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ORIGINAL

CARBOHYDRATES SUPPLEMENTS DURING EXERCISE: EFFECTS ON THE ELECTROLYTES AND GLUCOSE

SUPLEMENTOS DE CARBOHIDRATOS DURANTE UN EJERCICIO: EFECTOS SOBRE LOS ELECTRÓLITOS Y GLUCOSA

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ABSTRACT

Objective: To identify if the form of presentation of carbohydrate supplements (CS) influences the response of the plasma concentration of electrolytes and glucose during a long-term exercise. Twelve men performed four 90-minute tests on a cycloergometer (55-60% VO2max), followed by 6 km at maximum speed, consuming CS in different presentations (liquid, gel or solid) or just consuming water. The concentrations of sodium, potassium and glucose in blood were analyzed before exercise, every 30 minutes of testing, and after 6 km. There was no significant difference in the electrolyte response for the different ingestion conditions. There were significant differences ($p < 0.05$) in blood glucose when CS were consumed independently of its presentation versus the exclusive consumption of water. It is concluded that the form of presentation of the CS does not influence the blood glucose concentration during the long-term exercise.

KEY WORDS: Sports Nutrition, Hydration, Plasmatic electrolytes

RESUMEN

Objetivo: Identificar si la forma de presentación de los suplementos de carbohidratos (SC) influye en la respuesta de la concentración plasmática de electrólitos y glucosa durante un ejercicio de larga duración. Doce hombres realizaron cuatro pruebas de 90 min en cicloergometro (55-60%$VO_{2máx}$), seguidas por 6 km a máxima velocidad, consumiendo CS en diferentes presentaciones (líquido, gel o sólido) o solamente agua. Se analizaron las concentraciones de sodio, potasio y glucosa en sangre antes del ejercicio, cada 30 minutos de prueba, y tras los 6 km. No hubo diferencia significativa en la respuesta de los electrolitos en función de la ingesta. Hubo diferencias significativas ($p<0,05$) en la glucosa sanguínea cuando se consumieron CS independientemente de su presentación frente al consumo exclusivo de agua. Se concluye que la forma de presentación de los CS no influye en la concentración de glucosa en sangre durante el ejercicio de larga duración.

PALABRAS CLAVE: Nutrición deportiva, Hidratación, Electrolitos plasmáticos.

INTRODUCTION

During the practice of physical exercise there is an increase on the internal temperature (Marins, 2011). Depending on the work intensity, the environmental conditions and the type of clothing used, the thermal load can be increased and a significant increase in body temperature can occur (Cheuvront et al., 2010). As a mechanism to control the body temperature, there is an increase in the blood flow to the skin and, consequently, an increase in the production of sweat. The evaporation of sweat is the primary way to release the excess of heat that results in a continuous loss of body fluids and electrolytes, mainly sodium and potassium (Cheuvront et al., 2010, Sawka et al., 2007).

If lost liquids and electrolytes are not adequately replaced, a significant hydro-electrolyte imbalance can be generated, resulting in damage to health and compromising physical performance (Hernandez et al., 2009 Casa et al., 2005; Marins et al., 2001; Casa et al., 2000).

Dehydration as well as reducing performance during aerobic exercises, mainly long-term ones (Cheuvront et al., 2010; Kenefick et al., 2010; Casa et al., 2010; Sawka et al., 2007) can alter the intra- and extra-cellular osmotic balance, increase cardiovascular effort due to the disproportionate increase in heart rate with a concomitant reduction in cardiac output (Marins et al., 2000; Montain and Coyle, 1992) and decrease the body's ability to dissipate heat (Fortney et al., 1984).

A degree of dehydration greater than 4% is related to a worsening of anaerobic profile activities (Kraft et al., 2012). Therefore, a correct replenishment of liquids and electrolytes during exercise prevents dehydration and electrolyte imbalance.

In addition to electrolytes, carbohydrates are frequently included in sports drinks to provide exogenous energy, assist in the absorption and retention of liquids, and to improve the palatability and thus increase their consumption during an exercise (Osterberg et al., 2009).

