Journal of Human Kinetics volume 67/2019, 133-142 DOI: 10.2478/hukin-2018-0076
Section II- Exercise Physiology & Sports Medicine

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Mouth Rinsing Cabohydrates Serially does not Improve Repeated Sprint Time

by

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Sensing carbohydrates via the oral cavity benefits performance outcomes during brief high intensity bouts of exercise. However, the extent to which carbohydrates need to be present in the oral cavity to influence sprint performance is less understood. The purpose of this study was to determine if serial increases in carbohydrate rinse time across sprint sets attenuates increases in sprint time compared to no serial increases in carbohydrate rinse time across sprint sets. Fifteen sprint trained participants completed three repeated anaerobic sprint tests (RAST), 3 sets of 6 x 35-m sprints, under two different carbohydrate mouth rinsing (CMR) conditions; (1) rinsing for only 5 seconds (s), and (2) rinsing for 5 s, 10 s and 15 s (serial rinse). Prior to a RAST, participants provided perceived recovery status (PRS) and perceived feeling of arousal (FAS). Upon completion of each individual sprint, participants gave a rating of perceived exertion (RPE). A lactate sample was taken upon completion of each individual sprint set and after all 3 RASTs a session rating of perceived exertion (S-RPE) was measured. There were no significant differences in peak ($p = 0.18$) and average sprint time ($p = 0.41$). There were no significant differences in perceptual measures: RPE, PRS, FAS, S-RPE or for blood lactate concentration between CMR conditions. Overall, serial rinsing resulted in changes that were most likely trivial, but showed a 50% chance in perceiving a sprint session as less difficult. Rinsing carbohydrates in a serial manner between repeated sprint sets produces trivial changes of sprint speed and perceptual measures from sprint performance.

***Key words**: RAST, high intensity, PRS, speed, RPE, sprinters.*

Introduction

Carbohydrate (CHO) supplementation during prolonged endurance exercise improves performance and delays fatigue from an increased rate of CHO oxidation (Jeukendrup et al., 2004). However, an accumulation of observations suggests CHO supplementation for exercise lasting about one hour (h) is unlikely to have an important role in fueling performance (Burke et al., 2005; Michalczyk et al., 2018). Further investigations, where intensity was sufficiently high, found that there was an achieved benefit from individuals rinsing their mouths with a glucose or maltodextrin solution (Beaven et al., 2013; Carter et al., 2004a; Gam et al., 2013; Lane et al., 2013). The benefits seen therefore may not necessitate exogenous feeding of CHO. A simple exposure of CHO to the oral cavity results in stimulation of reward centers in the brain that lead to an increase in pace or work output (Chambers et al., 2009).

CMR has been shown to enhance performance when compared to water and/or a placebo design in both cycling and running (Carter et al., 2004a; Chambers et al., 2009; Fares and Kayser, 2011; Rollo et al., 2010). Despite these observations, the effect of CMR on brief high intensity sprint performance is less established.

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Authors submitted their contribution to the article to the editorial board.
Accepted for printing in the Journal of Human Kinetics vol. 67/2019 in June 2019.

Intermittent sports (rugby, hockey, soccer, etc.) compriseof repeated transitions of varying exercise intensities that challenge individuals metabolically (Johnston and Gabbett, 2011; Laurent et al., 2014; Siegler et al., 2003). A potential drawback is that the CHO mouth rinse solution may not be powerful enough to offset peripheral signals of fatigue - signals that come from longer or more intense exercise periods. These peripheral signals are related to other mechanisms seen during intermittent sport such as alterations in intramuscular phosphates and reductions in phosphocreatine (Bogdanis et al., 1996; Glaister et al., 2005). Thus, adequate rinse time needed to stimulate the oral receptors is critical for optimizing an ergogenic effect from CMR.

