



## Carbohydrate Mouth Rinse Improves Relative Mean Power During Multiple Sprint Performance

GARET W. SIMPSON<sup>†1</sup>, ROBERT PRITCHETT<sup>‡1</sup>, ERIC O'NEAL<sup>#2</sup>, GARRETT HOSKINS<sup>†1</sup>, KELLY PRITCHETT<sup>†1</sup>

<sup>1</sup>Department of Nutrition, Exercise, and Health Sciences, Central Washington University, Ellensburg, WA, USA; <sup>2</sup>Department of Health, Physical Education and Recreation, University of North Alabama, Florence, AL, USA

\*Denotes undergraduate student author, <sup>†</sup>Denotes graduate student author, <sup>‡</sup>Denotes professional author

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### ABSTRACT

*International Journal of Exercise Science 11(6): 754-763, 2018.* Multiple investigations have confirmed carbohydrate mouth rinse (CMR) enhances high intensity endurance performance lasting under 1 hour, but the effects of CMR on high intensity intermittent exercise has received less attention. This study examined the effect of CMR on high intensity multiple sprint performances in a protocol designed to emulate a cyclocross or mountain biking event. Seven trained men ( $28.2 \pm 6.8$  years,  $185 \pm 9$  cm,  $85.3 \pm 14.8$  kg,  $VO_{2peak} 51.4 \pm 7.3$  ml/kg\*min<sup>-1</sup>) completed two, 48 min high intensity intermittent cycling protocols that consisted of 6 bouts of 5 min cycling at 50%  $VO_2$  peak followed by sets of three, 10-s Wingate sprints with 50 s of recovery between sprints. Prior to each set of Wingate sprints, either a 6.4% carbohydrate solution (CMR) or placebo (PLA) were rinsed for 10 s using a counterbalanced crossover design. There was a significant main effect (CMR  $10.51 \pm 0.82$ , PLA  $10.33 \pm 0.87$  W/kg;  $p < 0.05$  ES=0.21) for mean power, but post hoc tests only revealed statistically significant performance improvement with CMR during the 6th bout (CMR  $10.5 \pm 0.75$ , PLA  $10.22 \pm 0.92$  W/kg;  $p = 0.01$  ES=0.33). No treatment effect was exhibited for peak power, fatigue index, ratings of perceived exertion, or blood glucose. Most team sport situations provide multiple opportunities for access to beverages, but gastrointestinal distress associated with fluid intake may reduce desire for significant beverage consumption. Under such circumstances, a small but practical ergogenic advantage may be exhibited if the fluid rinsed in the mouth contains carbohydrates.

KEY WORDS: Mouth wash, cycle sprint, Wingate

### INTRODUCTION

In a seminal study, carbohydrate mouth rinse (CMR) enhanced 1 hour cycling time trial performance compared to a placebo rinse (PLA), suggesting that oral receptors may augment performance through cortical activation (6). The mechanism responsible for these performance improvements has been attributed to the presence of carbohydrate in the oral cavity activating the insular cortex or the reward center of the brain (7, 15, 27). Increasing evidence supporting

performance benefits with the use of a CMR (6, 7, 9, 16, 18, 23) has led to current ACSM guidelines recommending that CMR for sustained high intensity exercise lasting 45-75 min (1). The influence of CMR on shorter, maximal intensity activities is less understood. In regards to prolonged, single effort maximal sprint bout, Chong et al. (9) observed 3.5% less power decline over a 30 s sprint preceded by CMR. Beaven et al. (2) examined a CMR on 5 x 6-s maximal cycling sprints (24 s rest) on 12 recreationally trained males and observed a higher mean and peak power during the first and second sprint effort for CMR, but a greater decrease in mean power was observed for CMR during the later sprints. However, the efficacy of CMR to improve performance during protocols that more resemble team sport activity with repeated bouts of sprinting and jumping required between periods of lower intensity efforts (e.g. soccer or basketball) is sparse and provides little evidence to support the incorporation of CMR for such scenarios (3, 11, 24).