The greater absorption of liquids generated by the presence of carbohydrates in sports drinks is due to the mechanism of co-transport of water in the small intestine by means of the sodium-dependent glucose transporter (SGLT1), which has an important role in absorption of water (Marins, 2011). For each molecule of glucose absorbed via SGLT1, 260 water molecules are also absorbed, independent of the osmotic gradient (Loo et al, 1996). By means of that mechanism, an increase in glucose uptake would have an additional benefit in increasing water absorption. In addition, the presence of carbohydrates can also generate greater fluid retention due to the insulin response produced by hyperglycemia, that can lead to an increase in the reabsorption of sodium and fluids in the renal tubules (Sechi and Bartoli, 1996).

Apart from sports drinks, there are other types of carbohydrate supplements (CS) that are sources of electrolytes and carbohydrates, such as carbohydrate gels and energy bars, which provide athletes with other alternatives to ingest these nutrients during exercise. When these SCs are taken with water, it is supposed that the hydration is improved thanks to the partial replacement of electrolytes. However, the form of presentation of the CS could generate different speeds of gastric emptying (Bergmann et al., 1992, Vincent et al., 1995).

The time of gastric emptying of the water is relatively fast, without major alterations up to about 60 g of carbohydrates (CHO) per liter (Silva et al, 2009). On the other hand, it is possible that when consuming CHO based on energy gels or bars simultaneously with water, they do not get to mix completely in the stomach, since it has been observed that this acts as a filter retaining denser and larger particles in the antrum (Schulze, 2006), thus impairing the speed of gastric emptying and, consequently, the absorption of both CHO and electrolytes in the intestine, affecting its plasma response during exercise.

Most studies on water-electrolyte and energy replenishment focus solely on sports drinks (Yanagisawa et al., 2012; McRae and Galloway, 2012; Phillips et al., 2010; Anastasiou et al., 2009; Osterberg et al. ., 2009, Carvalho et al., 2007, Rogers et al., 2005, Gisolfi et al., 2001, Vrijens and Rehrer, 1999, Ryan et al., 1998), being scarses studies that contrast simultaneously different forms of energy supplementation and electrolytes.

However, some studies that contrasted the effect of CS in solid versus liquid form (Pfeiffer et al., 2010b, Rauch et al., 1999, Robergs et al., 1998, Lugo et al., 1993, Mason et al. , 1993) or in the form of gel versus liquid (Pfeiffer et al., 2010a, Patterson and Gray, 2007). The work of Phillips et al. (2012) studied only the effect of gel consumption, without contrasting with other physical forms of energy intake or electrolytes.

Therefore, it seems interesting to compare the effect of a sports drink against other forms of CS presentation such as gel and bar, ingested simultaneously with water, to observe the influence on the response of plasma electrolytes and blood glucose. This can provide important information about what type of CS the athlete should consume to perform better during long-term exercises.

The objective of this work has been to identify if the consumption of the different forms of presentation of CS (gel, solid or liquid) influences the response of the plasma concentration of sodium, potassium and glucose throughout a long-term exercise.

MATERIAL AND METHODS

Sample

Twelve regular cycling or running men (age = 22 ± 3 years, weight = 71.5 ± 8.3 kg, height = 1.75 ± 0.06 m; VO_{2max} = 54.56 ± 4.85 $mL.kg^{-1}.min^{-1}$) volunteered in the study. The subjects trained at least three times a week, at least for 2 hours and during the last 2 years. All the evaluated ones were considered healthy, according to the questionnaire PAR-Q on fitness for physical activity (Shephard, 1988) and the table of coronary risk proposed by the Michigan Heart Association (MCardle et al., 2001). All were informed about the objectives, dynamics and risks of the study before they signed the written consent to participate. The research adopted the ethical procedures proposed by the Brazilian Government (CSN, #196/96), being the study approved by the Ethics Committee of the Federal University of Viçosa.

Preliminary tests

After meeting the inclusion criteria, the volunteers underwent an anthropometric data collection. To measure body weight, a digital scale with a precision of 50 g was used (Soehnle, model 7820-21, Asimed S.A., Barcelona, Spain). The stature was recorded by means of a stadiometer with a precision of 1 mm (Standard Sanny, American Medical do BrasilLtda, São Paulo, Brazil).

