COMPARISON OF EPOC AND RECOVERY ENERGY EXPENDITURE BETWEEN HIIT AND CONTINUOUS AEROBIC EXERCISE TRAINING

COMPARAÇÃO DO EPOC E GASTO ENERGÉTICO DE RECUPERAÇÃO ENTRE HIIT E AERÓBICOS CONTÍNUOS

COMPARACIÓN DEL EPOC Y GASTO ENERGÉTICO DE RECUPERACIÓN ENTRE HIIT Y AERÓBICOS CONTINUOS

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ABSTRACT

Objectives: The objective of this study was to compare EPOC - excess post-exercise oxygen consumption and recovery energy expenditure between high intensity interval aerobic exercise (HIIT) and continuous aerobic exercise in adult amateur runners. Methods: The study included 10 runners, with a mean age of 35.7 ± 5.87 years, height 1.69 ± 0.11 m; body mass 74.13 ± 11.26 kg; fat percentage 19.31 ± 4.27% and maximal oxygen consumption (VO_2max) of 3.50 ± 0.64 l/kg/min-1. The continuous aerobic exercise protocol consisted of 20 minutes of running with intensity of 70-75% HRmax. Two 20-second cycles of 8 sprints were performed for HIIT at the highest possible speed, with 10 seconds of rest and a 3-minute interval between cycles. The sample group performed the two protocols at least 48 hours and at most one week apart. EPOC was observed using ergospirometry after the running protocols, and mean consumption was analyzed between 25-30 minutes after exercise. Oxygen consumption at 9-10 minutes was used for resting consumption. The study has a cross-sectional experimental design. Results: Oxygen consumption of 0.57 ± 0.29l/kg/min^{1} and energy expenditure of 2.84 ± 1.44 kcal/min were observed for continuous aerobic exercise, with values of 0.61 ± 0.62 l/kg/min^{-1}and 3.06 ± 1.10 kcal/min respectively (p <0.05) for HIIT. Conclusion: The protocols performed did not show a statistically significant difference in terms of EPOC and energy expenditure, but the performance of HIIT increased lipid metabolism for exercise recovery, which may favor the weight loss process. Moreover, this activity model takes up less time. ***Level of evidence I, randomized clinical trial.***

Keywords: High-intensity interval training; Oxygen consumption; Aerobic exercise; Energy expenditure.

RESUMO

Objetivos: O presente estudo teve como objetivo comparar o EPOC - consumo excessivo de oxigênio pós-exercício - e o gasto energético na recuperação entre o exercício aeróbico intervalado de alta intensidade (HIIT) e os aeróbicos contínuos em corredores amadores adultos. Métodos: Fizeram parte do estudo 10 corredores com idade média de 35,7 ± 5,87 anos, estatura 1,69 ± 0,11 m; massa corporal 74,13 ± 11,26 kg; percentual de gordura 19,31 ± 4,27% e consumo máximo de oxigênio (VO_2máx.) de 3,50 ± 0,64 l/kg/min^{-1}. O protocolo de exercício aeróbico contínuo consistiu em 20 minutos de corrida com intensidade de 70-75% FCM. Para HIIT foram realizados dois ciclos de 8 sprints de corrida na maior velocidade possível, com duração de 20 segundos/10 segundos de descanso e três minutos de intervalo entre os ciclos. A amostra realizou os dois protocolos com no mínimo 48 horas e no máximo uma semana de intervalo. Após os protocolos de corrida, observou-se o EPOC através da ergoespirometria e foi analisado o consumo médio entre 25-30 minutos após o exercício. Para o consumo em repouso, utilizou-se o consumo de oxigênio de 9-10 minutos. O estudo possui delineamento experimental do tipo transversal. Resultados: Observaram-se um consumo de oxigênio de 0,57 ± 0,29 l/kg/min^{-1} e um gasto energético de 2,84 ± 1,44 kcal/min para o exercício aeróbico contínuo, já para o HIIT 0,61 ± 0,62 l/kg/min^{-1} e 3,06 ± 1,10 kcal/min respectivamente (p<0,05). Conclusão: Os protocolos realizados não demonstraram diferença estatística significativa em relação ao EPOC e ao gasto energético, porém a realização do HIIT aumentou o metabolismo dos lipídeos para a recuperação do exercício, podendo favorecer o processo de emagrecimento, além de ser necessário um menor tempo para praticar esse modelo de atividade. ***Nível de evidência I, estudo clínico randomizado.***