A study conducted by Sinclair et al. (2014) showed that 10 s CMR duration was superior to 5 s in a 30-min cycling time trial. The purpose of this study was similar to the Sinclair et al.'s (2014) design, and helps determine whether CMR serially attenuates an increase in sprint time differently than not rinsing serially during intermittent sprinting. Rinsing CHO serially increasing in duration could be a practical strategy for intermittent sports given the brief periods of rest combined with high intensity bouts. It can also assist in avoiding complete ingestion of CHO solutions that can lead to individual gastrointestinal distress (Sinclair et al., 2014). Testing different CMR duration strategies on sprint time and changes in perception may help incorporate CMR into ergogenic nutritional strategies. However, it is still unclear if rinsing CHO solutions/beverages for periods longer than 5 s is beneficial to individual sprint performance. We hypothesized that serial increases in CMR time across repeated sprint sets would attenuate increases in sprint time and change perceptual measures compared to no serial increases in CMR.

Methods

Participants

Fifteen asymptomatic men (n = 7) and women (n = 8) volunteered to participate in the study (Table 1). To be included in the study, participants needed to currently perform sprint training and compete in an intermittent-type sport (e.g., soccer, rugby, and hockey) at least 2 days per week for a minimum of 6 months. Before testing, participants were instructed to refrain from drinking alcohol 24 h and caffeine 4 h before testing. Participants were also instructed to abstain from intense physical activity 48 h before testing sessions. Before each testing session, participants were questioned about guidelines set for dietary intake and physical activity. If a participant experienced any discomfort or developed an illness during testing, then he or she was asked by the researcher to withdraw from the study. After the participant completely understood the study's procedures and had all his or her questions satisfactorily answered, he or she was asked to sign an informed consent form. This study was approved by the Bowling Green State University Institutional Review Board.

Design and Procedures

Randomized, counterbalanced trials were conducted to test the effects of two different CMR conditions on sprint time and perceptual measures. Participants reported to the laboratory on three separate occasions: session one representing the familiarization session and the next two sessions that were testing sessions. All the sessions were scheduled between a minimum of 48 h and maximum of 72 h. Upon arrival to the laboratory for the familiarization session, participants were assessed for body height (centimeters) and body mass (kilograms) using a stadiometer and beam scale (Detecto Scale Company, Webb City, MO, USA). Body fat percentage estimations were performed using the 3-site method (men: chest, abdomen, and thigh; women: tricep, iliac, and thigh; Pollack et al., 1980) by skinfold calipers (Lange, Cambridge, Maryland, USA). Then participants began a standardized warm-up that was adopted from procedures developed by Vetter (2007) prior to beginning the repeated anaerobic sprint test (RAST). After completing the standardized warm-up, participants ran one RAST (Zagatto et al., 2009), on a Curve non-motorized treadmill (Woodway USA, Inc., Waukesha, WI, USA). The RAST set consisted of 6, 35-m sprints performed maximally, with 10 s of rest between each sprint. After one set was completed, participants were encouraged to ask any questions or express any concerns they may have about the procedures. An ideal competition meal was explained by a registered dietitian (USDA's MyPlate for athletes) as well as instructions on how to record dietary intake 24 h prior to the first testing time and then to replicate

the same diet to the next scheduled testing session time.

Measures

The changes in sprint time and perceptual measures from two different CMR conditions were examined via participants completing multiple sets of RASTs. Two sprint sessions were performed to determine the effects of a 10% maltodextrin mouth rinse (independent variable) on the following (dependent variables): fastest sprint time (FST), average sprint time (AST), blood lactate, and rating of perceived exertion (RPE) using the Adult OMNI Scale of Perceived Exertion for running (Utter et al., 2004), global rating of perceived effort scale (S-RPE) (Foster et al., 2001), as well as perceived recovery status (PRS) using a modified Perceived Recovery Status Scale developed by Laurent et al. (2011). The PRS scale was a 0–10 scale used to determine an individual's PRS with a score of 0 representing very poorly recovered and a score of 10 representing very well recovered, and feeling of arousal (FAS) (Svebak and Murgatroyd, 1985). The FAS is a six-point measure ranging from 1 (low arousal) to 6 (high arousal). Backhouse et al. (2007) reported the FAS as an acceptable measure when observing supplementation interventions.