Next, the evaluated ones realized a test in electromagnetic cycloergometer (SCIFIT model ISO1000, Oklahoma, the United States), with incremental load to determine the maximum consumption of oxygen (VO_{2max}). The test was divided into two parts: a 3-minute warm-up with a load of 50 W and a main part in which an initial load in watts was established for each subject, which the individuals considered "a bit heavy" according to the Rate of Perceived Effort scale (RPE) (Borg, 1982). From that point, the load was increased by 30 W every minute until the maximum, according to the criteria proposed by Howley et al. (1995).

Respiratory changes were measured throughout the trial through a metabolic gas analyzer (MedGraphics VO2000, Minnesota, United States), heart rate (HR) using a cardiac monitor (M31, Polar, Kempele, Finland), while RPE was obtained every 2 minutes. At the end of the test, a sample of capillary lactate evaluated by a portable analyzer (Accutrend, Roche®, Mannheim, Germany). The results of the maximum testwere used to consider the initial load in the experimental tests.

Experimental Design

Each evaluated participated in four experimental tests performed on a cycle ergometer over 90 min at an intensity of 55 to 60% of VO_{2max}, ingesting water during that time or 0.7 g carbohydrate.kg^{-1}.$hour^{-1}$ (50.4 ± 6.1 g.hour-1) in the form of sports drink, gel or energy bar, with different electrolyte contents. The way to replenish carbohydrates was selected according to the recommendations of the American Dietetic Association, Dietitians of Canada and the American College of Sports Medicine (Rodriguez et al., 2009). Immediately after the 90 minutes of exercise, the evaluated pedaled for 6 km at the maximum possible speed with the same load they had during the main phase of the test, trying to reproduce a condition of competition.

The experimental design was a randomized cross-over type, with the tests separated by at least 2 days, like the protocol adopted in other studies (Altoe et al., 2011; Faria et al., 2011; Silva et al., 2010; Marins et al., 2002, 2003).

Composition of the CS

The CS used were produced and marketed in Brazil, without any manipulation of their nutritional properties. The CSs had a different nutritional composition (see Table 1) in terms of electrolytes and proteins in the gel, as well as fat, protein and fiber in the energy bar.

Water was ingested during the tests in which carbohydrates were consumed both in the form of gel and energy bar. The consumption of liquids during each of the experimental situations was 3 mL.kg^{-1} of the body weight, immediately before the start of the exercise, as well as every 20 minutes throughout the exercise, as after the final 6 km.

Table 1. Nutritional composition of the CS used in the study.

	Beverage (22,2 g Gatorade® powder(PepsiCo)	**Gel (30 g) VO2+Energy Gel® (Integral Médica)**	**Energy Bar (25 g) Banana, oats and honey Trio® (Trio)**
Energy (kcal)	76	80	88
Carbohydrates (g)	19	19	19
Proteins (g)	0	1	1.2
Fat (g)	0	0	0.8
Fiber (g)	0	0	0.6
Sodium (mg)	143	58	65
Potassium (mg)	38	13	0
Chlorine (mg)	133	3	0

Directions before the experimental test

The volunteers were asked to refrain from consuming alcohol and doing strenuous exercises the day before each test, in addition to maintaining the same type of diet and training program throughout the entire study. The diet of the participants was recorded by means of a 24-hour recall (Cintra et al., 1997), made before each test, to verify that the amount of calories and nutrients consumed on the day before were similar on the four experiments. These analyzes were performed by the same expert nutritionist.

Protocols of the experimental tests

The tests were carried out during the morning hours (between 6:00 and 9:00). The schedule of the first test chosen by the evaluated was the same for the other three. The subjects must always arrive after a 10- to 12-hours fasting period. At the laboratory, the evaluated ones ate 1 g of CHO by kilogram of body weight (443.5 ± 51.6 kcal, 71.5 ± 8.3 g of CHO, 13.3 ± 1.6 g of protein, 11.6 ± 1.3 g of fat and 2.3 ± 0.3 g of fiber), ingesting white mold bread, mozzarella cheese, apple and grape juice. The nutritional composition of breakfast was like the adopted in other studies that provided that food 1 hour before exercise (Bennard and Doucet, 2006, Stannard et al., 2000).