Previous investigations provide support for carbohydrate ingestion to improve gross and fine motor skills during prolonged team sport activities (12, 28, 30). A practical advantage for the CMR strategy is it may be an alternative for athletes seeking a carbohydrate related performance advantage but prefer to avoid fluid consumption during intense exercise due to gastrointestinal associated disturbances with fluid ingestion (10, 20, 21). However, it is unclear if CMR can improve high intensity intermittent exercise performance resembling cyclocross and mountain biking. Therefore, the purpose of this exploratory, application-based study was to examine the effect of a 6.4% CMR on high intensity, multiple sprint performance with interspersed sets of submaximal exercise. It was hypothesized that rinsing the mouth with a carbohydrate solution will improve high intensity multiple sprint performances versus a placebo rinse.

## Methods

### *Participants*

Seven recreationally competitive male athletes completed all procedures in this study. Inclusion criteria were ages 19-45 and exercising 5 days per week or more for at least 30 min each session. Four participants were cyclists and competed in on and off-road cycling, the remaining 3 participants trained primarily for running competitions. The first visit involved an assessment of age, height, weight, and  $VO_2$  peak assessment. The age, height, body mass, and aerobic capacity of the participants were  $28.2 \pm 6.8$  years,  $185 \pm 9$  cm,  $85.3 \pm 14.8$  kg,  $VO_2$  peak  $51.4 \pm 7.3$  ml/kg\*min<sup>-1</sup>. Upon arrival, participants were fully informed of the purposes and risks associated with the study procedures, a written informed consent was obtained. All procedures for this study were approved by the Central Washington University Human Subjects Review Board.

### *Protocol*

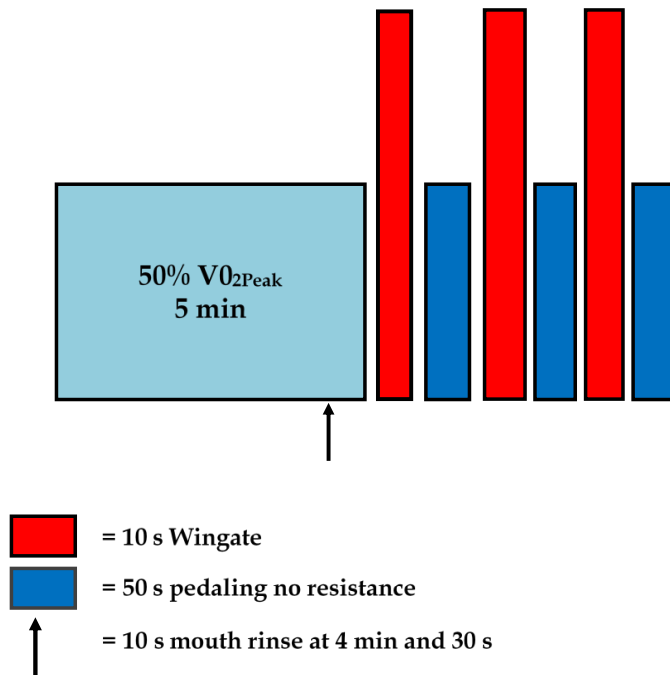
$VO_2$  peak testing and familiarization procedures: Each participant performed an introductory test and two experimental trials. All exercise bouts were completed on a cycle ergometer (Velotron RaceMate, Seattle, USA). Following anthropometric assessments in the initial session, participants completed an incremental cycling protocol to volitional fatigue. Seat

height was appropriately set for each individual, with handlebars adjusted based on individual preference. Participants were required to maintain a cadence of 60 rev/min which was displayed on a projector. Participants were fitted with an appropriately sized breathing apparatus (Hans Rudolph Inc., Shawnee, USA), nose clip, headgear, and a heart rate (HR) monitor transmitter (Polar, Stanford, CN, USA) at the level of the sternum. Expired air was directed through a valve and plastic tubing connected to a metabolic cart (Parvo-Medic True Max 2400, Sandy, USA) which was calibrated prior to each test with a known gas composition. A 3-L syringe (Hans Rudolph Inc., Shawnee, USA) was used to calibrate the system for measurement of ventilation. Participants completed a 2 minute warm-up on the cycle ergometer with no resistance to the flywheel. The workload was then increased by 0.5 kp every minute thereafter until a  $VO_2$  peak was achieved by at least one of the following (i) RER greater than at least 1.1, (ii) HR within 10 beats per minute of age predicted maximum, (iii) a plateau in  $VO_2$  with an increase in resistance. The  $VO_2$  peak test was followed by a short familiarization trial of the modified 10 second Wingate protocol and mouth rinse procedures.