The repeated sprint exercise protocol included three sets of repeated sprints ($RAST_1$, $RAST_2$, and $RAST_3$) with a seven-minute passive rest and a five-second self-administered CMR 20 s prior to each set. After the warm-up, each participant performed three RAST sets. The investigators gave the participant a 5 s countdown to which they were prompted to start jogging on the treadmill belt. After the 5 s countdown, individuals were given a verbal cue to initiate their sprint. Verbal encouragement was provided to the participants in a similar manner throughout the series of sprint sets. Immediately after the completion of each 35-m sprint, participants were given a verbal cue to straddle the treadmill belt again for their 10 s passive recovery period. Once six sprints had completed (one RAST), the participants were seated in a chair for a seven-minute seated passive recovery period. The recovery period of 7 min was chosen to allow for optimal phosphocreatine repletion (Bogdanis et al., 1996). During the recovery period, each participant was permitted to drink water ad libitum within the first 2 min of the 7 min recovery period. Participants vigorously swished a 25-mL CHO solution in their mouths. Then, they were asked to spit the solution into a styrofoam cup that had been pre-weighed in grams (g) using an electronic scale (Fristaden & Company LLC, Chicago, Illinois, USA). Styrofoam cups were reweighed to assess the amount of solution spit back into the cup to determine unintentional swallowing of the solution by the participant.

One sprint session required the participant to rinse his or her mouth with the CHO solution for 5 s in duration then spit the solution out prior to each RAST (5 s rinse). The second sprint session required the participant to rinse the carbohydrate solution serially prior to each RAST: 5 s for the first set, 10 s for the second set and 15 s for the third set (serial rinse). After each sprint, rating of perceived exertion (RPE) was recorded within a 10 s period between each sprint. Raw treadmill belt speed data (peak speed [$m \cdot s^{-1}$], and mean speed [$m \cdot s^{-1}$]) from the non-motorized treadmill were recorded by a transducer in the non-motorized treadmill platform and monitored "real time" on a personal computer containing the manufacturer's computer software (World Wide Software Solutions Firmware version 1.32). Upon the end of the repeated sprint set, blood lactate concentration was assessed through samples by means of a fingerstick and capillary puncture and analyzed by an enzymatic portable blood lactate analyzer (Lactate Plus; Nova Biomedical Corp., Waltham, WA, USA). At 25 s left in the recovery period, participants gave their PRS. Then the participant swirled the carbohydrate solution in their mouth for the respected duration, before spitting the solution back into a styrofoam cup. Immediately following the rinse, the participant had their FAS evaluated. At 15 min post testing session, participants provided S-RPE. The serial rinse trial followed the same protocol as the 5 s rinse trial. However, in this session, individuals were required to rinse the carbohydrate solution serially prior to each RAST set (5 s, 10 s and 15 s). All testing took place at approximately the same time of the day.

Statistical Analyses

Multiple separate, two-way, within-subjects analyses of variance (ANOVAs) (rinse condition [5 s vs. Serial rinse] × sprint set [RAST]) were used to analyze AST, FST, RPE, PRS, FAS, and blood lactate. Paired dependent samples t-test was used to analyze the S-RPE, total volume of

expectorate and total hours fasted. When appropriate, follow-up analyses included Bonferroni-corrected dependent samples t-tests on the marginal means. Partial-eta squared effect sizes were calculated for each ANOVA. Additionally, to make inferences about true (population) values of the effect of CMR rinse conditions on repeated sprint performance and perceptual measures, the uncertainty in the effect was expressed as 90% confidence limits and as likelihoods that the true value of the effect represented substantial change (harm or benefit) (Batterham and Hopkins, 2006). An effect was deemed unclear if its confidence interval overlapped the thresholds for substantiveness, that is, if the effect could be substantially positive and negative or beneficial and detrimental. The type I error rate was set at 5%. All data was analyzed using the SPSS version 22.0 (SPSS, Inc., Chicago, IL, USA).

Results

Paired t-test revealed no significant difference in volume of expectorate (p = 0.11), or hours fasted (p = 0.70) between rinse conditions.

Average sprint time

A repeated measures ANOVA revealed no main effect of condition on average sprint time (F = 0.712, p = 0.41, η_p^2 = 0.052). There was a significant main effect of RAST set on average sprint time (F = 20.234, p < 0.05, η_p^2 = 0.609). There was no interaction effect (condition x RAST) (F = 1.326, p = 0.28, η_p^2 = 0.093). A Bonferonni corrected t-test revealed significant difference of average sprint time between $RAST_1$ and $RAST_2$ (p < 0.05) and $RAST_2$ and sprint $RAST_3$ (p < 0.05), but there was no significant difference between $RAST_1$ and $RAST_3$ (p < 0.05).

