Performance Nutrition

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Influence of carbohydrate mouth rinsing on repeated interval swimming performance in well-trained adolescent swimmers

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Abstract

Background Carbohydrate mouth rinsing (CHO-MR) may provide an ergogenic effect for exercise performance, with small beneficial effects demonstrated in cycling and running exercise ≤ 1 hour. There is little evidence supporting the use of CHO-MR during high-intensity intermittent activity such as some swimming disciplines. As such, the aim of this study was to explore the impact of CHO-MR on sprint time, perceptions of effort and arousal, and gastrointestinal comfort in well-trained adolescent swimmers. Eleven participants completed three trials (CHO-MR, placebo and control) in a randomised, double-blinded fashion. Participants were fasted and completed four 50m sprints separated by 30-seconds rest, with rinsing occurring prior to each sprint.

Results There were no significant differences between conditions for fastest (CHO-MR: 29.7 ± 3.3 s; PLA: 30.0 ± 3.2 s; CON: 29.3 ± 3.2 s), mean (CHO-MR: 31.4 ± 3.0 s; PLA: 31.4 ± 2.8 s; CON: 30.8 ± 2.6 s), total sprint time (CHO-MR: 125.5 ± 12.2 s; PLA: 125.5 ± 11.4 s; CON: 123.3 ± 10.5 s) or percentage decrement score (CHO-MR: 5.8 ± 4.2%; PLA: 4.9 ± 4.2%; CON: 5.7 ± 4.7%). Furthermore, no significant differences between conditions were observed for rate of perceived exertion, arousal, or gastrointestinal comfort.

Conclusion The results of this study do not support the use of CHO-MR as an ergogenic aid for repeated interval swimming. Future research could explore the impact of CHO-MR on longer duration swimming given the potential ergogenic effect in other disciplines.

Keywords CHO, Ergogenic aid, Exercise

Background

Carbohydrate mouth rinsing (CHO-MR), whereby individuals swill a CHO solution in the oral cavity for 5–10 seconds before expectorating, may represent a practical strategy for improving performance and reducing the perception of effort during exercise [3]. The proposed mechanisms stem from central effects via the detection of sweet stimuli by G-protein-coupled receptor proteins Taste 1 Receptor 2 and Taste 1 Receptor 3 on the tongue, following which the neurotransmitter α-gustducin is secreted and sends information to the brainstem via primary afferent nerve fibre terminals [22]. Research suggests that independently of sweetness, when carbohydrate is present in the mouth there is activation of brain regions believed to be involved in reward, motor control, and visual cue recognition [4, 25]; as such, improvements in exercise performance following CHO-MR may be related to counteracting negative inputs that may

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contribute to fatigue and collectively highlighting the potential ergogenic effect for exercise performance.

CHO-MR has consistently demonstrated a small beneficial effect for exercise durations of ≤ 1 hour in primarily cycling or running disciplines, however literature in shorter duration, high-intensity intermittent activity is conflicting [18]. CHO-MR with a 6% CHO solution has also been shown to improve 10m sprint time, number of repetitions during bench press and squat, counter-movement jump height and arousal [6]. Evidence in single sprint efforts suggests that improvements in peak power output may be observed [19] and the use of CHO-MR as an ergogenic aid can improve relative power output during repeated sprint activities, with an effect in favour of CHO-MR in the final sprint set [23]. However, an ergogenic effect has not been observed in other studies for a single sprint [5], or during repeated sprint activity, intermittent shuttle testing, nor on perceived exertion during exercise [8]. Collectively, the overall effect across different exercise protocols is equivocal [12, 18] however the use of CHO-MR may present a convenient, ergogenic benefit in disciplines where time to consume CHO either prior to, or during activity is limited.