**Treatment Sessions:** Participants, on two subsequent occasions separated by at least 48 h, but no longer than 2 weeks between trials completed a 48-minute exercise protocol designed to simulate intermittent sprint activities. Each trial was preceded by a standardized evening meal at 19:00 hour. Participants were asked to replicate the same breakfast and lunch the day before the trial. An evening meal was provided although food volume was self-selected. The amount consumed was recorded for any differences in energy consumption between the two trials and subjects were instructed to replicate and consume the same amount of food for the second trial. The meal consisted of 150 g of cooked white spaghetti, 128 g of tomato basil sauce, 96 g of cooked 93% lean hamburger (93 g of cannellini beans for the one vegetarian athlete), a serving of strawberry yogurt, 1 banana, 1 apple, and 1 serving of chocolate cookies and had a caloric content of 988 total calories (593 kcal of carbohydrate, 258 kcal of fat and 137 kcal of protein). The vegetarian meal substituted a  $\frac{1}{2}$  cup of cannellini beans for 966 calories (665 kcal of carbohydrate, 201.5 kcal of fat and 99.5 kcal of protein). Participants refrained from consuming alcohol, tobacco, and caffeine 24 hr prior to testing. Participants fasted overnight and arrived to the testing facility in the morning. Participants were asked to keep their normal diet practices during the testing sessions and avoided exercise the day before the trial.

The exercise protocol consisted of six, 8 min bouts (Figure 1). During each bout participants cycled for 5 min at 50% of  $VO_{2peak}$ . Participants then completed 3 x 10 s of 'all out' bicycle modified Wingate sprints at (7.5% kp per kg of subject's body weight) interspersed with 50 s rest periods (18 total modified Wingate tests). RPE was assessed on a 6 - 20 scale (4) after each Wingate sprint. HR was also recorded immediately after each Wingate sprint. During each Wingate sprint cycle, the peak power, mean power, and fatigue index (FI) were recorded using computer software (Velotron Wingate, Seattle, USA) integrated with the ergometer. Dependent variables were averaged over 3 sprints (a total of six bouts) for data analyses. After the third Wingate sprint, capillary blood was immediately collected from a finger stick and 10 $\mu$ L of blood was analyzed for glucose concentration (Analox Instruments, Atlanta, GA, USA) in duplicate with the average of the two measurements used in data analysis. The table top analyzer was calibrated prior to each trial using a 10 $\mu$ L 8 mmol glucose standard. Pre exercise

blood glucose levels were  $4.3 \pm 1.0$  and  $4.8 \pm 0.9$  mmol/L for CMR and PLA, respectively, indicating that participants were fasted.



**Figure 1.** Overview of high intensity intermittent exercise protocol. 8 min per set: 5 min of steady state exercise followed by 3 x 10 sec Wingate sprints (repeated 6 times). Subject were given the treatment (CMR or PLA) prior to each set of Wingate sprints

Mouth rinse protocol: A carbohydrate or PLA solution was administered during treatment trials, using a randomized, double-blind crossover design. At minute 4:30 during each 5 minute steady state cycling segment, subjects were provided a pre-weighed cup containing 25 mL of either carbohydrate or PLA solution (24). Participants were instructed to rinse the solution in their mouth for 10 s and then expectorate back into the cup (24). The mean expectorated fluid mass was  $25.5 \pm 1.1$  g and  $26.3 \pm 1.1$  g for carbohydrate and PLA solutions, respectively, assuring compliance to the rinsing protocol. Sinclair et al. (25) observed that a 10 second MR duration improved a 30 min time trial cycling performance when compared to PLA, suggesting a longer MR is more beneficial. Both treatment solutions consisted of a commercially available non-caloric sport beverage (Powerade Zero, Coca-Cola, GA, USA) (24). One solution consisted of the caloric sport beverage while the other was the caloric sport beverage with 64 g of maltodextrin (Home Brew Supply LLC, TX, USA) that was mixed and diluted for every 1000 mL of the sport beverage in the CMR (24). Maltodextrin was used because of the tasteless property, both beverages were flavor matched. The sport beverages were placed in a refrigerator the night before each trial to chill ( $5^{\circ}$  C) (24). The beverages were marked numerically and then poured into individual cups at the mouth rinsing station (24). The day of the trial, solutions were prepared by the same investigator 15 min before the first trial to reduce variability (24). All participants and investigators excluding those who prepared the beverages were blinded to what solution was being consumed (24). Taste testers were not able to distinguish between beverages due to maltodextrin being tasteless.