Peak sprint time

A repeated measures ANOVA revealed no main effect of condition on peak sprint time (F = 2.017, p = 0.18, η_p^2 = 0.134) (Figure 1). There was a significant main effect of RAST set on peak sprint time (F = 20.845, p < 0.05, η_p^2 = 0.616). There was no interaction effect (condition x sprint set) (F = 1.146, p = 0.334, η_p^2 = 0.081). A Bonferonni corrected t-test revealed no significant difference of peak sprint time between $RAST_1$ and sprint $RAST_2$ (p = 0.08), but a significant difference between $RAST_2$ and $RAST_3$ (p < 0.05) and sprint set 1 and sprint set 3 (p < 0.05).

Rating of Perceived Exertion (RPE)

A repeated measures ANOVA revealed no main effect of condition on the RPE (F = 1.965, p = 0.18, η_p^2 = 0.131). There was a significant main effect of sprint set on the RPE (F = 16.807, p < 0.05, η_p^2 = 0.564). There was no interaction effect (condition x sprint set) (F = 2.137, p = 0.23, η_p^2 = 0.108). A Bonferonni corrected t-test revealed a significant difference of the RPE between $RAST_1$ and sprint $RAST_2$ (p < 0.05) and $RAST_1$ and $RAST_3$ (p < 0.05), but no significant difference between $RAST_2$ and $RAST_3$ (p = 0.30). The session rating of perceived exertion was not different between CMR conditions (t = 1.103, p = 0.29).

Perceived Recovery Status (PRS)

A repeated measures ANOVA revealed no main effect of condition on PRS (F = 0.361, p = 0.56, η_p^2 = 0.027). There was a significant main effect of sprint set on PRS (F = 18.324, p < 0.05, η_p^2 = 0.585). There was no interaction effect (condition x sprint set) (F = 1.640, p = 0.21, η_p^2 = 0.112). A Bonferonni corrected t-test revealed a significant difference of PRS between $RAST_1$ and $RAST_2$ (p < 0.05) and $RAST_1$ and $RAST_3$ (p < 0.05), but no significant difference between $RAST_2$ and $RAST_3$ (p = 0.77).

Rating of Perceived Activation (FAS)

A repeated measures ANOVA revealed no main effect of condition on PRS (F = 0.098, p = 0.76, η_p^2 = 0.007) or on the sprint set (F = 0.977, p = 0.39, η_p^2 = 0.070). There was no interaction effect (condition x sprint set) (F = 1.380, p = 0.27, η_p^2 = 0.096).

Blood lactate

A repeated measures ANOVA revealed no main effect of condition on blood lactate (F = 1.243, p = 0.29, η_p^2 = 0.087). However, there was a main effect of the sprint set on blood lactate (F = 39.569, p < 0.05, η_p^2 = 0.753). There was no interaction effect (condition x sprint set) (F = 3.177, p = 0.58, η_p^2 = 0.196). A Bonferonni corrected t-test revealed a significant difference of blood lactate between all $RAST_1$, $RAST_2$ and $RAST_3$ (p < 0.05).

Effects on performance

Table 2 shows the mean changes in sprint speed and related measures for the 5 s and serial rinse groups' statistics for the difference in the changes. There were mostly trivial beneficial effects on all measures of performance except for S-RPE, which showed a likely positive beneficial effect (50%). The RPE and PRS showed a 10.1% and 7.5% beneficial effect on performance, respectively.

Table 1

Descriptive characteristics of the subjects.

Characteristics	Total (N = 15)	Male (n = 7)	Female (n = 8)
Age (years)	22.0 ± 2.3	22.5 ± 2.7	21.7 ± 1.5
Body height (cm)	173.4 ± 8.4	180.0 ± 5.6	166.7 ± 4.5
Body mass (kg)	74.3 ± 13.9	86.7 ± 5.9	62.0 ± 7.1
Body fat (%)	20.2 ± 4.9	17.2 ± 3.1	23.2 ± 4.6

All results are reported as mean ± SD.