One hour after breakfast, each participant offered a urine sample to assess their hydration status before exercise by means of specific urine gravity and urine density methods. When dehydration was observed, the test was not continued. After the urinalysis, the participants were weighed without any clothes, using a digital scale with a precision of 50 g (Soehnle, model 7820.21, Asimed S.A., Barcelona, Spain).

Next, a nurse introduced an intravenous #22 Yelco catheter into a vein in the forearm and fixed a 3-way screw type device that was cleaned with a 0.9% physiological solution after each blood sample, to avoid coagulation in the blood and to maintain venous access, allowing blood to be taken during exercise. Before each blood draw, the saline solution and 1 mL of blood was removed with a disposable syringe and discarded before obtaining the blood sample for analysis.

After the first blood sample, the evaluated patients starter the 90-min exercise in a cycloergometer at 55 to 60% of VO_{2max}. Additional blood samples were taken every 30 minutes during the test and after the final 6 km.

In each of the tests the evaluated ones ingested one of the three forms of CS with water (sports drink powder diluted in water, gel + water or bar + water) or only water at the beginning of the exercise, every 20 minutes during the exercise and at the end of the 6 km at maximum pace. The water consumption (1295 ± 157.7 mL) and carbohydrate consumption (75.5 ± 9.2 g) were the same for all treatments.

All the experimental tests were performed under similar environmental conditions of temperature and relative humidity (RH) being 22.6 ± 0.8 ºC and 72.3 ± 5.5% (water); 22.5 ± 1.1 ºC and 73.3 ± 5.4% (sports drink); 22.2 ± 1.2 °C, 73.0 ± 5.3% (gel); 22.3 ± 0.8 ºC and 72.9 ± 6.3% (energy bar).

Blood tests

Blood samples (1 mL) were obtained in syringes and immediately transferred to Eppendorf cuvettes, from which 100 µL of blood were collected for analysis by means of an automatic pipette (Labtec, São Paulo, Brazil). Next, the rest of the blood sample was injected into a single-use disposable cartridge and analyzed by amperimetry using a portable blood analysis device (i-STAT, Abbott®, Illinois, United States) to determine glucose, sodium, and potassium. Sodium and potassium were measured by potentiometry of ion-selective electrodes, calculating their concentrations using a potential determinedby the Nernst equation.

Considering the integrity of the evaluated, only the experimental tests were allowed in case the blood parameters were in the ranges of normality proposed by Soares et al. (2002), being from 60 to 110 mg / dL for glucose, 137 to 145 mmol.L^{-1} for sodium and 3.5 to 5.5 mmol.L^{-1}for potassium.

Statistical analysis

Initially the normality of data was tested by the Kolmogorov-Smirnov test. The data presented a normal distribution thus allowing a descriptive analysis. To compare the different experimental treatments and the different phases of the training, One-Way ANOVA test of repeated measures associated with Tukey HSD post-hoc was used. The values of $\alpha<0.05$ were considered to establish the level of statistical significance. The statistical analyzes were carried out using the software SPSS® 15 for Windows (Chicago, Illinois, United States).

RESULTS

The sodium and potassium concentrations at rest, during exercise at 55-60% of VO_{2max} and after the final 6 km are shown in Figures 1 and 2 respectively. The resting sodium and potassium concentrations were similar in all treatments. Sodium concentrations remained constant without significant differences during the 90 minutes of exercise and after the final 6 km, in all treatments.

No differences in sodium concentrations were observed between the different types of treatments. None of the evaluated subjects presented hyponatremia (sodium concentration below 137 mmol.L^{-1}) or hypernatremia (sodium concentration above 145 mmol.L^{-1}) during all the blood samples in the study.