Competitive swimmers compete in various swimming distances that last from 20 s (50 m) to 15 min (1500 m), and energy demands are covered by both aerobic and anaerobic metabolic systems with varying percentages of contribution [24]. Focusing on sprint swimming in particular, the phosphagen (5–80%), glycolytic (2–80%) and aerobic (2–54%) energy systems contribute to ATP resynthesis [21]. Consequently, there are opportunities for performance to be improved via the potential ergogenic effects of carbohydrate. Trained adolescent swimmers typically have congested schedules due to engagement in mandatory education, alongside large training volumes [15]. Furthermore, appropriate substrate availability for exercise may be impaired due to sleep patterns and attendance at educational institutions limiting the time available for feeding prior to and following morning and afternoon sessions [11, 26]. Given that prior consumption of CHO may be difficult due to these schedules and the potential to cause gastrointestinal distress, and limited time during sessions may be prevent consumption during training and competitions, the use of CHO-MR may support adolescent swimmers to optimise performance and enhance adaptations. Despite this, no research currently exists in this population and as such, the aim of this study was to explore the impact of CHO-MR on sprint time, perceptions of effort and arousal, and gastrointestinal comfort in well-trained adolescent swimmers.

Methods

Participant information

Fourteen participants were recruited via convenience sampling from a high-performance, swimming club based in Birmingham, UK. Three participants did not complete the third trial due to illness, and as such eleven participants completed all trials (age: 17.8 ± 3.1 years; height: 1.70 ± 0.1 m; body mass: 63.3 ± 7.8 kg; n=6 male, n=5 female). As some participants were <18 years of age, informed consent was required from the participant and their guardian. Both prospective participants and guardians were provided with a copy of the participant information sheet and informed on the requirements of the study. All swimmers were completing 5–8 pool (mean volume: 48.2 ± 6.5 km/week) and 1–3 gym-based training sessions per week (mean volume: 48.2 ± 6.5 km/week) at the time of the study, with a typical weekly training schedule for the participants is presented in Table 1. Swimmers were classified as "highly-trained" or "elite" as per McKay et al. [16] classifications. Ethical approval was granted from the Birmingham City University Health, Education and Life Sciences Faculty Academic Ethics Committee before any research was conducted (approval code #11738).

Table 1 Weekly Training Schedule

	AM	PM
Monday	5500m; main set: speed	7000m; main set: threshold Land: 15 min circuit
Tuesday	Rest	6500m; main set: aerobic Land: 15 min core
Wednesday	5500m; main set: speed/kick	Rest
Thursday	Rest	8500m; main set: speed/aerobic
Friday	7000m; main set: aerobic	6000m; main set: speed push/kick
Saturday	6000m; main set: recovery Land: 45 min resistance exercise	Rest
Sunday	Rest	Rest

Study design and procedures

A double-blind randomised, placebo-controlled crossover control study was conducted, and participants were randomly assigned to either the CHO-MR, placebo, or control trials. Before the trials, anthropometric data including height (Seca Stadiometer SEC-225, Seca, Hamburg Germany) and body mass (Seca Digital Column Scale SEC-170, Seca, Hamburg, Germany) were measured.

The trial was completed in three sessions with a 1-week washout period between each trial. Trials were conducted at the same time of day, within a morning session between 05:00 – 06:00 to ensure no variances in circadian rhythm. Testing was conducted in the same swimming pool with the same lighting and layout and was familiar to participants. All group completed the same standardised warm-up outlined by the head coach. Participants were asked to refrain from alcohol and caffeine 24-hours before the trial [7]. They arrived at the trials in a fasted state, with their last meal being the evening before the trial (~8-hours) which was confirmed anecdotally prior to testing.

An overview of the experimental design is displayed in Fig. 1. Participants were familiar with all measures, warm-up procedures and the swimming protocol used for experimental testing. Baseline Felt Arousal Scale (FAS) and gastrointestinal discomfort (GI) were measured prior to testing. FAS ranging from 1 to 6 was implemented to assess arousal levels during the set. GI was measured using a 12-point scale with 0 indicating "neutral", 4 "uncomfortable", 8 "very uncomfortable" and 12 "painful" [22]. Following this, a self-selected 40-minute warm-up was completed by the participants, typically consisting of 10-minutes of land-based activity (~3-minutes skipping, ~3–5-minutes mobility, ~3–5-minutes strength exercises) followed by a progressive intensity 30-minute pool warm-up. Following the warm-up, swimmers were organised into swimming lanes ready to complete 4 × 50m maximal effort sprints in their specialist swimming stroke. Immediately following each 50m sprint, FAS, GI and ratings of perceived exertion (RPE) were measured. Time taken to complete each 50m split was recorded using a stopwatch by a trained coach with the fastest sprint and mean sprint times used for subsequent analysis. To assess fatigue, a percentage decrement score (Sdec) was used, which has been shown to be the most valid and reliable measure for quantifying fatigue in this kind of test [10]. The following formula was used:

$$\text{Sdec}\ (\%) = \left[100 \times \left(\text{total sprint}\frac{\text{time}}{\text{ideal}}\text{sprint time}\right)\right] - 100$$

where total sprint time = sum of sprint times from all sprints and ideal sprint time = number of sprints × fastest sprint time.