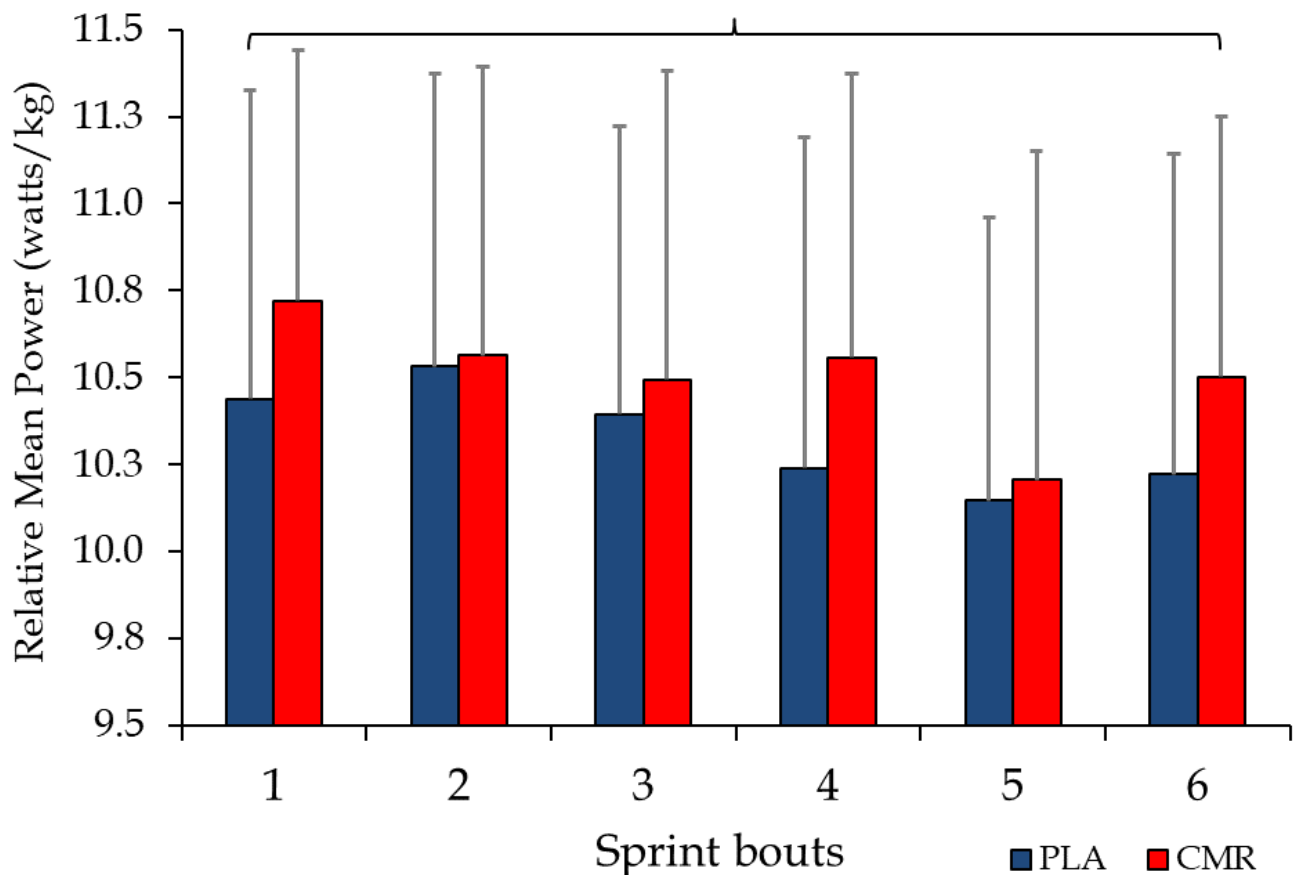
#### Statistical Analysis

All data were analyzed using IBM SPSS Statistics Version 23.0 software and are reported as means  $\pm$  standard deviations unless otherwise stated. Wingate performance measures