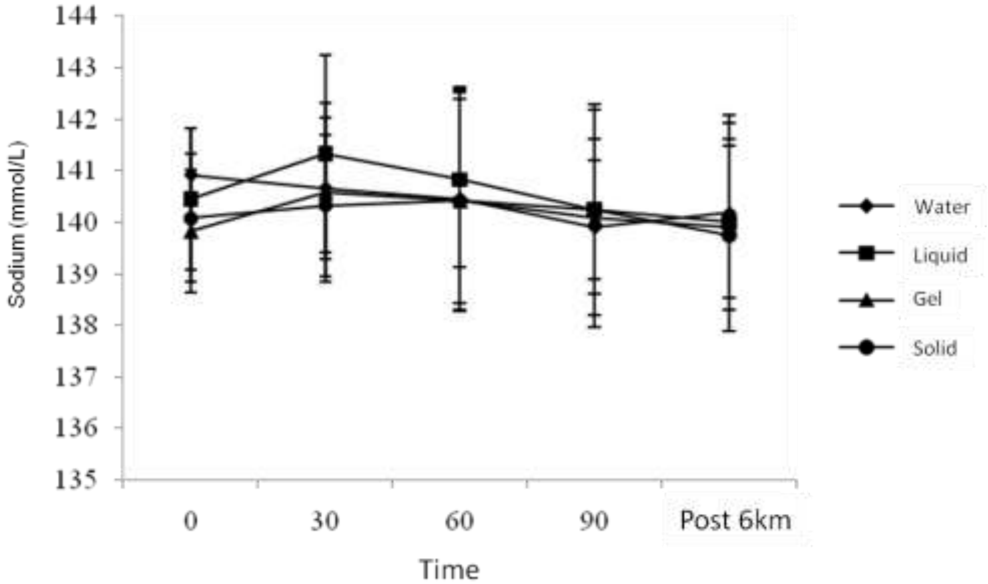

Figure1. Sodium concentration with water consumption, sports drink, gel and bar. Values as mean ± standard deviation.

There were no significant differences between the resting plasma potassium values during the four experimental moments. However, potassium concentrations were significantly higher ($p < 0.05$) during the 90-min exercise between 55-60% of VO_{2max} and after the final 6 km when compared with resting values in all treatments.

No significant differences were observed in the plasma potassium response between the different types of supplementation. None evaluated had hypokalemia (potassium concentration below 3.5 $mmol.L^{-1}$) in all the blood samples taken. However, hyperkalemia results (potassium concentration above 5.5 $mmol.L^{-1}$) were obtained during the tests. During the consumption of the sports drink, one subject presented hyperkalemia during the 90-min exercise and after the final 6 km; during gel consumption there was only one case after the final 6 km; and during the energy bar consumption two evaluated exhibited hyperkalemia after the final 6 km. Regarding the exclusive consumption of water, plasma potassium values remained always in the normal range. (Figure 2).