Supplementation

Participants were provided with a 25mL bolus in a non-transparent plastic cup containing either a 6.4% maltodextrin solution (Maltodextrin, MyProtein, UK), a taste and colour-matched placebo [1], or no liquid in the control condition. The order of conditions was randomised for each individual participant. Participants vigorously swished 25mL of the bolus around the oral cavity for 10 seconds before spitting it back into the cup. Participants were instructed on how to perform this prior to each rinsing session, and researchers counted each participant through the 10-second process. Artificial non-caloric sweeteners (FlavDrops, MyProtein, UK) were added to both solutions to ensure they were indistinguishable

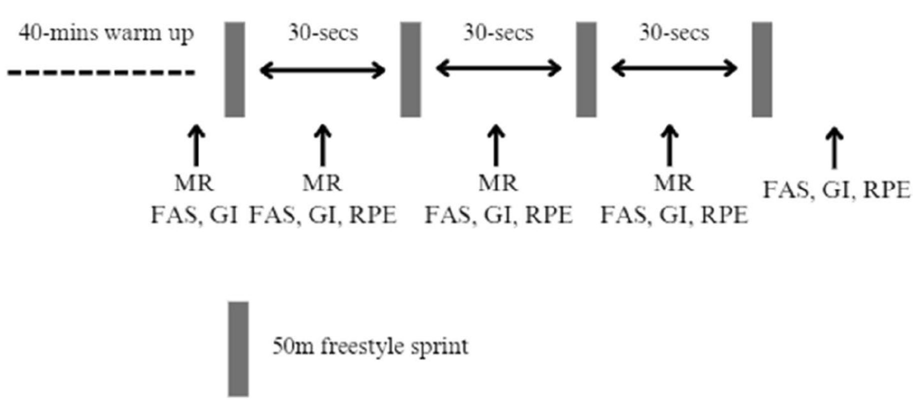

Fig. 1 Study Overview. MR: Mouth-rinse; FAS: Felt Analogue Scale; GI: Gastrointestinal discomfort; RPE: Rate of Perceived Exertion

through taste and colour [8]. The solutions were prepared by a member of the research team who was not involved with the data collection. The same investigator prepared the solutions using electronic laboratory scales and water at room temperature.

Statistical analysis

Data are reported as the mean ± the standard deviation (SD). Normality testing was conducted using Shapiro-Wilk test, with data confirmed to be parametric. A one-way analysis of variance (ANOVA) for repeated measures was applied to fastest, mean and Sdec and a two-way ANOVA with repeated measures was used for FAS, RPE and GI. Sphericity was analysed by Mauchly's test of sphericity followed by the Greenhouse-Geisser adjustment where required. When any differences were identified, post-hoc pairwise comparisons with Bonferroni correction were conducted. All data was analysed using JASP (Version 0.19.1). Confidence intervals (95%CI) and effect sizes, [partial eta squared (η_P^2)], defined as trivial (<0.01), small (0.01–0.05), moderate (0.06–0.13) or large (≥0.14), and Hedge's g defined as trivial (≤0.19), small (0.20–0.49), moderate (0.50–0.79) and large (≥0.80) (Cohen, 1992) were also calculated. The smallest worthwhile change (SWC) was used to determine individual changes in performance (0.2 * standard deviation) (Hopkins, 2004).

