Original article (short paper)

Carbohydrate mouth rinse reduces rating of perceived exertion but does not affect performance and energy systems contribution during a high-intensity exercise

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Abstract — Aim: The study aimed to verify the effect of carbohydrate (CHO) mouth rinse on time to exhaustion, energy systems contribution and rating of perceived exertion (RPE) during a high-intensity exercise. **Methods:** Fourteen men performed an incremental exercise test to determine their maximal oxygen uptake and peak power output (PPO) and two time-to-exhaustion tests at 110% of PPO. Participants rinsed their mouth with 25ml of 6.4% of CHO or placebo (PLA) solution immediately before the time-to-exhaustion test, using a crossover design. The contribution of the energy systems was calculated using the free software GEDAE-LaB®. **Results:** Time to exhaustion was similar between the conditions (CHO:174.3±42.8s; PLA:166.7±26.3s; p=0.33). In addition, there was no difference between the CHO and PLA condition for aerobic (CHO:135.1±41.2kJ and PLA:129.8±35.3kJ, p=0.34), anaerobic lactic (CHO:57.6±17.1kJ and PLA:53.4±15.1kJ, p=0.10), and anaerobic alactic (CHO:10.4±8.4kJ and PLA:13.2±9.2kJ, p=0.37) contribution. Consequently, total energy expenditure was similar between conditions (CHO:203.2±46.4kJ and PLA:196.5±45.2kJ, p=0.15). However, CHO mouth rinse reduced the RPE at the moment of exhaustion (CHO:18.2±1.0units and PLA:19.1±1.1units; p=0.02). **Conclusion:** CHO mouth rinse neither increased time to exhaustion nor altered energy systems contribution during a high-intensity exercise, but reduced the perceived effort at the exhaustion.

Keywords: ergogenic aid; maltodextrin; mouthwash; supramaximal exercise; supplementation.

Introduction

Exogenous carbohydrate (CHO) is a largely recognized nutritional supplement able to enhance exercise endurance since it provides “extra” CHO to oxidation when muscle glycogen becomes depleted[1,2]. However, during high-intensity exercises, the muscle glycogen is not fully emptied and CHO availability may not be a limiting factor for exercise performance[2,3]. Rather, it seems that CHO mouth rinse might be a promising strategy for improving performance during high-intensity exercise[4]. In fact, some studies have shown the efficacy of CHO mouth rinse before high-intensity effort[5,6,7].

One possible explanation for improving the performance during high-intensity exercise with CHO mouth rinse is that the contact of CHO with the oral CHO receptors may trigger an afferent signal to the central nervous system[8,9], which would be associated with a facilitation of motor output[10]. The CHO mouth rinse seems to stimulate reward-associated areas in the sensorimotor cortex such as insula/frontal operculum, orbitofrontal cortex and striatum[8,9], which might be integrated with descending motor outputs and neuromuscular activation. Interestingly, activation of reward areas in the sensory cortex is also associated with an increased power output[8,11] or longer time until exhaustion[12] for the same rating of perceived exertion (RPE). In addition, due to the facilitation of motor output, there may be a greater recruitment of motor units, which may modify the energy profile during exercise.

The quantification of the energy contribution during the exercise is a key point for the development of strategies to improve performance[13]. However, there are no studies investigating the effects of CHO mouth rinse on energy systems contribution during high-intensity exercise. Thus, the purpose of the present study was to evaluate the influence of CHO mouth rinse on performance, energy systems contribution and RPE during a high-intensity exercise. It was hypothesized that CHO mouth rinse will improving performance and altering the contribution of energy systems during a high-intensity exercise.

Methods

Participants

Fourteen healthy and physically active men (age: 23±2 years; body mass: 74.1±11.4 kg; height: 170.0±1.0 cm; body fat: 14.6±6.7 %; VO_{2max}: 40.0±7.4 ml.kg^{-1}.min^{-1}), who performed a minimum of 150 min of physical activity per week, were recruited. Participants were provided with information regarding experimental risks and signed an informed consent form before starting the experiments. The study procedures were conducted in accordance with the Declaration of Helsinki (2008) and were approved by the local ethics committee (protocol number: 16573413.8.0000.5013).

