The effect of different durations of carbohydrate mouth rinse on cycling performance

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Key words: carbohydrate, mouth rinse, oral receptors, cycling performance.

Abstract

Carbohydrate mouth rinse has been shown to improve time trial performance. Although the exact mechanism remains un-established, research postulates that there are oral cavity receptors which increase neural drive. Increasing the duration of the mouth rinse could potentially increase stimulation of these receptors. The aim of the current investigation was to determine whether the duration of mouth rinse with 6.4% carbohydrate affected 30min self-selected cycling performance. Eleven male participants (age =24.1 ±3.9 years) performed three 30min self-paced trials. On one occasion water was given as a mouth rinse for 5s without being ingested (PLA), on the other two occasions a 6.4% carbohydrate solution was given for 5 and 10s. Distance cycled, heart rate, ratings of perceived exertion, cadence, speed and power were recorded throughout all trials. The main findings were that distance cycled during the 10s mouth rinse trial (20.4 ±2.3km) was significantly greater compared to the PLA trial (19.2 ±2.2km; $P<0.01$). There was no difference between the 5 and 10s trials ($P=0.15$). However, 10 out of 11 participants cycled further during the 5 s trial compared to PLA, and 8 cycled further during the 10s trial compared to the 5s. In conclusion, although there was an improvement in distance cycled with the 5s mouth rinse compared to the PLA it was only significant with 10s suggesting a dose response to the duration of mouth rinse.

Introduction

The ingestion of carbohydrate (CHO) prior to and during prolonged endurance exercise (>2h) has been observed to improve performance as a result of increased CHO oxidation, muscle glycogen sparing and thus maintaining euglycaemia (Coyle, Coggan, Hemmert & Ivy, 1986). Considering the main mechanisms for improving endurance performance it is surprising that CHO has been observed to improve high intensity (HI) exercise for durations lasting less than an hour where CHO endogenous stores and hypoglycemia are not limiting factors for performance (Jeukendrup Moseley, Mainwaring, Samuels, Perry, & Mann, 2006). In this direction, the increase of CHO oxidation should be the main responsible for the possible ergogenic effect of CHO ingestion in this type of exercise. Carter et al. (2004b) tested this hypothesis, by infusing 20 % glucose solution in to the blood stream which had no effect on cycling performance suggesting that the potential mechanism for the improvement in performance in HI exercises with CHO may be central rather than metabolic. This led Carter, Jeukendrup & Jones (2004a) to investigate the central effect of swilling a CHO solution and spitting it out. The results showed improved performance in comparison to placebo and therefore suggested that there are CHO receptors in the oral cavity modulating central pathways associated with motivation. This ergogenic outcome of rinsing the mouth out with CHO has since been repeatedly observed (Chambers, Bridge & Jones, 2009; Pottier, Bouckaert, Gilis, Roels & Derave, 2010; Rollo, Williams, Gant & Nute, 2008), including, several qualitative reviews have been published addressing this issue (Painelli et al., 2010; Jeukendrup & Chambers, 2010; Rollo & Williams, 2011).

The CHO receptors have yet to be discovered, however they are thought to activate the anterior cingulated cortex and ventral striatum as well as other brain regions (Haase, Cerf-

Ducastel & Murphy, 2009). This activation of the brain could influence the pacing strategies employed by athletes during self-paced exercise tasks (Jeukendrup & Chambers, 2010). In addition, if there are CHO receptors in the mouth that have a central effect, then they could be affected by an increase in CHO concentration and/or the duration at which the CHO is held in the mouth. In line with the well-established occupancy theory the greater the concentration of solution the more receptors that are activated (Clark 1926). Therefore, if a longer duration or higher concentration of CHO rinse was used potentially more receptors could be stimulated and thus elicit a greater improvement in performance. The aim of the current investigation was to determine the effect of different durations of CHO mouth rinse on cycling performance, comparing the 5 and 10 seconds durations. Our hypothesis is that the 10 seconds mouth rinse will produce a greater central activation, and hence, a more substantial effect on performance compared to the 5 s mouth rinse.