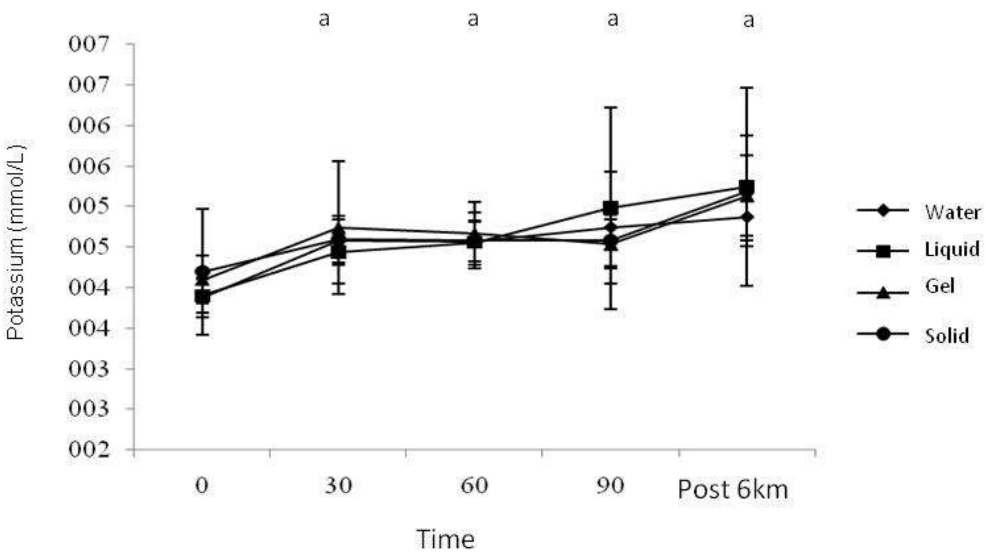

Figure 2. Concentration of potassium with water consumption, sports drink, gel and bar. Values as mean ± standard deviation. [a] Significantly higher concentration ($p <0.05$) compared to resting values.

Figure 3 shows the behavior of plasma glucosein which can beverified, with the water consumption, a maintenance of the rest values with the exception of the end of the exercise. On the other hand, with the exception of the rest state, with three experimental treatments, regardless of the form of carbohydrate offering, the values obtained are higher when compared to water consumption. At the end of the exercise, the values of glycemia with CHO consumption were significantly higher ($P <0.05$) than those obtained at rest

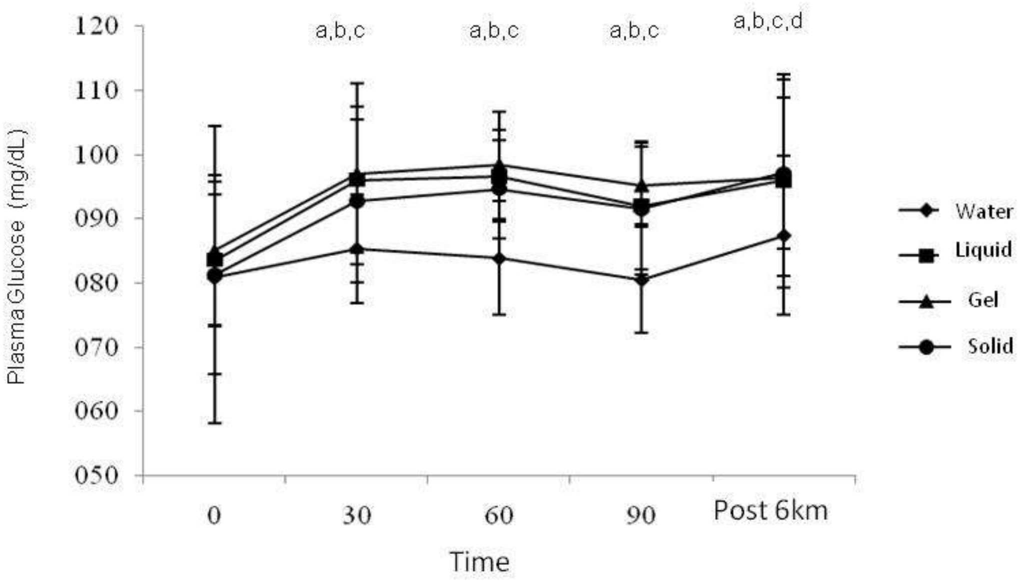

FIGURE 3. Plasma glucose concentrations with water consumption, sports drink, gel and bar. Values as mean ± standard deviation. (a) Treatment with drink significantly greater compared to water consumption ($p < 0.001$). (b) Gel treatment significantly greater than water ($p < 0.001$). (c) Bar treatment significantly greater than water ($p < 0.001$). (d) Significant difference ($p < 0.05$) of all treatments compared to the corresponding resting values.

Plasma glucose concentrations were significantly higher ($p < 0.001$) for all CS presentations compared to water consumption at all the moments of the 90-min exercise and after the final 6 km, without differences between the CS ingested.

In all the treatments, it was observed that the glucose concentrations were significantly higher ($p < 0.05$) after the final 6 km when compared with the resting ones. None of the evaluated had a plasma glucose concentration less than 60 mg.dL^{-1} during exercise.

Two subjects evaluated who consumed sports drink and one who consumed gel had a glucose concentration higher than 120 mg.dL^{-1} after the final 6 km. In the other treatments, hyperglycemia was not observed.

