Journal of Sports and Games
Volume 2, Issue 1, 2020, PP 10-16
ISSN 2642-8466

Comparative Effect of Carbohydrate Overcompensation in Sprinters and MMA Fighters

Graciana Teixeira Costa[1*], Gislei Frota Aragão[1,2]

[1]*Universidade Federal do Ceará, Fortaleza, Ceará, Brasil*
[2]*Universidade Estadual do Ceará, Fortaleza, Ceará, Brasil*

***Corresponding Author:** Graciana Teixeira Costa, Universidade Federal do Ceará, Fortaleza, Ceará, Brasil.*

ABSTRACT

The ergogenic effect of overcompensating carbohydrates is widely studied and proven only in long-term performance. Some questions remain about the optimal nutrition in the training model to improve aerobic performance in sprinters and MMA athletes. Our goal is for carbohydrate overcompensation to improve the performance of two high-intensity exercises. We evaluated the athlets physiological responses before and after the carbohydrate overcompensation protocol. Anthropometric measurements were collected and a food history was made. Cardiopulmonary exercise was performed to determine the peak oxygen uptake, running time, blood glucose and power profile before and after the protocol. None difference was observed in peak oxygen uptake between athletes. A significative decrease ($p < 0.05$) was observed in the running time and blood glucose rate in sprinters while was observed an increase in power profile in MMA fighter. A correlation was observed between peak oxygen uptake and running time and power profile, suggesting sprinters can be more aerobic capacity in anaerobic exercise. The exercise-diet procedure using carbohydrate as ergogenic showed a favorable result related to increased performance, especially in anaerobic exercises of short duration and high intensity, such as sprinters.

Keywords: *MMA fight; sprinters; carbohydrates overload; ergogenic; aerobic capacity; blood glucose in the exercise; anaerobic threshold.*

INTRODUCTION

The ergogenic role of carbohydrates in responding to physiological adaptations, in glycogen reserves and energy substrates in human studies has not been fully investigated. Some questions remain about improving nutrition in the training model to increase aerobic performance and reduce stress biomarkers [1].

In the search for optimizing sports performance, several methods have been used in different areas of knowledge. These support lines have been conventionally called ergogenic resources. Ergogenic is any substance or phenomenon capable of improving work or performance, based on an improvement in an athlete's strength, speed, response time or endurance [2].

It is known that carbohydrate overload before and during high-intensity aerobic exercise benefits performance, increasing body glycogen stores in athletes [3], but it is not established in anaerobic exercise. The low availability of muscle glycogen can influence muscle fatigue and resistance exercise performance [4-6]. However, muscle glycogen stores can be affected by exercise mode, training status and a diet or exercise procedure for concentrations two to three times above normal [7,8].

There are several recent relevant reviews of the recommended amount of carbohydrate that support training and competition [9-12]. Increased glycogen storage in the liver and muscles maximizes performance, especially in exercises requiring prolonged exertion (65 - 75%) of peak oxygen uptake (VO_{2peak}) of high intensity exercise. The carbohydrate overcompensation protocol is based on depletion of muscle glycogen reserves through a low carbohydrate diet for few days, followed by a carbohydrate overload diet for several days [5, 13, 14]. An improvement of approximately 50% in the subsequent performance of resistance exercise can be expected, delaying muscle fatigue [5].

The cardiopulmonary or cardiorespiratory or ergospirometric, actually carries information about the integrity of all systems involved in the transport of gases, that is, it involves not only cardiovascular and respiratory problems, but also neurological, humoral and hematological problems [15]. Basically, the function of the cardiovascular and pulmonary systems is to maintain the process of respiration and cellular nutrition, and one way of assessing this function is through direct analysis of the VO_{2peak} and the production of carbon dioxide (VCO2), reflecting the integrity of these systems, as well as their adaptations during exercise [15].

Some studies have been carried out to determine whether carbohydrate intake leads to improved performance, such as glycemic profile, aerobic capacity and anaerobic threshold, during high-intensity anaerobic exercise. It is hypothesized that carbohydrate overcompensation protocol improve performance in endurance exercise, but its role in anaerobic exercise is not fully established.

