Figure 1 - The percentages of HR_{max} obtained in the rounds of the HIRT session with different intervals between stimuli (A), and the mean HR sessions (B)

Figure 2 illustrates the number of repetitions in the rounds of the HIRT sessions with different intervals between stimuli (A), as well as the average number of repetitions for each session (B). The comparison of the number of repetitions obtained in the different rounds of the HIRT sessions (A), detected some differences between sessions ($P < 0.05$). In addition, when comparing the mean of repetitions obtained in each session, the session with 30 s interval produced a greater number of repetitions compared to sessions with 10 s interval and SS interval ($P < 0.05$).

Figure 3 illustrates the mean value of repetitions obtained in each exercise in the HIRT sessions performed with different intervals between stimuli. In all exercises, the mean value of repetitions of the session with 30 s of interval between stimuli differed from the sessions with 10 s of interval ($P < 0.001$), and with SS interval ($P < 0.001$).



(A): * and ** = difference between the first and second round of the session with a 10-s interval in relation to the others (P < 0.05); + = difference between all rounds of the session with a 30 s interval between stimuli (P < 0.05); # and ## = difference of the first round in relation to the others in the session with AS interval (P < 0.05); ¥ = difference in the second, third and fourth round between sessions with 10 s of interval and 30 s of interval (P = 0.003; P = 0.001 and P < 0.001, respectively); ‡ = difference between sessions with 10 s interval and SS interval in the second, third and fourth round (P = 0.01, P = 0.007 and P = 0.006, respectively). (B): * = difference between HIRT sessions with 10 s interval and 30 s interval (P = 0.02); ** = difference between HIRT sessions with 30 s interval and SS interval (P = 0.01)
Figure 2 - Number of repetitions in the rounds of HIRT sessions with different intervals between stimuli (A), and mean of repetitions obtained in each session (B)



* = difference between the session with a 30 s interval between stimuli and a session with a 10 s interval between stimuli (P < 0.001); + = difference between the session with 30 s interval between stimuli and session with SS interval
Figure 3 - Average of repetitions in the Thruster (A), Swing (B), Snatch (C) and Mountain Climber (D) exercises, obtained in the HIRT sessions with different intervals between stimuli

Discussion

This study compared the HR and training volume responses in HIRT training sessions performed with fixed and SS recovery intervals. The main findings revealed that HR differed only between the rounds of each session, without any difference between the different sessions. When the training volume was compared in each isolated session, difference was verified between the rounds of each session. On the other hand, the comparison of the training volume between the different sessions revealed that the session with a 30 s interval between stimuli produced a greater number of repetitions when compared to 10 s and SS intervals. When comparing the training volume in each isolated exercise, considering the four rounds of the circuit, the session with 30 s interval resulted in a greater number of repetitions when compared to 10 s and SS intervals. The same pattern was verified in all exercises.

HR is one of the main variables used for monitoring the exercise intensity [15]. The HR responses found in this experiment indicated that both intervals between stimuli were effective in maintaining high intensities throughout the session. Based on the classification recommended by the American College of Sports Medicine [11], the HR values obtained during HIRT sessions allow us to classify the exercise intensity as vigorous. Despite the vigorous intensity of the HIRT sessions, all participants were able to complete the sessions without interruptions. This aspect may be related to their high level of physical conditioning, since all of them were experienced in mixed activities, and had a high level of cardiorespiratory fitness (VO_{2peak} 56.6 ± 7.5 $ml.kg^{-1}.min^{-1}$).

Sustaining high intensities during exercise is a fundamental aspect in physical conditioning programs aimed at improving cardiorespiratory fitness [15-17]. From the HR responses verified in all HIRT sessions, along with their duration, we highlight the exercise session with 30-s interval between stimuli. In this interval strategy, the high intensity was maintained for a longer period. Although the objective of this study is focused on acute responses to exertion, it is possible that a longer exercise duration sustained at the highest intensity may be associated with greater improvements in cardiorespiratory condition, compared to other intervals between stimuli. To elucidate this hypothesis, studies with longitudinal follow-up should be carried out. On the other hand, the session with SS interval was also effective in keeping the HR high during the HIRT session. This means that the individual's perception of recovery interval between stimuli can be considered in the control of the effort intensity in trained participants. Thus, SS recovery intervals between stimuli can be used due to their easy application during the sessions.