Table 2

Changes in performance of all RASTs in 5 s and serial rinse conditions, and qualitative inferences about the effects on competitive performance. ±90% CL: add and subtract this number to the mean effect to obtain the 90% confidence limits for the true difference.

	Change in measure					
Performance Measure	5 s duration	Serial rinse duration	Difference; ± 90% CL	Harm (%)	Benefit (%)	Practical Assessment
FST (s)	5.84	5.75	0.085 ±1.1	0.0	0.0	Most likely trivial
AST (s)	6.37	6.34	0.03 ±0.91	0.0	0.0	Most likely trivial
RPE	6.89	6.63	0.26 ±0.32	0.0	10.1	Likely trivial
S-RPE	7.87	7.37	0.50 ±0.63	0.6	50.0	Likely positive
PRS	4.55	4.69	0.14 ±0.41	0.8	7.5	Likely trivial
FAS	2.96	2.90	0.06 ±0.18	0.0	0.0	Likely trivial

**Fastest sprint time = FST, Average sprint time = AST, Rating of perceived exertion = RPE, Session of rating of perceived exertion = S-RPE, Perceived recovery status = PRS, Felt arousal = FAS, s = seconds.*

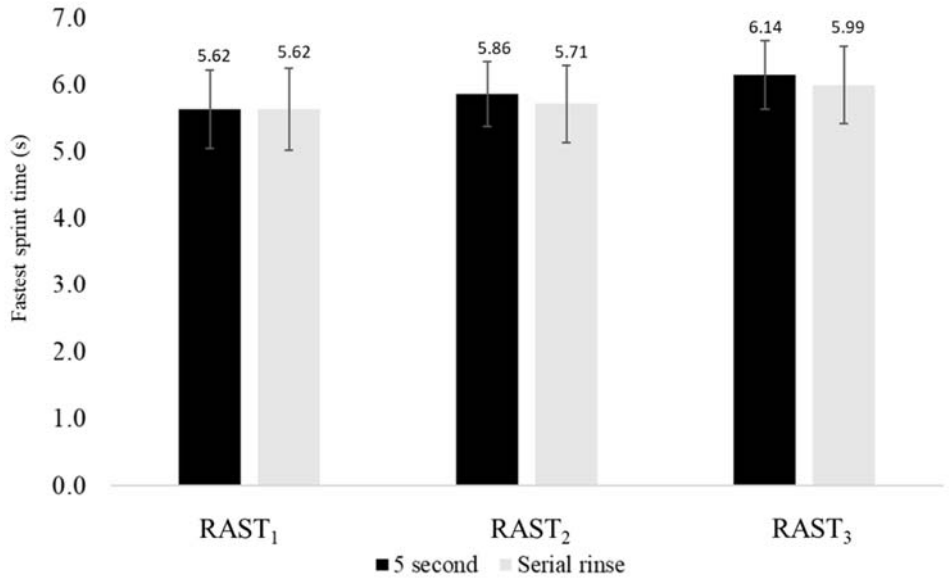

Figure 1

The fastest average sprint time for each RAST set for both the 5 s and serial rinse conditions. The black columns represent the 5 s rinse condition and the grey columns represent the serial rinse condition.