In this perspective, we aim to characterize the carbohydrate overcompensation response and compare potential mechanisms underlying this phenomenon and estimate changes in biomarkers under controlled experimental conditions and aerobic capacity in sprinters and MMA athletes.

METHOD

Ethical Approval

Ethical approval was obtained from the Federal University of Amazonas and the State University of Ceará to carry out the study. All participants provided written consent to their willingness to participate in the study.

Type of study and Population

The research is descriptive and experimental on the effects of overcompensation carbohydrate in sprinters (n = 9) and MMA athletes (n = 16) in the cardiopulmonary exercise test.

Anthropometry

Athletes were measured for body weight and height. Weight was measured with possible minimal clothing on a calibrated scale (Model: EF912; BIOLAND) and height was measured on a calibrated compact stadiometer (Model: 2M; MD). The body mass index (BMI) was calculated as weight (kg) / height (m^2).

Cardiopulmonary Exercise Test

The sprinters participated in the cardiopulmonary exercise test, by direct analysis of the VO_{2peak}, with a device called an ergospirometer. The Harbor Protocol was used. This protocol was adjusted according to the individual's physical profile. The relative air humidity, the ambient temperature (ºC) and the barometric pressure were measured at the evaluation site.

In addition, the test was accompanied by a doctor specialized in sports medicine, equipped with equipment, in the event of an accident during the test's applicability. At the beginning and after the exercise test, blood glucose was measured and, during the test, the anaerobic threshold was used to verify the influence of both measures on the athlete's performance. The anaerobic threshold was measured by the ergospirometer device through the value of O_2 and CO_2 during the test.

MMA athletes completed each time trial together, through the indirect analysis of the VO_{2peak}, around an outdoor running circuit (gravel) on an athletics track. The race distance was marked between the place of departure and the place of arrival, testing a 3200m time trial run [16]. The ambient temperature was approximately 30.7 °C and 33.8 °C and the relative air humidity of 66% and 75% at the time of the running test.

All subjects were familiar with running before performing a climb test to determine VO_{2peak}. Blood glucose were registered with a Digital Arm Blood Pressure Gauge G-Tech and a Glucometer G-Tech at the beginning and at the end of each running test.

Experimental Design

At the beginning and after the cardiopulmonary exercise test the blood glucose was measured and during the test the anaerobic threshold was used to verify the influence of both measures on the athlete's performance (Figure 1).

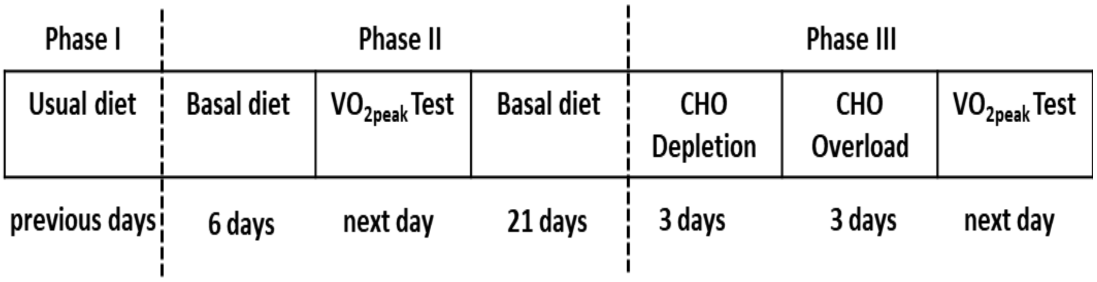

Figure1. *Representation of the experimental model applied in sprinters and MMA athletes.*

Phases of the Study

The present study was completed in three distinct phases (Figure 1). In the firts phase of the study, we collected usual dietary information. In second phase, the basal diet was developed for adaptation and third phase, was performed the carbohydrate overcompensation protocol [3].

Phase 1: Usual Diet

A dietary data questionnaire was provided to all participants to determine the energy and nutrients in the usual diet. The questionnaire contained all possible foods consumed by the athletes. Participants were asked to write down all the food they had eaten for their main meals and snacks, including water, coffee, tea, supplements or other drinks and liquids. Participants recorded food intake for a week before this research.