Experimental Design

This study was conducted in a crossover, randomized, counterbalanced, and single-blind design. Participants performed three experimental sessions, separated by at least 72 h. During the first visit, anthropometric parameters were obtained and a maximal incremental exercise test was performed to determine maximal oxygen uptake (O_{2max}) and the peak power output (PPO). In the second and third visits, a high-intensity exercise was performed at 110% PPO until voluntary exhaustion, which was preceded by either CHO or placebo (PLA). Mouth rinse was performed 10 s before the test. All tests were performed at the same time of the day, 2 h after the last meal[14]. Participants were instructed to replicate their food intake in the 24 h prior each experimental trial. Compliance with the diet recommendations was checked before each test by dietary recall. The participants were asked to refrain from exhaustive exercise as well as alcohol and caffeine ingestion 48 h prior to each experimental trial.

Anthropometry and maximal incremental exercise test

Firstly, body weight, height and skinfolds (chest, abdominal and thigh) were measured. Body density was estimated using the generalized equation of Jackson and Pollock[15], and converted to body fat percentage using the equation of Siri[16].

Then, a maximal incremental exercise test was carried out on an electromagnetically braked cycle ergometer (Ergo Fit 167, Ergo-FitGmbH & Co., Pirmasens, Germany). The seat height was adjusted for each participant, allowing near full leg extension during each pedal revolution. The seat height was noted and reproduced in all subsequent experimental sessions. After a 3-min, warm-up at 30 W, the power output was increased 30 W min^{-1} maintaining pedal cadence between 60 and 70 rpm until voluntary exhaustion, which was defined as the incapacity to maintain a minimum pedal cadence of 60 rpm for more than five consecutive seconds. The participants received strong verbal encouragement to continue as long as possible.

Oxygen uptake (O_2) was measured breath-by-breath throughout the test using a gas analyzer (Quark, Cosmed, Rome, Italy) and averaged over 30 s intervals. The calibration of the gas analyzer was performed according to manufacturer specifications using ambient air, a gas containing 20.9% of O_2 and 5% of CO_2, and a 3-L syringe. O_{2max} was determined when two or more of the following criteria were met: an increase in O_2 of less than 2.1 ml·kg^{-1}·min^{-1} on two consecutive stages, a respiratory exchange ratio greater than 1.1 and to reach ± 10 bpm of the maximal age-predicted heart rate[17]. The highest power output reached during the trial was considered as PPO.

High-intensity exercise

The high-intensity exercise was performed at 110% of PPO. This intensity was chosen based on Weber and Schneider[18] for estimating the maximal anaerobic contribution in non-athlete individuals. Participants remained quietly on the cycle ergometer for 5 min to determine O_2 baseline. Then, the participants warmed up for 4 min at 30 W. After that, the power output was adjusted to 110% of PPO. Participants were asked to maintain pedal cadence between 60-70 rpm. The test was finished when the pedal cadence was less than 60 rpm for more than five consecutive seconds. Verbal encouragement was used during the test. Peak oxygen uptake was defined as the average of the last 30 s of the test. Blood samples were collected from the ear lobe at rest and at immediately, 3 and 5 min after the exercise. Peak lactate was defined as the highest value found after the end of the test. The RPE was recorded immediately after the test using the Borg Scale (6–20)[19].

Net aerobic energy was estimated by subtracting VO_2 at rest from the VO_2 area integrated over time during test by the trapezoidal method. The contribution of the anaerobic alactic system was considered to be the fast component of excess post-exercise oxygen consumption (10 min). The breath-by-breath VO_2 data were fitted to a monoexponential model and anaerobic alactic system was obtained by integration of the exponential part. To estimate anaerobic lactic energy a value of 1 mmol 1^{-1} was considered to be equivalent to 3 ml O_2 kg^{-1} body mass[20]. A caloric equivalent of 20.9 kJ 1 O_2^{-1} was considered for the three energy systems. Total energy expenditure was calculated as the sum of the energy expenditure of the three energy systems. All calculations were made using the free software GEDAE-LaB®[21], available at http://www.gedaelab.org.