including peak power, mean power, and fatigue index were averaged across the 3 sprints in each of the 6 individual bouts for analysis. Due to the heterogeneity in participant body mass, all power related variables were analyzed relative to body mass versus absolute power. Statistical significance was set at  $\alpha < 0.05$ . Repeated measures ANOVA was used to determine if main effects for beverage or time were exhibited. If main effects were found for beverage paired t test were incorporated for each time point comparison. Cohen's d effect sizes were calculated when significant main effects for treatment were found.

## RESULTS

There was a main effect ( $p = 0.02$ ) for beverage type on relative mean power (CMR  $10.51 \pm 0.82$ , PLA  $10.33 \pm 0.87$  W/kg; ES = 0.21). Post hoc testing revealed that only the last bout differed significantly ( $p = 0.01$ ) between treatments (Figure 2). Relative mean power output had small effect sizes in sprint bouts 1, 4, and 6 (0.34, 0.36, 0.33 respectively). Relative peak power did not differ significantly between treatments (Figure 3). Small effect sizes of relative peak power were observed in sprint bouts 4, 5, and 6 (0.48, 0.31, 0.28 respectively). There was no main effect of treatment or significant interaction for RPE, blood glucose, or fatigue index, but all 3 variables exhibited expected main effects for time ( $p < 0.01$ ) (Table 1).