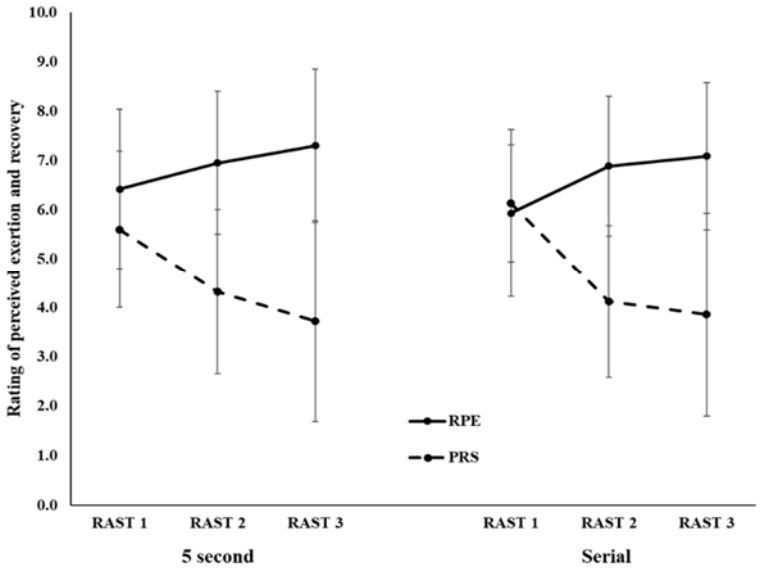

Figure 2

Average rating of perceived exertion (RPE) and perceived recovery status (PRS) are shown as a solid or a dotted line. Both perceptual ratings were measured during each RAST under the 5 s and serial rinse conditions.

Discussion

This study was designed to help maximize CMR as a potential strategy to improve sprint performance that involves running, and mimics the intermittent nature of most sports. Our primary findings demonstrate that serially rinsing CHO does not improve intermittent high-intensity sprint time. As a secondary outcome, the study helped to determine if a serial rinse strategy influenced perceptual measures during repeated sprints. This study aimed to examine if serial rinses attenuated an increase in running time from repeated sprints. Additionally, previous studies were based on null-hypothesis testing, whereas these analyses included an approach to inferential statistics that emphasizes precision of estimation. To that end, we followed recommendations to show and interpret the practical importance of confidence limits (Altman et al., 2001; Sterne et al., 2001), which represent the uncertainty in the true value of each effect. We built on these recommendations by a rule for deciding when an effect was clear or unclear and by making quantitative assertions about the likelihood that the effect was beneficial or harmful. The most salient finding from this study reveals that rinsing serially most likely benefits an individual's perception of an entire sprint session (S-RPE, Table 2). Reasonably, participants who serially increase the CMR duration throughout repeated sprint sets are likely to benefit due to a lower perception of the entire sprint session as compared to individuals who do not rinse serially.

There was no significant effect from serial rinses of CHO on perceptual measures associated with sprint performance. Statistical analyses revealed no significant interaction between RASTs on PST or AST (Figure 1). Interestingly, there was a noticeable difference between conditions in RAST2, but not RAST1 or RAST3 for PST. This small difference aligns with results from Dorling and Earnest (2013). A study that required 8 young active males to complete a repeated sprint ability test (RSA) and a Loughborough Intermittent Shuttle Test (LIST), with and without mouth rinsing with a 6.4% CHO solution.

Another study conducted by Bortolotti et al. (2013) examined the CMR impact on sprint performance with 9 soccer players running a RSA test. However, no significant differences were reported. Dorling and Earnest (2013), Bortolotti et al. (2013) and our running sprint results do not support findings from Beaven et al. (2013) who reported that CMR enhanced initial sprint performance during repeated cycle sprint exercise, but did not maintain power over multiple sprints. Both Dorling and Earnest (2013) and Beaven et al. (2013) had participants that rinsed a carbohydrate solution for about five seconds, Bortolotti et al. (2013), for 10 s, whereas this study increased the CHO rinsing duration with subsequent RASTs.

Phillips et al. (2014) used a serial rinse condition that required participants to CMR for 5 s during the rest and warm-up period at different time points prior to sprinting and reported improvements in peak power output during a single 30 s sprint. Sinclair et al. (2014) showed that a 10 s CHO mouth rinse was superior to a 5 s mouth rinse (placebo) in a 30-min cycling time trial experiment. These results suggested a dose–response relationship with oral cavity exposure time and cycling performance. Thus, results from Phillips et al. (2014) and Sinclair et al. (2014) may be related to a dose-response relationship. However, it is likely the dose-response in our study was not evident due to the demand of the RAST protocol; having at least 10 s less of recovery time and 1-2 more sprints that were 35-m in length when compared to Beaven et al. (2013), Phillips et al. (2014), and Dorling and Earnest (2013). Although most likely trivial (Table 2), rising CHO serially may attenuate an increase in fastest sprint times during the latter portions where an individual is most likely performing sub optimally due to the negative consequences of high intensity work (i.e. pH disruption, metabolic byproduct accumulation, etc.) (Glaister, 2005).