Another aspect refers to the training volume responses from the investigated HIRT sessions. Despite several studies analyzing the acute responses in HIRT sessions, the training volume has been a neglected variable in favor of physiological variables [6,18,19]. To the best of our knowledge, the only study that focused on the training volume in HIRT training, in addition to physiological responses, was conducted by

Machado *et al.* [9]. These authors monitored the training volume in different exercises. However, as a descriptive study, it addressed only the training volume achieved in exercises with different muscle groups. In our experiment, the training volume in HIRT training sessions was compared by applying different strategies of intervals between stimuli.

Regarding the training volume responses in this experiment, the session with a 30 s interval was more effective in producing a greater number of repetitions, when compared to 10 s and SS intervals. This result was expected, since the fixed interval of 10 s proposed by Tabata *et al.* [20] is three times smaller than the fixed interval time of 30 s. In addition, although they could rest if they deemed necessary to perform the next stimulus in the session with SS intervals, the average recovery time of our sample was 15 s, which also negatively impacted the recovery compared to the session with 30 s of interval between stimuli. Therefore, when the objective of the session is to obtain a greater training volume, the session with 30 s should be preferred. It should be noted that the comparison of training volume from HIRT sessions with a fixed interval of 10 s versus SS interval did not reveal any difference. This implies that both intervals can be used without affecting the training volume.

Finally, this study has some limitations. The loads used to perform some exercises were self-selected by the practitioner. Although no specific strength test was applied to determine the loads, participants were used to training in the exercises of our experiment, which may have minimized possible errors. Furthermore, participants were instructed to perform the exercises at all out intensity, but we cannot ensure that this has actually taken place. However, maximum effort is inherent in all HIRT sessions and there is no reason to imagine that exercise intensity has been overestimated.

Conclusion

The HR responses in the HIRT sessions were similar in all of the investigated recovery intervals between stimuli. Since SS intervals were as effective as the fixed intervals in controlling the effort intensity, they can also be applied due to their practicality. Nevertheless, 30 s intervals must be applied when the objective of the session is to obtain a higher training volume.

Potential conflict of interest
No potential conflicts of interest relevant to this article have been reported.

Financing source
There were no external funding sources for this study.

Author's contributions
Research conception and design: Monteiro W, Farinatti P; **Data collection:** Fidalgo A, Pilon R, Oliveira A, Medeiros R; **Data analysis and interpretation:** Fidalgo A, Matos-Santos L, Baladán R; **Statistical analysis:** Fidalgo A, Pilon R, Matos-Santos L; **Writing of the manuscript:** Fidalgo A, Monteiro W; **Critical review of the manuscript regarding important intellectual content:** Monteiro W, Farinatti P.

References

1. Sperlich B, Wallmann-Sperlich B, Zinner C, Von Stauffenberg V, Losert H, Holmberg HC. Functional high-intensity circuit training improves body composition, peak oxygen uptake, strength, and alters certain dimensions of quality of life in overweight women. Front Physiol 2017;8:1-9. doi: 10.3389/fphys.2017.00172

2. Buckley S, Knapp K, Lackie A, Lewry C, Horvey K, Benko C, *et al.* Multimodal high-intensity interval training increases muscle function and metabolic performance in females. Appl Physiol Nutr Metab 2015;40(11):1157-62. doi: 10.1139/apnm-2015-0238

3. Laursen P, Buchheit M. Science and application of high-intensity interval training: solutions to the programming puzzle. Human Kinetics; 2019.