Phase2: Basal Diet

A basal diet of adaptation was calculated and given to athletes. Energy values were calculated using the Harris-Benedict equation.

The basal diet was established with 60% carbohydrates, 15 - 20% protein and less than 25% lipids of the total energy of total calories, vitamins and minerals suitable for 100% of the Dietary Reference Intakes, 1997-2001, fiber 38 g/day of adequate intake and cholesterol at 300 mg/day of the World Health Organization (WHO).

The basal diet was eaten for six consecutive days. On the seventh day, the athletes participated in the cardiopulmonary exercise test. The athletes maintained a basal diet for 3 weeks until the next phase.

Phase3: Carbohydrate Overcompensation-induced Diet

The Carbohydrate Overcompensation-induced diet protocol was divided into a carbohydrate depletion diet and a carbohydrate overload diet. First, the athletes ingested three days on a carbohydrate depletion diet with a distribution of 40% carbohydrates, 30 to 35% proteins and 25 to 30% lipids of the total calories. The diet was enriched with a protein supplement to reach the protein percentage. Over the next three days, the athletes ate a carbohydrate overload diet with 70% carbohydrate, 15% protein and 15% lipid distribution of total calories. On the seventh day, the athletes participated in the cardiopulmonary exercise test. The means ± SD values before and after cardiopulmonary exercise test were expressed through delta symbol (Δ).

Statistical Analysis

Descriptive statistics was used to determine the mean and standard deviation (Mean ± SD), according to the normality standard (parametric and nonparametric variables), applying the Kolmorogov-Smirnov test. The significance of the differences between the means was determined by the Student's t test and the strength of the relationships was described by the Pearson product moment correlation coefficient. Statistical calculations were performed using the statistical analysis program GraphPad Prism® version 5.00 for Windows, GraphPad Software, San Diego, California, U.S.A., www.graphpad.com. The method was used to verify the degree of significance ($p < 0.05$). All data were reported as Mean ± SD.

RESULTS

Effects of Carbohydrate Overcompensation on VO_{2peak}

Its physiological and performance characteristics are measured in the cardiopulmonary exercise test. The VO_{2peak} rate (Δ) between sprinters and MMA fighters was not significantly different ($p > 0.05$) (Figure 2). The response of an individual's VO_{2peak} rate (Δ) during the cardiopulmonary exercise test was found at 55.83 ml kg^{-1} min^{-1} in sprinters and 50.73 ml kg^{-1} min^{-1} in MMA fighters.

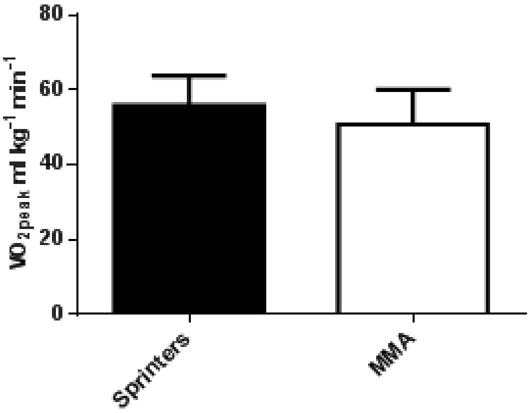

Figure2. *Evaluation of the VO_{2peak} rate (Δ) in athletes. Values are means ± SD. $p > 0.05$*

Effects of Carbohydrate Overcompensation on Running Time

The running time (Δ) for sprinters was significantly lower ($p < 0.0001$) compared to MMA fighters (Figure 3A). The response of an individual's running time rate (Δ) during the cardiopulmonary exercise test to determine VO_{2peak} rate (Δ) was found at 8.16 s in sprinters and 14.17 s in MMA fighters.