DISCUSSION

Plasma sodium concentrations (Figure 1) remained within the normality ranges (137-142 mmol.L^{-1}) (Soares et al., 2002), throughout the exercise and after the final 6 km when compared against the concentrations at rest. Neither were they significantly modified between the treatments, clearly showing that the sodium concentrations existing in the drink, as well as in the gel or energetic bar did not differ among themselves, even compared to the exclusive consumption of water.

Similar results were found by Campbell et al. (2008), who compared drink, gel, caramels and water ingestion during a 75% exercise of VO_{2max}. They did not observe changes in plasma sodium concentrations during exercise in relation to rest and between different treatments. Marins et al. (2003) reported that in two types of sports drinks containing 22 mg and 4 mg of sodium per 100 mL in addition to carbohydrates did not alter the plasma sodium concentration when the data was compared with mineral water consumption.

The results clearly demonstrate that the sodium content in the CS does not influence the plasma concentrations of sodium and that the proposed exercise did not generate significant losses by sweating (1.67 ± 0.48 L for the treatment with water, 1.70 ± 0.47 L with sports drink, 1.63 ± 0.55 L with gel and 1.68 ± 0.34 L with bar) without producing a state of hyponatremia in the participants.

The results obtained confirm that it is very difficult to reach a state of hyponatremia during exercise with the characteristics that were performed in our study. The cases of hyponatremia are usually related to more than four hours of continuous activity, with high heat, great production of sweat (usually higher than 1.5 liters per hour), in addition to absence or insufficient consumption of sodium during exercise, or during their usual diet (Asplund et al., 2012; Marins, 2011; Sawka et al., 2007; Marins et al, 2001 and 2003). Another situation where a hyponatremic case can be generated is when hyper-hydration occurs (that is, the amount of fluid consumed exceeds the amount of sweat produced over more than four hours of exercise), causing dilutional hyponatremia (Hernandez et al., 2009; Chorley et al., 2007)

The fact of not finding differences in the response of plasma sodium does not mean that it should not be present in these products, since its presence in the CS carries out other functions, such as: a) ancillary mechanism of co-transport for glucose absorption at intestinal level; b) auxiliary in the palatability of the food; c) stimulate the thirst mechanism; d) help to retain the liquids consumed (Marins, 2011, Marins et al., 2001 and 2003).

The responses obtained in the plasma concentrations of potassium (Figure 2), indicate that there are no statistical differences ($p > 0.05$) between the different treatments. However, unlike what happened with sodium, during the 90-min exercise and after the final 6 km, concentrations were significantly higher ($p < 0.05$) compared to those recorded at rest. Even though, in most cases the potassium concentrations were within the normal range (3.5 - 5.5 $mmol.L^{-1}$).

During exercise, potassium is released from inside to the outside of the skeletal muscle cell and, subsequently, into the bloodstream (Nielsen et al., 2004), thus producing an increase in potassium concentration compared to basal levels. Plasma potassium, which originates in the muscles during exercise, increases at the beginning but tends to stabilize in exercises with intensities below 100% of VO_{2max} (Hallen, 1996). This behavior was observed in the study, considering that there were no statistically significant differences between the values during the exercise. On the other hand, during the final 6 km phase there was a significant increase in all the experimental treatments, compared to the resting values. This clearly indicates that the potassium response has a marked rise when there is an intense effort, regardless of the type of CS that is being consumed in the amounts proposed in the study.

It is important to note that the behavior of potassium (Figure 2) is clearly ascending throughout the exercise, when resting values are considered as a reference. Considering that the duration of the exercise was limited to 90 minutes, the cases of hyperkalemia were exceptional. However, during cycling or mountain bike training, with durations close to 180 minutes, it is possible to assume a greater occurrence of hyperkalemia cases.