CHO mouth rinse

Participants washed their mouth immediately before the trial with a solution containing 25 ml of 6.4% of maltodextrin (CHO) or PLA (juice without CHO). The solutions had the same taste, smell and texture. Participants were asked to perform tongue movements to keep the solution in the mouth during 10 s and then spat the fluid out into a bowl, as recommended[22].

Statistical analysis

The data distribution was analyzed using the Shapiro-Wilk test. Data are reported as mean and standard deviation (SD). A paired t test was used to examine the differences between CHO and PLA conditions for time to exhaustion, and aerobic, anaerobic lactic and anaerobic alactic contributions, and lactate peak. The Wilcoxon test was used to compare the CHO and

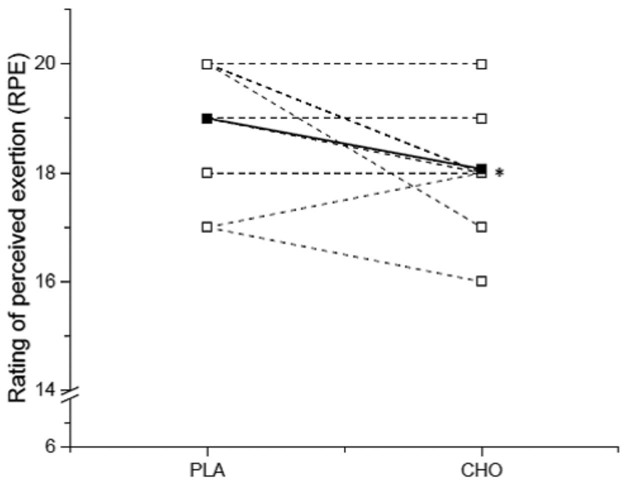
PLA groups for the variables that did not present normality in the distribution, such as the total contribution of the energy systems and the RPE. The level of significance was set at $p < 0.05$. All statistical calculations were performed with SPSS 17.0 for Windows (SPSS, Inc., Chicago, IL).

The effect size was calculated for all carbohydrate and PLA variables. The thresholds for the small, moderate, and large effects were 0.20, 0.50, and 0.80, respectively. The effect size was determined by the formula: (mean1 - mean2) / grouped standard deviation[23].

Results

Time to exhaustion was similar between CHO and PLA conditions (CHO: 174.3±42.8 s; PLA: 166.7±26.3 s; $p = 0.33$; effect size = 0.21). However, the RPE at the exhaustion reduced with CHO mouth rinse ($p = 0.02$; effect size = 0.84; Fig 1).

Figure 1. Rating of perceived exertion (RPE) at the moment of exhaustion with CHO and PLA mouth rinse.



There was no significant difference for aerobic ($p = 0.34$; effect size = 0.13), anaerobic lactic ($p = 0.10$; effect size = 0.26), and anaerobic alactic ($p = 0.37$; effect size = 0.31) contribution as well as total energy expenditure ($p = 0.15$; effect size = 0.31) (Table 1). There was also no difference in lactate peak between CHO and PLA conditions (13.4 ± 2.8 and 12.5 ± 2.3 mmol, $p = 0.12$; effect size = 0.31, respectively).

Discussion

To the best of our knowledge, this is the first study investigating the effect of pre-exercise mouth rinse on energy systems contribution during a high-intensity exercise. The results of the present study provide interesting new insights considering the effects of the CHO mouth rinse, which suggests that CHO mouth rinse does neither improve time to exhaustion nor alter energy systems contribution during a high-intensity exercise in physically active man, but attenuated RPE at the exhaustion.