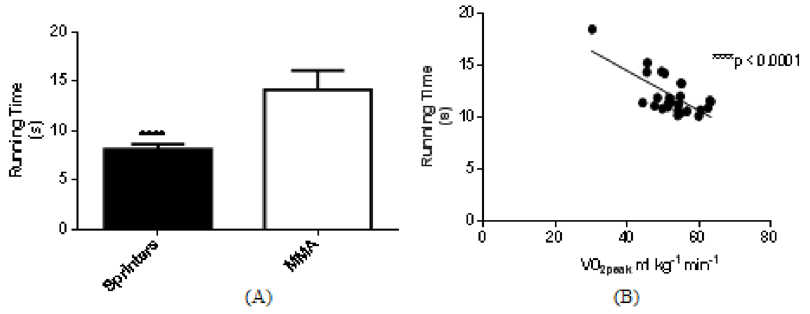

Figure3. *(A) Evaluation of the running time (Δ) in athletes. Values are means ± SD, ****$p < 0.0001$; (B) Running time (Δ) and VO_{2peak} rate (Δ) correlation test in athletes. Values are means ± SD, ****$p < 0.0001$.*

A negative linear correlation ($r = -0.6931$; $p < 0.0001$) was found between running time (Δ) and VO_{2peak} rate (Δ) in athletes. These results show that VO_{2peak} value (Δ) at 52.64 ml kg^{-1} min^{-1} can be predicted from the level reached at a running time rate (Δ) at 12.06 s (Figure 3B).

Effects of Carbohydrate Overcompensation on Blood Glucose

The blood glucose rate (Δ) in sprinters was significantly higher ($p < 0.0001$) compared to MMA fighters (Figure 4A). The blood glucose rate (Δ) response of an individual during the cardiopulmonary exercise test to determine VO_{2peak} (Δ) was found at 103,4 mg/dL in sprinters and 193.2 mg/dL in MMA fighters.

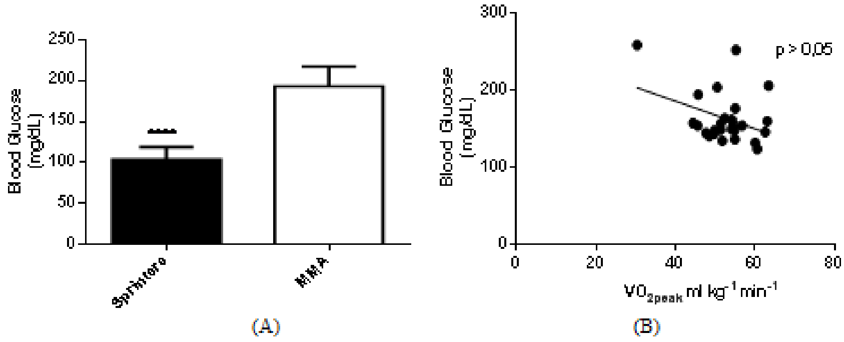

Figure4. *(A) Assessment of mean blood glucose rate (Δ) in athletes. Values are means ± SD, ****$p < 0.0001$; (B) Blood glucose rate (Δ) and VO_{2peak} rate (Δ) correlation test in athletes. Values are means ± SD $p > 0.05$.*

Non linear correlation ($r = -0.3707$; $p = 0.06$) was found between blood glucose rate (Δ) and VO_{2peak} rate (Δ) in athletes. These results show that VO_{2peak} value (Δ) at 52.64 ml kg^{-1} min^{-1} can be predicted from the level reached in the blood glucose rate (Δ) at 163 mg/dL (Figure 4B).

Effects of Carbohydrate Overcompensation on Power Profile

The power profile rate (Δ) in MMA fighters was significantly higher ($p < 0.001$) compared to sprinters (Figure 5A). The response of an individual's power profile rate (Δ) during the cardiopulmonary exercise test to determine VO_{2peak} rate (Δ) was found at 918.6 W in sprinters and 11190 W in MMA fighters.