Methods

Participants

Eleven healthy active male recreational cyclists (age = 24.1 ± 3.9 years, body mass = 77.9 ± 7.1 kg and height = 174.1 ± 3.0 cm) volunteered to take part in this investigation. All were injury free and completed an informed consent form in accordance with the declaration of Helsinki. Participants had previous experience of cycle ergometry, and were fully familiar with the experimental techniques. The procedure utilised for this investigation was approved by the University of Central Lancashire, School of Sport Tourism and Outdoors, ethical committee.

Procedure

All data collection was completed using a cycle ergometer (Monark Ergomedic 874E, Monark Exercise, AB, Varberg, Sweden). The protocol involved a total of four visits to the laboratory. Visit 1 was a familiarization session, whilst visits 2-4 were the simulated time trials in which participants cycled for maximum distance over 30 min. For the data collection sessions: visits 2-4 participants were given either a tasteless 6.4 % maltodextrin (Maltodextrin 100, Sponsor Sport Food) solution (CHO) or a water bolus (PLA) to rinse around their mouths at 6 minute interludes in accordance with the overall time intervals utilised by Carter et al. (2004a). The participants were required to cycle as far as possible in 30 min. This study followed a counterbalanced blind design, with each visit separated by 1 week.

Visit 1

Visit 1 was a familiarization session, whereby participants completed a single 30 min protocol. Factors such as seat height and ergometer resistance were obtained from this session and maintained throughout the data collection protocol. Since a mechanically braked cycle ergometer was used, a resistance was determined (i.e. 2 kg) which was achievable for all participants at 60 revs.min^{-1}. This ensured that all participants were able to complete the same power output at the lowest pedal revolution allowed during the main visits. During the main experimental trials they could cycle at a self selected cadence with this resistance applied.

Visits 2-4

All participants reported to the laboratory 4 hours post prandial, having also abstained from alcohol, caffeine and exercise in the 24 hours prior to data collection. On arrival at the laboratory participants mass, height and age were recorded. Participants were then fitted with a heart rate transducer (Polar RS100, Polar Electro Oy Finland) and receiver, and positioned appropriately on the cycle ergometer. Participants performed each of their 30 minute trials at the same time of day to avoid data variations due to circadian rhythms. Prior to data collection participants completed a standardized warm-up consisting of 5 min of cycling against a resistance of 50 W which has been shown to be sufficient for intermediate cycling performance (Hajoglou et al., 2005).

The ergometer was linked to a computer which calculated the outcome measures of heart rate (HR), cadence ($rev.min^{-1}$), power output (W) and distance covered (km) which were quantified at 6 min intervals throughout the trials. The only information provided to participants during the trials was the total time elapsed. In addition, participants were also asked to rate their perceived exertion (RPE) using the 6 to 20 point Borg scale at 6 min intervals. With the exception of the RPE data collection and administration of the appropriate mouth rinse no interaction occurred between researchers and participants. No encouragement was given to participants.

Mouth rinse administration

Each participant was given a 25 ml bolus of either a tasteless 6.4 % maltodextrin (CHO) or water (PLA) for every 6 min of the total protocol. Participants rinsed the fluid around their mouths for the instructed time, and then spat the fluid back into a bowl.

Statistical analyses

Descriptive statistics (mean ± standard deviation) were calculated for the outcome measures. To provide an overall reflection of performance one way repeated measures ANOVA was conducted on distance completed during the 30 min protocol. To examine any effects of mouth rinse on pacing, HR and RPE 5 x 3 (time x condition) repeated measures ANOVA's were conducted with significance accepted at the $p \leq 0.05$ level. All post-hoc analyses were conducted using a bonferroni correction to control for type I error. The Shapiro-Wilk statistic for each condition confirmed that the data were normally distributed. All statistical procedures were conducted using SPSS 19.0 (SPSS Inc., Chicago, IL, USA).

Results

Distance cycled:

@@@ FIGURE 1 NEAR HERE @@@

There was a main effect for distance ($P<0.01$, $\eta^2= .50$). Distance cycled during the 10s mouth rinse trial (20.4 ±2.3 km) was significantly greater compared to the PLA trial (19.2 ±2.2 km; $P<0.01$) (Figure 1). However, 10 out of 11 participants cycled further during the 5 s trial compared to PLA, and 8 cycled further during the 10s trial compared to the 5 s.