Several studies showed that rinsing the mouth with CHO improves the performance during high-intensity exercises[5,6,7]. However, in the present study, we were unable to find an ergogenic effect of CHO mouth rinse during a high-intensity exercise performed at 110% of PPO. The differences concerning the exercise and mouth rinse protocols between our and these studies may have generated this divergence. For example, Beaven, Maulder, Pooley, KilduffL, Cook[5] investigated CHO mouth rinse effects on multiple sprints (5 x 6-s sprint with 24s recovery between them), while Phillips, Findlay S, Kavaliauskas M, Grant[7] and Chong, Guelfi, Fournier[6] investigated CHO mouth rinse effect on a 30-s and 45-s all-out exercise, respectively. In all of these studies, performance was improved with CHO mouth rinse. Another possibility would be the number of mouth rinses. In these studies[6,7] the participants performed a greater number of oral rinses before the test (~ 9 mouthwashes). However, Beaven, Maulder, Pooley, Kilduff, Cook[5] used only one rinse before a 6-s sprint and found that CHO mouth rinse rapidly enhanced the sprint power in the first, thus requiring more studies elucidating the effects of multiple oral rinses compared to just one previous oral rinse.

Similar to Chong, Guelfi, Fournier[6] and Phillips, Findlay, Kavaliauskas, Grant[7], our study did not find difference in the lactatemia. Furthermore, no significant differences for aerobic, anaerobic lactic, anaerobic alactic and total energy expenditure were found in the present study. Regarding the anaerobic contribution in high intensity exercise, studies verifying the effect of caffeine[24] and metformin[25] showed that even with a higher time to exhaustion, there was no significant difference in the anaerobic contribution in these exercises, probably because the anaerobic energy reserve may be a finite source[26]. On the other hand, as well as CHO mouth rinse, CHO intake did not increase time to exhaustion and anaerobic contribution in physically active cycling at 110% PPO[27].

Nevertheless, even without significant difference, time to exhaustion was 4.4% longer in CHO than in PLA, and was

Table 1. Energy systems contribution in CHO and PLA conditions.

	CHO Contribution (kJ)	PLA Contribution (kJ)	CHO Contribution (%)	PLA Contribution (%)
W_{AER}	135.1 ± 41.2	129.8 ± 35.3	66.4	66.1
W_{PCR}	57.6 ± 17.1	53.4 ± 15.1	28.3	27.2
$W_{[La^-]}$	10.4 ± 8.4	13.2 ± 9.2	5.3	6.7
W_{TOTAL}	203.2 ± 46.4	196.5 ± 45.2	100	100

W_{AER} – aerobic contribution. W_{PCR} - anaerobic alactic contribution. $W_{[La^-]}$ - anaerobic lactic contribution. W_{TOTAL} - total energy expenditure. PLA - placebo. CHO - carbohydrate.

associated with a lower RPE, possibly because CHO mouth rinse may have activated brain regions (including areas of the insula/frontal operculum, orbitofrontal cortex and striatum) involved in reward[8,9]. This result corroborates recent findings[28] showing that even with a reduced RPE at the exhaustion after CHO mouth rinse, exercise endurance at 110% of PPO was not altered after a CHO mouth rinse. It was showed that CHO rinsing is able to maintain neuromuscular activation (i.e., the electromyographic signal of the vastus lateralis) along of time during moderate-, but not high-intensity exercise[28]. Probably, an activation of reward areas with CHO rinse is able to reduce feelings of fatigue during the high-intensity exercise, but it is not sufficient to translate in an improvement in the exercise performance in this kind of exercise.

A potential limitation of our study was to have used a blind model rather than double blind. However, to minimize this limitation, verbal encouragement was standardized for all tests.

Conclusions

The present study showed that CHO mouth rinse did not increase time to exhaustion or alter energy systems contribution during a high-intensity exercise in physically active man. However, this seems to attenuate RPE at the exhaustion.

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