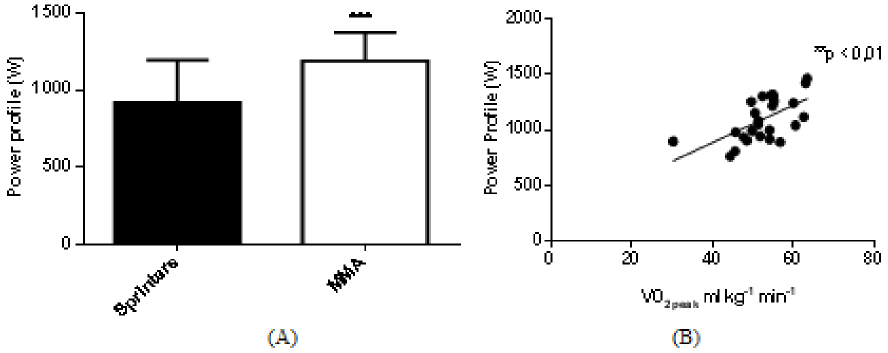

Figure5. *(A) Evaluation of the power profile rate (Δ) in athletes. Values are means ± SD. ***$p < 0.001$; (B) Power rate rate (Δ) and VO2peak rate rate (Δ) correlation test in athletes. Values are means ± SD **$p < 0.01$.*

A positive linear correlation (r = 0.6046; p = 0.0011) was found between power profile rate rate (Δ) and VO_{2peak} rate rate (Δ) in athletes. These results show that VO_{2peak} value (Δ) at 52.64 ml kg^{-1} min^{-1} can be predicted from the level reached on a power profile rate (Δ) at 1100 s (Figure 5B).

DISCUSSION

The aim of this study was to characterize the carbohydrate overcompensation response and to compare the effect on aerobic capacity in sprinters and MMA fighters. Research is lacking documenting the effect of carbohydrate overcompensation on anaerobic exercise. Our results are important because they enabled the characterization of the acute physiological response and nutritional strategies appropriate to training in anaerobic exercises.

The improvement in the performance of short-term exercises with the ingestion of carbohydrates as ergogenic is not well understood, but it is known that nutrition is one of the factors that optimizes athletic performance, reducing fatigue, allowing the athlete to train for longer, or even recover faster. exercise sections [17-19].

Depletion of muscle glycogen and low caloric dietary intake are invariably associated with reduced exercise and possible interruption of strenuous exercise caused by muscle fatigue, resulting from a decrease in energy reserves [20-22, 17, 23].

VO_{2peak} measurement is determined by the increase in blood flow due to the increase in cardiac output to the muscles, thus being the most widely used measure of cardiovascular conditioning [24-26]. In this study, there is no difference in the performance evaluated by VO_{2peak} rate (Δ) between sprinters and MMA fighters submitted to carbohydrate overcompensation.

Low calorie intake compared to energy needs was seen in MMA fighters, which can result in fatigue earlier. In addition, these athletes also consume an amount of carbohydrates below or within the limit (50%) of that recommended for non-athletes, which can help to decrease muscle glycogen reserves. This is probably because athletes who need muscle hypertrophy consider protein intake to be more important than carbohydrates.

In the contrast, the sprinters showed a high caloric intake compared to energy needs, which in turn can also compromise performance at the expense of weight gain caused by caloric excess. These athletes consume a large amount of carbohydrates, which denotes their knowledge about the role of sugar in anaerobic sport. All dietary parameters were corrected in the prescription of the basal diet as a standard cutoff point for the group of athletes in this study.

However, our scientific evidence that consuming a carbohydrate-rich diet (> 60% of total calories) is sufficient to replace the carbohydrate used during rest and training. The increase in carbohydrate reserves in the liver and muscles before and during exercise helps to decrease fatigue in a prolonged run and carbohydrate intake immediately after exercise quickly restores glycogen reserves in the liver and muscles [27].

In one study, carbohydrate oxidation did not change significantly during exercise, although fatigue values tended to be lower (p = 0.069) than those observed in the 30 minutes (Angus et al and contributors (2002). These results corroborate the results that showed a decrease in running time (Δ) by sprinters compared to MMA fighters, probably due to the fact that sprinters train to record time, while fighters train muscle strength, a negative correlation was found in relation to running time (Δ) in relation to VO_{2peak} rate (Δ) of both athletes. This result shows that the carbohydrate overcompensation influences the increase in VO_{2peak} and, therefore, improves performance in the running time.

A significant decrease in running time was seen by sprinters compared to MMA fighters. Apparently, sprinters are better conditioned to anaerobic exercise than fighters, probably, they consume a greater amount of carbohydrates and the body improves blood glucose through insulin. This increase in glycemia after physical activity may be due to the fact that insulin and glucagon are more regulated by sympathetic activity during exercise than by plasma glucose concentration may not change or even increase at first hour of exercise [17].