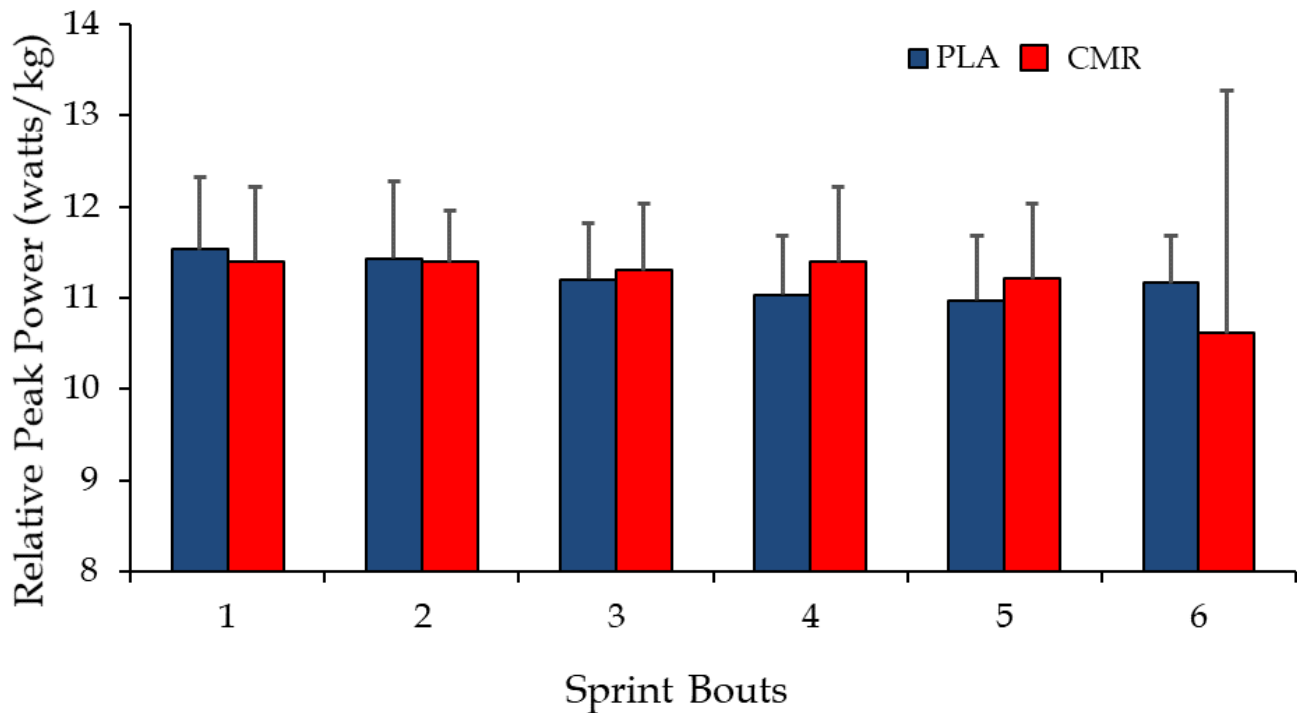


**Figure 2.** Mean power relative to subject's body mass for each set of sprints (3 x 10 s). †Significant main effect for beverage type ( $p = 0.02$ ). \*Significant difference between bouts found during post hoc testing ( $p < 0.05$ ).

**Table 1.** Fatigue index, blood glucose, and RPE responses during exercise protocol ( $n = 7$ ; mean  $\pm$  SD).

	Bout						Mean
	1	2	3	4	5	6	
<b>Fatigue Index (W/sec)</b>							
CMR	23 $\pm$ 12	23 $\pm$ 10	26 $\pm$ 9	27 $\pm$ 15	27 $\pm$ 15	30 $\pm$ 15	26 $\pm$ 13*
PLA	23 $\pm$ 10	25 $\pm$ 15	27 $\pm$ 12	24 $\pm$ 9	31 $\pm$ 21	32 $\pm$ 21	27 $\pm$ 15*
<b>Glucose (mmol/L)</b>							
CMR	4.0 $\pm$ 0.5	4.2 $\pm$ 0.9	4.6 $\pm$ 1.0†	5.1 $\pm$ 0.9† §	5.1 $\pm$ 1.1†	5.3 $\pm$ 1.4††	4.7 $\pm$ 1.0*
PLA	4.2 $\pm$ 0.4	4.5 $\pm$ 0.7	4.7 $\pm$ 0.7	5.1 $\pm$ 0.5	5.1 $\pm$ 1.0	5.3 $\pm$ 1.0	4.8 $\pm$ 0.7*
<b>RPE</b>							
CMR	13.7 $\pm$ 2.5	14.6 $\pm$ 2.5†	15.7 $\pm$ 2.8††	16.3 $\pm$ 2.6††	17.0 $\pm$ 2.4†† §	17.5 $\pm$ 2.4†† §	15.8 $\pm$ 2.5*
PLA	13.9 $\pm$ 3.4	15.8 $\pm$ 2.5	16.3 $\pm$ 2.3	17.2 $\pm$ 2.3	17.6 $\pm$ 2.0	17.9 $\pm$ 1.8	16.4 $\pm$ 2.4*

\* = Main effect for time ( $p < 0.01$ ). † = Significant effect for time versus first bout ( $p < 0.05$ ). ‡ = Significant effect for time versus second bout ( $p < 0.05$ ). § = Significant effect for time versus third bout ( $p < 0.05$ ).



**Figure 3.** Peak power relative to subject’s body mass for each set of sprints (3 x 10 s). No significant difference was found.

## DISCUSSION

The aim of this study was to determine if CMR improved multiple sprint performance when interspersed with bouts of submaximal exercise resembling sports like mountain biking and cyclocross. The main finding in the current study, was that despite no changes elicited in RPE, peak power, or fatigue index, a higher relative mean power output, approaching 2%, was

observed with CMR when compared to PLA. The most significant impact occurred during the 6<sup>th</sup> (last) bout of sprints.