The only cases of plasma alterations within the range of normality observed in this study were related to hyperkalemia, already described in the results section, all concentrated at the end of 90 minutes or after the sprint. That response was also obtained by Marins et al. (2002) after evaluating twelve cyclists for 120 minutes at 65% VO_{2max}, where they observed a high frequency of hyperkalemia, mainly in the final phase of the exercise. A state of hyperkalemia can cause changes in the conduction of nerve impulses in the heart muscle (Armstrong et al., 2007, Clausen, 1998). In the skeletal muscles such alterations may favor the appearance of muscle cramps, impairing performance. Thus, maintaining potassium levels in the normal range is interesting for performance, since its increase may be related to muscle fatigue (Green et al., 2011, Marins et al., 2001 and 2002, Paterson, 1996).

Based on the plasmatic responses of potassium in this study, it can be stated that the potassium content present in the CS consumed does not represent a risk to the health of the athlete, since the amounts that comprise it are low. On the other hand, it should be noted that there are CSs with amounts of potassium in their composition much higher than those used in this study, which may mean an increased risk to produce situations of hyperkalemia.

It is possible to establish that the concentrations of electrolytes present in the food consumed in this study during 90 minutes of exercise do not tend to produce an elevation of the electrolyte concentrations in the organism, thus not having any biological risk for its consumption. It is also important to note that these concentrations (Table 1) maintained mineral homeostasis without dangerously altering the normal levels in blood of both sodium and potassium. A limitation of the present study was the lack of measurement of the concentration of electrolytes in the sweat. This could have provided more information about the mineral balance during the exercise.

The different forms of CS considered in this study (drink, gel and bar) were equally efficient to maintain plasma glucose levels during exercise. However, those levels were higher than when only pure water was consumed (Figure 3). Several studies demonstrate the maintenance of plasma glucose levels with the consumption of CS during an exercise (Pfeiffer et al., 2010a, 2010b, Campbell et al., 2008, Ivy et al., 2003, Febbraio et al., 2000; Patterson and Gray, 2007; Mason et al., 1993). It should be noted that among those who compared CS with different presentations, none found differences in plasma glucose concentrations between treatments. This seems to indicate that, as happened with the presence of solid particles in the stomach, there was no retention in the stomach since the food passed quickly and directly to the intestine, being the values statistically similar to those after the consumption of a sports drink.

A state of hypoglycemia during an exercise is decisive for a situation of fatigue (Marins, 2011, Faria et al., 2011, Pérez-Guisado, 2009). It is very important that during long-term exercises the blood glucose values are maintained in a normal range. In this study, regardless of the type of carbohydrate intake, this has happened, indicating that athletes can choose the best form of carbohydrate consumption according to their personal preference. It is important to emphasize that both the consumption in gel or energy bar should be accompanied by water, to keep the body hydrated.

Despite not having registered any cases of hypoglycemia, not even in the case of only water consumption, different trends when carbohydrates are clearly seen in figure 3. If the exercise is prolonged for longer, as is usual in cyclists, it can be predicted that the consumption of water alone would imply an increased risk of cases of hypoglycemia.

The fact that no cases of hypoglycemia have been detected with only water consumption can be justified in two ways: a) that the initial energy intake at breakfast had enough nutrients to sustain normalized glycemia during 90 minutes; b) that the intensity of exercise proposed, between 55 and 60% of VO_{2max} was very low taking into account the physical level of the participants, producing a greater predominance of fats in energy substrates and consequently saving blood glucose.

An interesting response was the increase in blood glucose after the end of the final 6 km period in all the experimental tests. This suggests that the intensity of exercise influences in some way the complex bioenergetic environment, with a possible participation of liver glycogen to release more glucose into the blood.

The present study showed that, during a moderate intensity exercise, in the environmental conditions in which they were performed (22.40 ± 0.97 ºC and 72.90 ± 5.45% RH), the CS in the form of gel or energy bar associated with water consumption (3 $mL.kg^{-1}$ of weight before exercise, every 20 minutes during the exercise and in the final 6 km), is similar to the consumption of a sports drink with a 6% concentration of CHOs, plus sodium and potassium.

Considering the environmental and exercise conditions proposed in this study, we concluded that, in the same amount of carbohydrates and ingested liquids, the CS in the form of gel or bar generate such energetic and electrolyte replacement that CS in the form of sports drink. What offers athletes more options when choosing how to recover energy and electrolytically during the exercise.

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