Results

There was no significant difference between any of the trials for fastest (CHO: 29.7 ± 3.3 s; PLA: 30.0 ± 3.2 s; CON: 29.3 ± 3.2 s; $F_{2,20}$=0.971; P=0.394; η_P^2=0.09), mean (CHO: 31.4 ± 3.0 s; PLA: 31.4 ± 2.8 s; CON: 30.8 ± 2.6 s; $F_{2,20}$=1.159; P=0.334; η_P^2=0.10, Fig. 2), total sprint time (CHO: 125.5 ± 12.2 s; PLA: 125.5 ± 11.4 s; CON: 123.3 ± 10.5 s; $F_{2,20}$=1.171; P=0.330; η_P^2=0.11) or percentage decrement score (CHO: 5.8 ± 4.2%; PLA: 4.9 ± 4.2%; CON: 5.7 ± 4.7%; $F_{2,20}$=0.137; P=0.873; η_P^2=0.01). Furthermore, there was no significant order effect for fastest ($F_{2,20}$=2.692; P=0.092; η_P^2=0.21), mean ($F_{2,20}$=2.040; P=0.156; η_P^2=0.17), total sprint time ($F_{2,20}$=2.040; P=0.156; η_P^2=0.17) or percentage decrement score ($F_{2,20}$=1.982; P=0.164; η_P^2=0.17).

Regarding subjective responses, RPE, ($F_{2,20}$=0.917; P=0.416; η_P^2=0.08), felt arousal ($F_{2,20}$=2.829; P=0.083; η_P^2 =0.22) or GI symptoms ($F_{2,20}$=0.583; P=0.568; η_P^2=0.06) were not significantly different between trials (Table 2).

Table 2 Subjective responses at rest and following every sprint during each trial. CHO: Carbohydrate; CON: Control; FAS: Felt Arousal Scale; GI: Gastrointestinal discomfort; PLA: Placebo; RPE: Rate of Perceived Exertion. Data are mean ± SD

	Rest	Sprint 1	Sprint 2	Sprint 3	Sprint 4
RPE					
CHO		7 ± 2	8 ± 1	9 ± 1	9 ± 2
PLA		8 ± 1	8 ± 1	9 ± 1	9 ± 1
CON		8 ± 1	8 ± 1	8 ± 1	9 ± 1
FAS					
CHO	2 ± 1	3 ± 1	3 ± 1	3 ± 1	3 ± 2
PLA	2 ± 1	3 ± 1	3 ± 1	3 ± 1	3 ± 2
CON	3 ± 1	3 ± 1	3 ± 1	4 ± 1	4 ± 1
GI					
CHO	3 ± 2	2 ± 3	2 ± 2	2 ± 2	2 ± 2
PLA	3 ± 2	2 ± 2	2 ± 2	2 ± 3	2 ± 3
CON	2 ± 3	2 ± 1	1 ± 1	1 ± 1	1 ± 1

Discussion

The aim of this study was to investigate the impact of CHO-MR on repeated swimming performance. The findings of this study are that this supplement strategy failed to produce any ergogenic effect, which does not support the use of CHO-MR as an ergogenic aid for short-duration high-intensity swimming. In addition, the use of CHO-MR had no influence on RPE, FAS, or GI. Based on the findings of this study, the use of CHO-MR is not supported for perceptual and/or performance benefits responses in swimming.

The findings of this study support others in varying athletic populations that have also reported no effects of CHO-MR [5, 8], and contrast with those reporting a performance benefit, despite employing a similar dose of CHO (~6%). On both a group level and individual level there was no evidence of a performance benefit. In using the SWC (0.6 seconds), only two participants improved following CHO-MR versus the placebo and control, however, three improved in the opposite direction (PLA or CON vs CHO-MR). Reasons to explain this discrepancy may be attributed to the mode of exercise, in that most studies reporting a benefit are subject to more localised muscle fatigue (e.g., bench press and cycling). The whole-body fatigue experienced in swimming may therefore negate any potential to detect a performance benefit following CHO-MR, particularly during short distance sets. It is also worth noting that no improvement in arousal was observed, which contrasts with the findings of Clarke et al. [6]. This may also explain why no effect on performance was observed. In future, studies may wish to investigate longer durations of sets to allow CHO-MR to influence performance or focus on stokes that induce more localised fatigue.