At the start of exercise, muscle glycogen decreases rapidly, so muscle uptake of circulating blood glucose increases markedly during the initial exercise stage and continues to increase with subsequent exercise, while total carbohydrate oxidation remains constant or decreases [3,17]. There is no doubt that carbohydrate over compensation is an efficient method for making tissue energy reserves available, making it an ergogenic effect [23].

The inability to maintain power or strength production during repeated muscle contractions generates fatigue and, consequently, interruption of work [24]. This study showed that MMA fighters increased the power profile rate (Δ) in cardiopulmonary exercise test compared to sprinters. In addition, a positive correlation was observed in the power profile rate (Δ) and VO_{2peak} rate (Δ) of athletes who use the ergogenic role of carbohydrate overcompensation without increasing the workforce. Sports demands do not necessarily seem to be influenced only by carbohydrate intake, as glycogen depletion in the sarcoplasmic reticulum of the peripheral muscle influences calcium flow and impairs muscle contractility [29, 30].

However, hypoglycemia induced by exercise has been speculated to be directly related to a reduced delivery of glucose as a substrate to the brain [31]. The practical implications in sports biomechanics, the previous use of carbohydrate overcompensation, appear to be a critical role in an anaerobic exercise, improving performance, especially in sprinters.

CONCLUSION

Our results may be important for a therapeutic intervention or studies with human beings that still need to establish reference values in relation to the physiological responses in sprinters and MMA fighters. This study suggests a favorable result related to increased performance, especially in short time, high intensity anaerobic exercises, such as sprinters.

ACKNOWLEDGEMENTS

We would like to thank Pedro Ferreira da Silva for translate, essential for this manuscript.

REFERENCES

[1] Ferreira JCB, Rolim NPL, Bartholomeu JB, Gobatto CA, Kokubun E, Brum PC. Maximal lactate steady state in running mice: effect of exercise training. Clin Exp Pharmacol Physiol 2007;34(8):760–5.

[2] Wilmore JH, Costill DL. Fisiologia do esporte e do exercício. Manole; 2001.

[3] Mcardle WD, Katch FI, Katch VL. Fisiologia do exercício: Energia, nutrição e desempenho humano. Guanabara Koogan; 2003.

[4] Roberts PA, Fox J, Peirce N, Jones SW, Casey A, Greenhaff PL. Creatine ingestion augments dietary carbohydrate mediated muscle glycogen super compensation during the initial 24 h of recovery following prolonged exhaustive exercise in humans. Amino Acids 2016; 48(8): 1831-1842.

[5] Bergström J, Hultman E. A study of the glycogen metabolism during exercise in man. Scand J Clin Lab Inves 1967;19(3):218–228.

[6] Bergström J, Hermansen L, Hultman E, Saltin B. Diet, muscle glycogen and physical performance. Acta Physiol. Scand 1967; 71(2–3): 140–150.

[7] Blom PC, Costill DL, Vøllestad NK. Exhaustive running: inappropriate as a stimulus of muscle glycogen super-compensation. Med Sci Sports Exerc 1987; 19(4):398–403.

[8] Foss ML, Keteyian SJ. Bases fisiológicas do exercício e do esporte. Guanabara koogan; 2000.

[9] Burke LM, Hawley JA, Wong SHS, Jeukendrup AE. Carbohydrates for training and competition. J. Sports Sci 2011; 29(Suppl 1):S17-S27.

[10] Phillips SM, Sproule J, Turner AP. Carbohydrate Ingestion during Team Games Exercise. Sports Med. 2011; 41(7):559–85.

[11] Stellingwerff T, Maughan RJ, Burke LM. Nutrition for power sports: middle-distance running, track cycling, rowing, canoeing/kayaking, and swimming. J Sports Sci 2011;29 Suppl 1:S79-89.

[12] Jeukendrup A. A Step Towards Personalized Sports Nutrition: Carbohydrate Intake During Exercise. Sports Med 2014; 44 (Suppl 1):25-33.