Descritores: *Treinamento intervalado de alta intensidade; Consumo de oxigênio; Exercício aeróbico; Gasto energético.*

RESUMEN

Objetivos: El presente estudio tuvo como objetivo comparar el EPOC - consumo excesivo de oxígeno post ejercicio - y el gasto energético en la recuperación entre el ejercicio aeróbico con intervalos de alta intensidad (HIIT) y los aeróbicos continuos en corredores amateurs adultos. Métodos: Formaron parte del estudio 10 corredores con edad promedio de 35,7 ± 5,87 años, estatura 1,69 ± 0,11 m; masa corporal 74,13 ± 11,26 kg; porcentual de grasa 19,31 ± 4,27% y consumo máximo de oxígeno (VO_2máx.) de 3,50 ± 0,64 l/kg/min^{-1}. El protocolo de ejercicio aeróbico continuo consistió en 20

minutos de carrera con intensidad de 70-75% FCM. Para HIIT fueron realizados dos ciclos de 8 sprints de carrera en la mayor velocidad posible, con duración de 20 segundos/10 segundos de descanso y tres minutos de intervalo entre los ciclos. La muestra realizó los dos protocolos con como mínimo 48 horas y como máximo una semana de intervalo. Después de los protocolos de carrera, se observó el EPOC a través de la ergoespirometría y fue analizado el consumo promedio entre 25-30 minutos después del ejercicio. Para el consumo en reposo, se utilizó el consumo de oxígeno de 9-10 minutos. El estudio posee delineación experimental del tipo transversal. Resultados: Se observó un consumo de oxígeno de 0,57 ± 0,29 l/kg/min^{-1} y un gasto energético de 2,84 ± 1,44 kcal/min para el ejercicio aeróbico continuo, ya para el HIIT 0,61 ± 0,62 l/kg/min^{-1} y 3,06 ± 1,10 kcal/min respectivamente (p<0,05). Conclusión: Los protocolos realizados no demostraron diferencia estadística significativa con relación al EPOC y al gasto energético, aunque la realización del HIIT aumentó el metabolismo de los lípidos para la recuperación del ejercicio, pudiendo favorecer el proceso de adelgazamiento, además de ser necesario un menor tiempo para practicar ese modelo de actividad. ***Nivel de evidencia I, estudio clínico aleatorizado.***

Descriptores: *Entrenamiento en intervalos de alta intensidad; Consumo de oxígeno; Ejercicio aeróbico; Gasto de energía.*

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INTRODUCTION

Energy balance results from the ingestion and expenditure of energy. When it is unbalanced a reduction or increase of corporeal fat reserve can occur[1]. The amount of calories spent per day is divided into three components: basal resting metabolic rate, thermic effect of diet and physical exercise, this last one being the most varying component because it varies according to the person's involvement in exercise programs[2].

Aerobic exercises became popular for being the main method used to lose weight and to increase cardio-respiratory capacity[3]. These exercises stimulate the cardio, respiratory, and metabolic functions recruiting a lot of muscle mass in a rhythmic way for this type of physical exercise[4].

Continuous training consists in a long-lasting rhythmic with moderate intensity exercise with a VO_2 max[1] between 60% and 80% keeping, this way, the heart rate around 70% of the maximum[5]. Otherwise, the HIIT is an exercise program with periods of exercise and recuperation[6].The interval of recuperation can be passive or active, depending on the intensity and the goals implied in the training because it can hone different energy transferring systems[7,8].

After an exercise session the metabolic rate stays elevated in relation to the resting values in order to the organism to return to its balanced state[6]. This moment is called EPOC, consisting in two components: the fast and the prolonged. Even though the precise causes of these responses are not clear, it is probable that these factors contribute to the re-synthesis of ATP/CP, increasing the sodium potassium bomb activity, restoring the tissue, removing lactate, restoring the increased heart rate, and the increased body temperature. During the prolonged component, processes to the return of the physiological homeostasis occur in a lower level and in a continuous way. These processes can include a higher use of fatty acids in the Krebs cycle; increase the effect of hormones such as GH, insulin, ACTH, cortisol and thyroid hormones. It also increases the sympathetic activity, mitochondrial respiration, the temperature, myoglobin re synthesis, hemoglobin and glycogen[6,7].