Pacing:

@@@ Table 1 near here @@@

Table 1 illustrates the mean overall values for each rinse condition. As can be seen in Figure 2a, there was a main effect for time for cadence ($P=0.001$, $\eta^2= .78$) with post hoc analysis showing cadence increasing after 12 minutes until the end of the exercise. There was no main effect for trial, therefore the mouth rinse had no effect on the cadence (*P*=0.144, η^2= .18). Speed also increased from 18 minutes until the end of exercise (main effect for time; *P*=0.001, η^2= .65). There was a tendency for a main effect for trial (*P*=0.08, η^2= .22) with 10s mouth rinse producing a significantly greater speed than the control trial (*P*=0.01; Figure 2b). There was no difference in power between trials (*P*=0.68, η^2= .04), and there was only a tendency for an effect of time (*P*=0.07, η^2= .19).

@@@ FIGURE 2 NEAR HERE@@@

Heart rate and RPE

HR increased throughout all trials with a main effect for time (P=0.00, η^2= .74; Figure 3a) averaging at 168±10, 164 ±9 and 165 ±7 beats.min^{-1} for PLA, 5 s and 10 s respectively (Table 1). There were no differences between trials (*P*=0.39, η^2= .09). RPE increased with exercise duration with a main effect for time (*P*<0.01, η^2= .877; Figure 3b). RPE was significantly greater during the PLA trial compared to the 5 s trial (*P*=0.02). However, there were no differences between PLA and the 10 s trial (*P*=0.10) and between 5 and 10 s trials (*P*=0.77; Table 1).

@@@ FIGURE 3 NEAR HERE@@@

Blinding efficacy

For the CHO rinse trials 5 out of 11 correctly identified being administered CHO when the 5's rinse was administered and 6 out of 11 correctly identified the presence of CHO during the 10's rinse.

Discussion

The aim of the study was to determine whether the duration of the mouth rinse had an effect on performance. This represents the first investigation in which the influence of CHO rinse duration has been examined.

In recent years, a number of studies have been focusing on the ergogenic effects of CHO mouth rinse on exercise performance, with some (Carter et al., 2004a; Chambers et al., 2009; Pottier et al., 2010) but not all (Whitham & McKinney, 2007; Painelli et al., 2011; Chong et al., 2011) showing a beneficial effect on performance. The results of the current investigation illustrated a positive improvement in performance with the 10 s mouth rinse compared to the PLA; although there was no difference between the 10 and 5 s trials it was observed that 8 cyclists travelled further in the 10 s condition in comparison to 5 s. This suggests that there is some evidence of a dose response to the mouth rinse, although further work is necessary. The mouth rinse appears to have improved performance by increasing the speed of the cyclists and reducing the perception of fatigue. This is a similar finding to Pottier et al. (2010) who found that participants were able to produce more power for the same degree of discomfort (RPE).

The observations of the current investigation appear to support the conclusions of Carter et al. (2004a) who stated that there are oropharyngeal receptors in the mouth sensitive to non-sweet carbohydrate which may mediate the ergogenic effect of CHO mouth rinsing (Carter et al., 2004b). Previous investigations using functional magnetic resonance imaging (fMRI) have demonstrated that the presence of glucose in the mouth facilitates activation of the primary taste cortex and the putative secondary taste cortex in the orbitofrontal cortex (O'Doherty et al., 2001; de Araujo et al., 2003). These brain regions may stimulate behavioural and autonomic responses to rewarding stimuli, including taste (Rolls, 2007; Kringelbach, 2004) and thus may improve exercise performance.

As observed by Chaffin, Berg, Zuniga & Hanumanthu (2008) a pacing strategy was employed by the cyclists in the current investigation showing a much greater speed in the last 6 minutes of the trial. Overall speed was greater in the 10 s trial however. It is hypothesized that the mouth rinse increased motivation due to stimulation of oral receptors which allowed the cyclists to produce a greater speed overall resulting in improved performance. This is in contrast to Rollo et al. (2008) who found CHO mouth rinse to improve speed only in the first 5 min of a 30 min run. The reason for the contrasting results could be that the mode of exercise different and there is no upper body contribution during cycling. Chambers et al. (2009) found that a CHO mouth rinse enhanced motivation and activity of motor control centres of the brain, potentially facilitating the increases in speed and decrease in RPE found in the current study.