[13] Bergström J, Hultman E. Muscle glycogen synthesis after exercise: an enhancing factor localized to the muscle cells in man. Nature 1966; 210(5033):309–310.

[14] Sherman WM, Costill DL. The marathon: dietary manipulation to optimize performance. Am J Sports Med 1984;12(1):44–51.

[15] Neto TLB, Tebexreni AS, Tambeiro VL. Aplicações práticas da ergoespirometria no atleta. Rev Soc Cardiol Estado de São Paulo 2001; 11(3):695–705.

[16] Weltman A, Snead D, Seip R, Schurrer R, Levine S, Rutt R, et al. Prediction of lactate threshold and fixed blood lactate concentrations from 3200-m running performance in male runners. Int J Sports Med 1987 Dec;8(6):401–6.

[17] Liebman M, Wilkinson JG. Metabolismo de carboidratos e condicionamento físico. In: Wolinsky I, Junior JFH. Nutrição no exercício e no esporte. Roca; 2002. p.17-60.

[18] Aoki MS, Seelaender MCL. Lipid supplementation in endurance activities. Revista Paulista de Educação Física 1999 Dec; 13(2):230–8.

[19] Mcmurray RG, Anderson JB. Introdução à nutrição no exercício e no esporte. In: Wolinsky I, Junior JFH. Nutrição no exercício e no esporte. Roca; 2002. p.1-16.

[20] Guyton AC, Hall JE. Tratado de Fisiologia Médica. Guanabara koogan S.A.; 2002.

[21] Bowtell JL, Gelly K, Jackman ML, Patel A, Simeoni M, Rennie MJ. Effect of different carbohydrate drinks on whole body carbohydrate storage after exhaustive exercise. J Appl Physiol. 2000 May;88(5):1529–36.

[22] Marques LR, Tirapegui J. Carboidratos. In: Nutrição: fundamentos e aspectos atuais. Atheneu; 2000. p. 37-48.

[23] Lima HM, Barcelos M de FP, Sousa RV de, Morais AR de. Influence of carbohydrates forms of in physical training and glycogen over compensation in rats. Ciência e Agrotecnologia 2003 Jun; 27(3):605–17.

[24] Powers SK, Howley ET. Fisiologia do Exercício: Teoria e aplicação ao condicionamento e ao desempenho. São Paulo: Manole; 2000.

[25] Barros Neto TL, Tebexreni AS, Tambeiro VL. Aplicações práticas da ergoespirometria no atleta. Rev Soc Cardiol Estado de Säo Paulo 2001; 11(3):695-705.

[26] Tebexreni AS. Protocolos tradicionais em ergometria, suas aplicações práticas. Rev Soc Cardiol Estado de Säo Paulo 2001 May; 11(3): 519–28.

[27] Williams C, Rollo I. Carbohydrate Nutrition and Team Sport Performance. Sports Med. 2015 Nov; 45 Suppl 1:S13-22.

[28] Angus DJ, Febbraio MA, Hargreaves M. Plasma glucose kinetics during prolonged exercise in trained humans when fed carbohydrate. Am J Physiol Endocrinol Metab. 2002 Sep; 283(3): E573-577.

[29] Nielsen J, Holmberg H-C, Schrøder HD, Saltin B, Ortenblad N. Human skeletal muscle glycogen utilization in exhaustive exercise: role of subcellular localization and fibre type. J Physiol (Lond). 2011 Jun 1;589(Pt 11):2871–85.

[30] Gejl KD, Hvid LG, Frandsen U, Jensen K, Sahlin K, Ørtenblad N. Muscle glycogen content modifies SR Ca2+ release rate in elite endurance athletes. Med Sci Sports Exerc. 2014 Mar;46(3):496–505.

[31] Nybo L. CNS fatigue and prolonged exercise: effect of glucose supplementation. Med Sci Sports Exerc. 2003 Apr; 35(4):589–94.

Citation: *Graciana Teixeira Costa, Gislei Frota Aragão, "Comparative Effect of Carbohydrate Overcompensation in Sprinters and MMA Fighters", Journal of Sports and Games, 2(1), 2020, pp. 10-16.*