The EPOC has a direct relation with energetic expenditure, as long as it is taken into consideration that for each liter of oxygen consumed about five calories are spent in our organism[9]. This way, it is an important factor to be considered in weight loss because it increases the demand of energy beyond the already predicted in the physical activity [8,10]. Various studies have analyzed the contribution of EPOC to reduce body mass, considering that weight loss results from a negative daily energetic balance between ingestion and energetic expenditure [11,12].

In this context, the objective of the study is to compare the EPOC and the recuperating energetic waste between HIIT and continuous aerobe. The hypothesis is that HIIT will show significant differences in relation to continuous aerobe exercise.

MATERIAL AND METHODS

The present study took place in the Laboratory of Ergospirometry and Cardiopulmonary Rehabilitation of the Physical Education and Physiotherapy College of the University of Passo Fundo, RS, Brazil. The study was approved by the Ethics Comitee of the University, under the number 1.748.970.

Ten male volunteers took part in the study with median age of 35,7 +- 5,87, medium height of 1,69m +- 0,11m, body mass 74,13 Kg +- 11,26 Kg, fat percentage 19,31 +- 4,27, and VO2max of 3,50 +- 0,64 l/kg/min, they all were runners for more than six months and practice at least three times a week. The participants were recruited from the local city, informed about the objectives of the research, answered the physical aptitude questionnaire PAR-Q[13], and signed the consent form after everything was explained.

To verify the aerobic capacity of the participants, the VO2max test was used following the Cooper protocol [14], where the subject needs to run or walk 2400 meters at the lowest time possible. To control the time of the test an Oregon S1210 chronometer was used (Oregon Scientific Brasil, Av. Ibirapuera 2907 – 1602, Moema, São Paulo, Brasil). The determination of VO2max was done according to Cooper [15].

The body composition was collected accordingly to the three folds of Pollock protocol[16], using a plicometer and a stenographer of Cescorf brand (*Cescorf Equipamentos para o Esporte LTDA, Av. Copacabana, 435, Porto Alegre – Brasil.*), both with milimetric precision, and an eletronic scale model PLE-180 (*Lucastec Balanças Eletrônicas LTDA, Rua Paulo Andrighetti, 149 - Belenzinho, São Paulo – Brasil*).

Procedure

All participants were asked not to practice any physical activity in the previous 48 hours from the data collection. First, the resting oxygen consumption was collected via direct analysis of gases using a silicon mask (Hans Rudolph. 8325 Cole Parkway Shawnee, KS 66227. EUA) and a gas analyser Ergo PC Elite VO 2000 (*Inbramed, Rua Santos Dumont. 1766/01 – Porto Alegre, Brasil*). For this procedure the participant laid down for 10 minutes in a stretcher, with the objective to analyze the last minute because it characterizes a bigger time of rest.

The running protocols took place in different days at the athletic field of 400 meters of the university, all with a minimum interval of 48 hours and maximum of a week. All participants did a standard warm-up of five minutes of low intensity running, and after this, they had a three minute rest before the beginning of the test.

To execute the HIIT, it was asked for the participants to run at the highest speed possible during the Sprints. It was used the Tabata Protocol[17]

adapted for running, where the participants ran eight cycles of 20 seconds of running and 10 seconds of active resting (walk). After that, it was allowed a passive rest for three minutes, and right after another eight cycles of the same protocol.

For the continuous aerobe exercises the subject were made to run for 20 minutes with moderate intensity, between 70% and 75% of each individual maximum heart rate (220-age)[18]. To monitor the heart rate it was used a cardiac monitor from the brand Oregon model HR102 (*Oregon Scientific Brasil, Av. Ibirapuera 2907 – 1602, Moema, São Paulo, Brasil*).

After each running test the participants took a 5 minute cool-down, after that the process to collect the EPOC took place. The analysis of the gases was verified according to instructions of the maker during 25-30 minutes after the exercise. The individuals laid down on the stretcher in the laboratory until the end of the collection.

The energy expenditure in recovery was calculated based on Foreaux et. al[9], where each liter of oxygen consumed varies from 4,69 to 5,05 kcal according to the mixture of energetic substrate that is being metabolized. In this study, a multiplication between the amounts of oxygen consumed by 5 kcal took place.