Practical implications

Gastrointestinal (GI) distress has been observed when ingesting CHO solutions during HI exercise (Brouns & Beckers, 1993); therefore rinsing the solution around the mouth is potentially a more practical ergogenic strategy. Furthermore it is likely that there is an additional physiological advantage of not having to ingest the solution, i.e. by reducing the required blood supply to and energy cost incurred by the gastro-intestinal tract to digest and absorb the carbohydrates. This notion is supported by Pottier et al. (2010) who observed using a cycling time trial protocol that mouth rinse has an ergogenic advantage in comparison to ingestion the carbohydrate solution. In addition mouth rinsing may be a performance enhancing strategy by which diabetic athletes could benefit from the ergogenic benefits of carbohydrate without the negative health consequences.

Although this study would appear to promote the use of a 10 s rinse, during 30 min cycling events this may be impractical during competition where the required breathing rate may be greater (Neary, Bhambhani & Quinney, 1995). During HI events using 5 s mouth rinse duration would appear to be a far more practical strategy than 10 s, as breathing could potentially be inhibited whilst rinsing the solution around in the mouth. This study observed that 10 out of the 11 cyclists performed better when using the mouth rinse for 5 s and therefore this could be adopted as recommended rinse duration when performing HI exercise. It could be more beneficial on performance if a shorter duration mouth rinse could occur to allow more effective breathing. With this in mind, activation of the oral receptors could potentially occur to a greater extent when higher concentrations of CHO are utilised.

Limitations

A potential limitation of the current investigation is the relatively small sample size. It is possible that a larger sample would have provided sufficient statistical power to detect significant differences between the 5 and 10 s rinses. It is recommended that future work replicate the current investigation with a larger cohort. In addition, the lack of a 10 s placebo condition may have influenced 10 s mouth rinse result due to an enhanced placebo effect. In future studies a 10 s placebo should be added to balance the research design more effectively.

That no fMRI measures were taken may also serve as a limitation of the current investigation. The results of this study support the accumulating evidence of central response from an oral CHO stimulus that may mediate performance improvements. fMRI analyses have found that oral CHO facilitates activation of the orbitofrontal cortex region of the brain (O'Doherty, Rolles, Francis, Bowtell & McGlone, 2001). Therefore, to observe the extent of the activation of this specific brain area with variations in rinse duration would be of interest from both a performance and academic standpoint.

Conclusions

In conclusion, the present study supports findings of previous research observing an increase of ~6.0 % in cycling performance with a CHO mouth rinse compared to a placebo. However, although there was an improvement in distance cycled with the 5 s mouth rinse compared to the placebo it was only statistically significant with 10 s. There appears to be a tendency for a dose relationship with regards to the duration of the mouth rinse held in the mouth. An increase in the mouth rinse duration may result in the brain areas linked to the motivation and motor control being activated for a greater period. This may be a result of more CHO receptors being activated and causing a decrease in the perception of discomfort. The underlying mechanism regarding the ergogenic influence of 10 s CHO mouth rinse has yet to be determined; potentially it could be the presence of CHO or fluid per se that leads to the improved performance. Nonetheless, athletes performing 30 min of cycling exercise could improve their performance by using a CHO mouth rinse.

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List of figures/tables

Figure 1: Mean (±SD) distance completed in 30 minutes during each condition (n=11). * denotes significant difference from PLA.

Figure 2: Mean (±SD) cadence (a) and speed (b) during the 30 minute exercise for each condition (n=11).

Figure 3: Mean (±SD) heart rate (a) and RPE (b) during 30 minute exercise in each condition (n=11).

Table 1: Mean (±SD) overall values for HR, RPE, cadence, power and speed for each condition (n=11) *denotes significant difference from placebo. ɨ denotes a tendency for a difference from placebo.