One possible explanation for the absence of an ergogenic effect of CHO-MR is possibly the mechanisms, which cause fatigue during intense activity, which may nullify any performance enhancing effects of CHO-MR

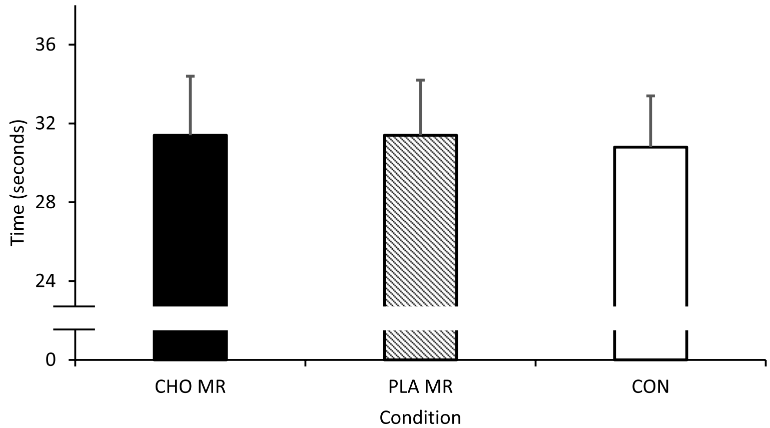

Fig. 2 Mean (and standard deviation) swimming performance following carbohydrate mouth rinse (CHO-MR), placebo (PLA), or control (CON). No significant difference between conditions (*P*=0.334).

[13]. During repeated sprints the proposed factors responsible for fatigue include limitations in energy supply such as phosphocreatine content and metabolic by-product accumulation such as inorganic phosphate [9], and these factors may have negated any ergogenic influence of the CHO-MR. Consequently, the benefits of CHO-MR effects on performance are potentially higher in exercises eliciting central more than peripheral fatigue, as the CHO centrally mediated effects could counteract fatigue-induced reductions in motor command and voluntary activation [17]. Alternatively, it could be that the requirement to rinse for 10-seconds limited the capacity to recover, as breathing would have been compromised limiting airflow, oxygen intake, ventilatory efficiency, and slower removal of CO_2 [2, 20]. Due to the short recovery in the current study (30 seconds), these effects might have limited the ergogenic effect of CHO-MR and resulted in similar performance times across all treatments. It is intuitive to suggest that future studies could use protocols with a longer recovery period to counter any initial negative effects of mouth rinsing on physiology to see an improvement.

Despite the theory that CHO-MR can increase activation of regions in the brain that influence reward [4], the closest measure employed in the current study was RPE and this revealed no change across any of the treatments. These findings are consistent with other studies investigating the effect of CHO-MR on RPE during a Loughborough Intermittent Shuttle Test [8] and a repeated-sprint cycling protocol [14]. Similarly, the current study data suggests no benefit to motor control or visual cue recognition as no ergogenic effect was observed, as in theory, benefits in these two key mechanisms for CHO-MR should have improved performance. It is worth nothing, however, that this study did not measure any of the purported mechanisms for CHO-MR in a direct way, and therefore future work should investigate this.

This study offers valuable insight into the effects of CHO-MR on swimming performance in a highly trained cohort; however, the authors do acknowledge some limitations. Performance data were collected using a stopwatch, and therefore human error may have impacted the results. Additionally, participants were not asked whether they could distinguish between the CHO-MR and placebo. Finally, due to the time testing was conducted (~5.30am) the fasted period prior to testing was likely shorter in duration than other studies, and may be subject to individual variability as participants may have consumed their evening meal at different times. Whilst this is consistent with the habitual training schedule of the population, this may have influenced the results of the study.

Conclusion

This study reports that CHO-MR had no effect on swimming performance, which questions the use of this strategy in practice. It is likely the short distance of each set and/or short duration recovery could have led to a limited window of opportunity for CHO-MR to be ergogenic, and future work should investigate longer swimming bouts and recovery windows.

Acknowledgements
The authors would like to thank the support staff who supported the collection of data, and all swimmers who participated in the study.

Authors' contributions
EB and MC conceptualisation; EB, MC, LG, JN and CJR methodology; EB, LG, JN and CJR investigation and data collection; NC and LG formal analysis; all authors; writing, review and editing. All authors approved the final version of the manuscript.

Funding
This study received no external funding.

Data availability
The dataset for this manuscript is available at https://www.open-access.bcu.ac.uk/id/eprint/16177.

Declarations

Ethics approval and consent to participate
Ethical approval was granted from the Birmingham City University Health, Education and Life Sciences Faculty Academic Ethics Committee before any research was conducted (approval code #11738).

Consent for publication
Availability of data and materials.

Competing interests
The authors declare no conflicts of interest.

Received: 18 December 2024 Accepted: 5 March 2025
Published online: 10 April 2025

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