Statistical Analysis

The results of this study were expressed through descriptive statistics by measures of central tendency (median) and dispersion (standard deviation). The assumption of normality was verified using the Shapiro-Wilk test. To verify the differences within the physiological variables, such as heart rate, oxygen and carbon gas consumption, respiratory quotient, an kilocalories consumed in resting conditions, after interval exercise and after continuous exercise, it was used an ANOVA of repetitive measures followed by a post hoc test of Tukey. The statistical analysis was calculated using statistical analysis software (SPSS16.0), and the level of significance adopted was of 5% ($p<0,05$).

RESULTS

It is possible to observe that the heart rate presented statistical significant difference after both types of exercises; it stayed elevated in comparison to the resting state. This finding was already expected due to the physiological process of recuperation and consequently of the EPOC. When compared the FC of one exercise with another, it was noticed a significant difference because this variable stayed elevated in the HIIT protocol. (Table 1)

The EPOC of the different protocols that took place in the present study does not show significant statistical difference, assuming, therefore, that the HIIT that took place, even though it produced different physiological responses, is not capable to alter the EPOC in relation to continuous aerobe exercise.

The amount of CO_2 exhaled by the participants did not show a significant difference when compared to the resting levels.

The Respiratory Quotient (R) showed a significant difference for the HIIT, considering that this consists of $R= VCO_2/VO_2$, this way it was observed and increase of the production of CO_2 in this protocol.

Table 1. Median Values and Standard Deviation of the variables analyzed.

Variables	Rest	Post aerobic continuous 25 to 30m	Post aerobic interval 25 30m to
HR (bpm)	58,8 ± 10,51	66,9 ± 11,55*	79,1 ± 13,29*@
$^{VO}_2$ (L/kg/min^{-1})	0,40 ± 0,14	0,57 ± 0,29*	0,61 ± 0,62*
$^{VCO}_2$ (L/kg/min^{-1})	0,41 ± 0,16	0.49 ± 0,25	0,49 ± 0,22
R (VCO_2/VO_2)	0,88 ± 0,8	0,87 ± 0,06	0,77 ± 0,07*@
Kcal/min	1,98 ± 0,72	2,84 ± 1,44*	3,06 ± 1,10*

Source: Research Data. *Significant statistical difference in relation to rest. @ Siignificant statistical difference in relation to the EPOC of 25 to 30 minutes of continuous aerobe.

DISCUSSION

The main finding of the present study is that after the HIIT protocol the EPOC was 0,61 ± 0,62 l02/kg/min^{-1} , and for the continuous aerobe it was 0,57 ± 0,29 l02/kg/min^{-1}, this way it showed a significant difference in the oxygen consumption during resting time which was 0,40 ± 0,14 l02/kg/min^{-1}. On the other hand, it was not found significant differences when compared among them. A study by Simmons et. al[19] corroborates with the data obtained with the current study because it analyzed the EPOC of nine individuals, five men and four women, that were subjected to two different types of exercise protocols in a stationary bicycle. The first had ten moments of one minute of exercise at 90% of the maximum aerobe capacity for ten intervals of one minute at 60% of the maximum aerobe capacity, characterizing this way a HIIT. At the second protocol the participants were subjected to a 30 minutes exercise with an intensity of 50% of the maximum aerobe capacity. The EPOC measured from 11 to 41 minutes was of 0,86 ± 0,31 l02/kg/min^{-1} for the HIIT protocol, for the continuous aerobe exercise protocol the EPOC was 0,84 ± 0,44 l02/kg/min^{-1}. Like in the present study the EPOC was not statistically different, even though it showed higher values.

Lira et. al[20] identified that after 30 minutes of running on a treadmill with intensity of 90% of the Anaerobic Limit the EPOC from 0 to 10 minutes was 5.65 l02/kg/min^{-1}, and from 11 to 20 min. the EPOC was 3,92 l02/kg/min^{-1}, and from 21 to 30 min. the EPOC was 3,51 l02/kg/min^{-1}, making this way an EPOC higher in relation to the present study.