4. Smilios I, Myrkos A, Zafeiridis A, Toubekis A, Spassis A, Tokmakidis SP. The effects of recovery duration during high-intensity interval exercise on time spent at high rates of oxygen consumption, oxygen kinetics, and blood lactate. J Strength Cond Res 2018;32(8):2183-9. doi: 10.1519/JSC.0000000000001904

5. Piero DW, Valverde-Esteve T, Redondo-Castán JC, Pablos-Abella C, Díaz-Pintado JVSA. Effects of work-interval duration and sport specificity on blood lactate concentration, heart rate and perceptual responses during high intensity interval training. PLoS One 2018;13(7):1-12. doi: 10.1371/journal.pone.0200690

6. Nuñez TP, Amorim FT, Beltz NM, Mermier CM, Moriarty TA, Nava RC, *et al.* Metabolic effects of two high-intensity circuit training protocols: Does sequence matter? J Exerc Sci Fit 2020;18(1):14–20. doi: 10.1016/j.jesf.2019.08.001

7. Gist NH, Freese EC, Cureton KJ. Comparison of responses to two high-intensity intermittent exercise protocols. J Strength Cond Res 2014;28(11):3033-40. doi: 10.1519/JSC.0000000000000522

8. Schoenmakers PPJM, Reed KE. The effects of recovery duration on physiological and perceptual responses of trained runners during four self-paced HIIT sessions. J Sci Med Sport 2019;22(4):462-6. doi: 10.1016/j.jsams.2018.09.230

9. Machado AF, Evangelista AL, Miranda JMQ, Teixeira CVLS, Rica RL, Lopes CR, *et al.* Description of training loads using whole-body exercise during high-intensity interval training. Clinics (Sao Paulo) 2018;73(12):e516. doi: 10.6061/clinics/2018/e516

10. Matthews CE, Heil DP, Freedson PS, Pastides H. Classification of cardiorespiratory fitness without exercise testing. Med Sci Sports Exerc 1999;31(3):486-93. doi: 10.1097/00005768-199903000-00019

11. ACSM Guidelines for exercise testing and prescription. 10th ed. Alphen aan den Rijn: Wolters Kluwer; 2018.

12. Silva SC, Monteiro WD, Cunha FA, Myers J, Farinatti PTV. Determination of best criteria to determine final and initial speeds within ramp exercise testing protocols. Pulm Med 2012;2012:9-12. doi: 10.1155/2012/542402

13. Weisman IM, Weisman IM, Marciniuk D, Martinez FJ, Sciurba F, Sue D, *et al.* ATS/ACCP Statement on cardiopulmonary exercise testing. Am J Respir Crit Care Med 2003;167(2):211-77. doi: 10.1164/rccm.167.2.211

14. Howley ET, Bassett DR, Welch HG. Criteria for maximal oxygen uptake: review and commentary. Med Sci Sports Exerc 1995;27(9):1292-301.

15. Mann T, Lamberts RP, Lambert MI. Methods of prescribing relative exercise intensity: Physiological and practical considerations. Sport Med 2013;43(7):613-25. doi: 10.1007/s40279-013-0045-x

16. MacInnis MJ, Gibala MJ. Physiological adaptations to interval training and the role of exercise intensity. J Physiol 2017;595(9):2915-30. doi: 10.1113/JP273196

17. Helgerud J, Høydal K, Wang E, Karlsen T, Berg P, Bjerkaas M, *et al.* Aerobic high-intensity intervals improve VO-2max more than moderate training. Med Sci Sports Exerc 2007;39(4):665-71. doi: 10.1249/mss.0b013e3180304570

18. Falcone PH, Tai C-Y, Carson LR, Joy JM, Mosman MM, McCann TR, *et al.* Caloric expenditure of aerobic, resistance, or combined high-intensity interval training using a hydraulic resistance system in healthy men. J Strength Cond Res 2015;29(3):779-85. doi: 10.1519/JSC.0000000000000661

19. Williams BM, Kraemer RR. Comparison of cardiorespiratory and metabolic responses in kettlebell high--intensity interval training versus sprint interval cycling. J Strength Cond Res 2015;29(12):3317-25. doi: 10.1519/JSC.0000000000001193

20. Tabata I, Nishimura K, Kouzaki M, Hirai Y, Ogita F, Miyachi M, *et al.* Effects of moderate-intensity endurance and high-intensity intermittent training on anaerobic capacity and VO2max. Med Sci Sport Exerc 1996;28(10):1327-30. doi: 10.1097/00005768-199610000-00018