Investigations examining the effects of CMR on maximal anaerobic activities are limited and have primarily examined running. Bortolotti et al. (5), observed no difference in 6 x 40-meter running sprint performance while utilizing a CMR 5 min before the trial. This is the longest distance, straight line repeated sprint CMR protocol the authors are aware of, but it is somewhat difficult to compare these findings to the current study. The participants (5) were youth athletes, and the total amount of exercise during the protocol was limited. Furthermore, it is unknown if they were in a pre or post prandial state, which appears to influence the influence of CMR on performance (3, 13, 18, 19). All other repeated sprint without change of direction studies we are aware of have included sprints of 20-m or less. Our findings are not in agreement with Dorling and Earnest (11) who found no improvements in 20 meter sprints performed under multiple conditions. The Loughborough Intermittent Shuttle Test and Repeated Sprint Ability Test involves alternating periods of sprinting with active recovery until volitional exhaustion. A non-practical number (n=27) of mouth rinses were undertaken during this protocol however no improvement was found with the high volume of sprints (n=44) and mouth rinses. Píibyslavská et al., (24) also found CMR did not improve 18 m sprint performance in collegiate female soccer athletes (n = 11) during a morning practice with small-sided games. CMR also failed to improve vertical jumping performance, while performance improvement approached (p = 0.06) statistical significance during one round of a 4 x 18 m shuttle run, a longer duration task. Furthermore, the current study examined cycling performance rather than running, therefore further research examining high intensity cycling is warranted. The use of CMR may be beneficial for cyclocross and mountain bike events where the typical duration is ~1 hour. In addition, bikers always have fluid on their bike and they can utilize CMR as needed.

While the studies cited above included sprint tests, perhaps the most significant interpretation of the past and current investigations is that only longer duration maximal effort tests are likely to be affected by CMR when high intensity intermittent protocols are incorporated. It is important to note that the power output was averaged over 3 sprints per bout versus reporting from a single bout which both increases the accumulation of acute fatigue in each bout and reduces the influences of outlier data during any single bout. Under these conditions higher means were displayed for CMR in all 6 rounds of sprints. Although the greatest statistical impact occurred during the final multiple sprint bout, similar trends of improvement were observed during bouts 1 and 4 supporting the findings of performance improvement in a single or very short duration and low volume CMR studies might be exhibited if the exercise stressor lasts ~30 s or longer (2,8). Also in support of past investigations using similar high intensity exercise, CMR (11, 24) does not exhibit any detectable improvement in RPE. Dorling and Earnest (11) saw no difference in RPE when comparing treatments. Píibyslavská (24) observed a small effect size of 0.40 in RPE during the second bout of their soccer scrimmages. In the current study, RPE significantly increased (p = 0.012) over time and small effect sizes were seen in bouts 2, 4, and 6 (0.31, 0.25, 0.40 respectively). In theory, if CMR could decrease

RPE this may aid performance, however our research and previously cited studies have not observed a meaningful drop in RPE with CMR.

The current study is not without limitations. Other than observing blood glucose levels, no attempt was made to explain the mechanistic contributions of CMR to gross muscle performance. In support of most past studies (14, 19, 22, 29, 31) there was no difference in the change in blood glucose between a CMR and PLA and maintenance of euglycemia throughout each trial. Also, competing in the fed state is optimal for performance and most common as the majority of team sports competitions do not occur early in the morning (17). However, most studies examining the effect of a CMR, including this one, have been conducted in a fasted state which is common during early morning practices, may inflate performance responses for CMR (13, 19, 26). Further research needs to be conducted to determine if CMR is similarly effective in a fed versus fasted state.

Recent sports nutrition recommendations (1) have included CMR as a practical nutritional ergogenic aid during sustained high intensity exercise lasting 45 to 75 min in duration. In the current study, the utilization of a CMR during exercise intended to mimic high intensity, aerobic team sports and resulted in modest improvements in mean repeated sprint power output late in exercise when compared to a PLA under fasted conditions providing support to this position stance. Although more research is warranted, the use of CMR may be useful to athletes with aversion to consuming carbohydrate beverages during play due to gastrointestinal distress issues associated with carbohydrate-electrolyte beverage consumption during activity. The mechanisms explaining these results are likely related to central factors and cannot be determined at this time due to methodological limitations of prolonged whole-body exercise and cerebral cortex imaging procedures. These findings cannot be confirmed for individuals in a non-fasted state and should be examined in future research.

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