The demand of the protocol in this study is evident via our participant's blood lactate levels. The levels of blood lactate our participants are in alignment with the minimal changes in the RPE and PRS between rinsing conditions (Figure 2). Most individuals accustomed to sprint-type training demonstrate the ability to reproduce optimal repeated sprint performance with similar perceptual and metabolic measures (Laurent et al., 2010). Thus, both ergogenic and sprint performance focused studies support the notion that participants can reproduce similar performance during a repeated sprint session. Nevertheless, it is worth noting a non-significant difference in the RPE is commonly reported in

CMR and caffeine trials (Dolan et al., 2017). Evidence has shown that decisions to terminate exercise in a constant power output, or a time to fatigue task is related to feed-forward regulatory control and is likely influenced by CMR (Bazzucchi et al., 2016; Burke and Maughan, 2015; Chambers et al., 2009; Gant et al., 2010).

However, exercise termination from CMR may be related to changes in perception of recovery. The Perceived Recovery Status Scale was used to identify any perceived changes in recovery (Laurent et al., 2011). A modified version of this scale was used to assess changes in PRS relative to expected performance between RASTs. Results from the study show that PRS values did not vary significantly between RASTs or rinsing conditions (Figure 2). Thus, it could be inferred the minimal differences seen between the RPE and rinsing conditions further suggest that CMR duration does not cause a dissociation between subjective recovery during repeated sprints. Further to the effects on perceived recovery, CMR has been proposed to improve feelings of arousal. There were no significant changes in feelings of arousal and the benefit was likely trivial (Table 2). These results are in contrast to Rollo et al. (2008), who reported that CMR increased feelings of pleasure and activation. This contrast may attest to the sprint design and its ability to override any motivation to perform well, and may negate any small changes in the feelings of activation induced by the presence of CHO in the oral cavity (Ali et al., 2017; Chambers et al., 2009).

In addition to noting the novel findings of this study, it is important to state its limitations. There was no blinding or use of a placebo. The choice to not to include a placebo in this study was based on the amount and quality of evidence supporting an ergogenic effect from CMR when compared to a placebo and/or water design (Carter et al., 2004a; Chambers et al., 2009; Pottier et al., 2010; Rollo et al., 2008). It is also worth noting the limited number of studies having shown no change when compared with a placebo (Stellingwerff and Cox, 2014). Another limitation is that participant blood glucose was not assessed throughout the repeated sprint sessions. However, a study that bypassed the mouth and gastrointestinal (GI) tract with carbohydrates showed that infusion of CHO straight into the blood stream resulted in unaltered performance as compared with no CHO supplementation (Carter et al., 2004b). We would like to note the blood lactate timing of blood draws may not have been collected in a period to optimally determine peak lactate concentration and should be considered in future research. The intention of this study was to focus on optimizing CMR as an ergogenic aid rather than solely determining if it has ergogenic effect on performance, thus the 5 s condition represented the control treatment. Prioritizing an optimization of CMR is further supported by a recent study quantifying the effect of CMR on exercise performance as small and trivial, which may be related to studies not considering the rinsing duration (Peart, 2016).

Conclusions

While some studies have used CMR in the field based approach to promote ecological validity (Bortolotti et al., 2013; Přibyslavská et al., 2016), the design and measures used may not have been sensitive enough to detect changes in performance that influence the feed-forward regulation mechanism. Determining the optimal rinse time and frequency as well as perceptual measures remain important variables to examine. The CMR serial rinse condition was incorporated to maximize the exposure of carbohydrates to the receptors in the oral cavity during high intensity exercise (Burke and Maughan, 2015). The study here sampled changes in speed at 120 Hz in a protocol that generated severe metabolic and perceptual strain, while using a valid test for sprint trained individuals (Zagatto et al., 2009). Additionally, the statistical analysis of these results offers a more practical interpretation for using CMR in sports that require high intensity sprints repeatedly. Rinsing CHO serially is likely to only have a trivial effect on sprint performance, but we also can determine that there will be a zero percent chance in harming intermittent sprint performance. This CMR strategy gives sprint trained individuals a 50% chance to perceive a session as less difficult and potentially could allow them to endure more training sessions.

Acknowledgements

Thanks to Adam Bialecki for assisting in data collection.

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