To the contrary of the data from this study, Laforgia et.al[21] observed in eight medium distance runners and EPOC of 9 hours the following values: 6,9 ± 3,8 l02/kg/min^{-1} for the protocol of sub maximum activity protocol that consisted of a 30 minute run in a treadmill at 70% VO2máx., for the supra maximum protocol twenty moments of running took place at a105% VO2máx with two minutes of rest, the EPOC showed was of 15,0 ± 3,3 l02/kg/min^{-1}, making this way a significant difference for the supra maximum training. Therefore, the protocols of that study show results much higher than of this present study.

In a more recent study Matsuo et. al[22] evaluated the EPOC of 180 minutes of ten male individuals that practiced 7 sets of 30 seconds of cycling at 120% VO2máx with 15 seconds of rest; 3 series of three minutes with intensity of 80 – 90% VO2máx with an active rest of 2 minutes at 50% VO2max.; and 40 minutes of continuous aerobe exercise with intensity of 60 – 65% VO2max. The EPOC found for each protocol was 6,8 ± 4,0 l02/kg/min^{-1}; 4,5 ± 3,3 l02/kg/min^{-1}; 2,9 ± 2,8 l02/kg/min^{-1} respectively. This study showed an EPOC higher for the HIIT in relation to the continuous aerobe, which is opposed to the results of the present study.

This way, even though the EPOC of the different protocols that took place in the present study do not show significant difference, it is supposed that the HIIT produces different physiological responses in relation to the continuous aerobe, however it is not capable to alter in a significant way the EPOC. Therefore, it is necessary less time of work to make this protocol happen, which can be beneficial and useful to individuals that have limited time to exercise. It is important to keep in mind that the HIIT is an excellent tool to increase physical conditioning and energetic expenditure.

The Respiratory Quotient (R) showed a significant difference for the HIIT, a fact probably justified by the increase of CO2 exhaled by the subjects in this protocol. It is possible to relate the R values with the energetic source that is being used to the recuperation of the subject after the exercise.

For Wilmore and Costill[23] as R gets closer to 1 the amount of subtracts coming from carbohydrates used to the return to homeostasis increases, that is, the values close to 0,7 suggest fat burn, near 0,9 and 1,0 it values the burn of carbohydrates. This way, the present study suggests

that the HIIT protocol favors the consumption of lipids for this process because the value showed was 0,77 for this protocol. At the continuous aerobe the value of R was 0,87, which suggests that the main energy source metabolized to muscle recovery in this protocol are the energetic substrate coming from carbohydrates.

The present work correlated the EPOC with the number of calories used during its collection. The results observed report that there was a considerable increase in relation to the calories burned while in rest, however it was not identified a significant difference when compared both protocols.

To the contrary of the data obtained in this study, Lins et al[24] analyzed the energetic expenditure while in recuperation of two hours after exercise sessions in a treadmill with different intensities. The group that did the high intensity exercise (80% VO_{2pico}), obtained a greater energetic expenditure in relation to the groups that did moderate activities (60% VO_{2pico}) or low intensity (60% VO_{2pico}). The authors also suggest that the higher the intensity of the exercise the greater the energetic expenditure that comes from lipids during the recuperation. This fact meets with the results found in the present study.

Many studies have been analyzing the physiological responses of exercises of different intensities, what is perceived is that the data obtained from them are, many times, controversial because some[25-27] suggest there is no difference between the variables analyzed, while others suggest that there is difference between the protocols.[28-30]

Analyzing all the data and comparing them with many studies it is perceived that the EPOC and the energetic expenditure in recuperation vary according to the type of exercise being practiced, the volume, and intensity applied in the exercise.

CONCLUSION

It is concluded, from the results of the present study, that there was no significant difference between the protocols in relation to the EPOC and the energetic expenditure; however, the HIIT can become a useful tool to those people who do not have time to exercise for longer hours, showing to be efficient because it promotes an EPOC and energetic expenditure of recuperation similar to those obtained in the continuous aerobic exercises, plus it increases the metabolism of the lipids in the recuperation of the exercise, which favors the process of losing weight.

Heart Rate (HR); Absolute volume of oxygen after exercise (VO_2); Absolute volume of carbon (VCO_2); Respiratory Quotient (R); Calories spent after exercise (Kcal); of the individuals at the moment of collecting EPOC of the continuous aerobic exercise and of the interval of high intensity.

All authors declare no potential conflict of interest related to this article

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