

Ergogenic Aid Evaluation: Carbohydrate Mouth Rinse

1. INTRODUCTION

The use of nutritional ergogenic aids in sport are well-documented at enhancing performance, primarily through affecting energy metabolism or the central nervous system (Maughan, 1999). There are some non-metabolic exceptions, including carbohydrate mouth rinsing (CHO MR). Leading to significant performance improvements (~3%), it involves rinsing the mouth repeatedly with a CHO solution but not ingesting it (Chong, Guelfi and Fournier, 2011; Pires *et al.*, 2024). CHO MR has been shown to reduce central fatigue and perceived exertion (RPE) while increasing muscular endurance and power output (Brietzke *et al.*, 2024; Murray *et al.*, 2018).

The underlying mechanism behind these benefits involves oral CHO taste receptors (T1R2/T1R3) stimulating increased central drive to locomotor muscles (Carter, Jeukendrup and Jones, 2004; Nie *et al.*, 2005). Chambers, Bridge and Jones (2009) provided fMRI evidence that CHO MR activates brain regions associated with motor control, reward and pleasure. Alongside this, increased corticomotor excitability from CHO MR may further attenuate neuromuscular fatigue (Gant, Stinear and Byblow, 2010; Jeffers *et al.*, 2015). However, most literature utilises fasted participants which potentially limits ecological validity in typical sport environments (Ferreira *et al.*, 2018).

While consistently well-established for endurance exercise, CHO MR yields mixed results in high-intensity, repeated sprint ability (RSA) (Luden *et al.*, 2016). RSA performance decrements are caused by metabolite accumulation and reduced central motor drive (Girard, Mendez-Villanueva and Bishop, 2011). Since maximal sprints rely on phosphocreatine (PCr) and anaerobic glycolysis rather than exogenous CHO oxidation, CHO MR's ergogenic potential lies in its ability to act as a neural stimulus to maintain supraspinal drive during fatigue (Sahlin, 2014; Painelli, Vitor de Salles, Nicastro and Lancha, 2010; Ali *et al.*, 2017). Practically, this strategy avoids potential gastrointestinal distress associated with bolus CHO ingestion, which can be exacerbated by metabolic acidosis occurring during maximal efforts (Nieuwenhoven, Brouns and Kovacs, 2005; Ali *et al.*, 2016; de Oliveira and Burini, 2014).

The primary objective of this trial was to evaluate the effect of a 6% maltodextrin mouth rinse on RSA. Specifically, the study aimed to determine if serial rinsing attenuates peak and average power declines across 10 repetitions compared to a placebo, while assessing its impact on participants' perceived exertion (RPE).

2. METHODOLOGY

This study employed a randomised, double-blind, crossover design to compare CHO MR against a placebo (PLA) on repeated sprint performance. All participants completed two trials under the same controlled conditions, with a 1-week washout period to eliminate carry over effects.

2.1 Participants

Recreationally active university students ($n = 7$: 6M,1F, body mass = 72.4 ± 11.9 kg; age = 21.7 ± 2.1 years; height = 173.9 ± 6.9 cm) volunteered and provided informed consent. All participants were screened using a Physical Activity Readiness Questionnaire (PAR-Q) to ensure suitability for maximal exertion.

2.2 Standardisation

To minimise confounding variables, participants arrived in a fasted state (≥ 4 -hours) and avoided strenuous exercise, caffeine and alcohol for 24 hours pre-trial. Trials were conducted at the same time and location.

2.3 Protocol

Following a 5-minute standardised cycle-ergometer warm-up (RPE 3-5) using a Wattbike Pro, participants completed 10x6-second maximal wattbike sprints, each separated by 24-seconds of recovery. Resistance was set to level 7 for males and 5 for females (Borg, 1998; Wattbike Ltd).

The supplementation procedure involved a 25ml mouth rinse of CHO (6% maltodextrin) solution or PLA, swilled for 10-seconds, both drinks used a standardised electrolyte-base to ensure taste and sensory consistency. This duration was selected to ensure oral receptor activation (Painelli, Vitor de Salles, Nicastro and Lancha, 2010). Rinsing occurred twice, once prior to the first sprint and again following the fifth. Solutions were visually identical, taste-matched and double-blinded (labelled A or B).

2.4 Data Collection

Peak Power Output (PPO) (W), Mean Power Output (MPO) (W) and RPE were recorded for each repetition (Borg, 1998).

2.4 Data Analysis

Data was analysed using Statistical Package for Social Sciences (SPSS v.30.0, IBM Statistics, USA). A two-way repeated measures ANOVA was used to determine differences in PPO, MPO and RPE between the CHO and PLA condition. Where Mauchly's test indicated a violation of sphericity, degrees of freedom were corrected using Greenhouse-Geisser estimates (Blanca *et al.*, 2023). Main effects for condition and time, as well as condition*time interaction, were examined. Effect sizes were calculated using partial eta squared (η^2_p) with thresholds defined as small (0.01), medium (0.06) and large (0.14) (Levine and Hullett, 2002). Statistical significance was set at $p < 0.05$ (Tenny, 2026).

3. RESULTS

Table 1: Summary of Performance Metrics During Repeated Sprint Protocol (Mean $\pm$ SD).

Measure	Placebo (Mean $\pm$ SD)	CHO rinse (Mean $\pm$ SD)	% Difference
Peak Power (W)	713.3 $\pm$ 175.5	690.9 $\pm$ 174.6	-3.1%
Average Power (W)	556.8 $\pm$ 120.9	554.2 $\pm$ 113.8	-0.4%
Mean RPE (6-20)	14.1 $\pm$ 1	14.8 $\pm$ 0.8	2.8%

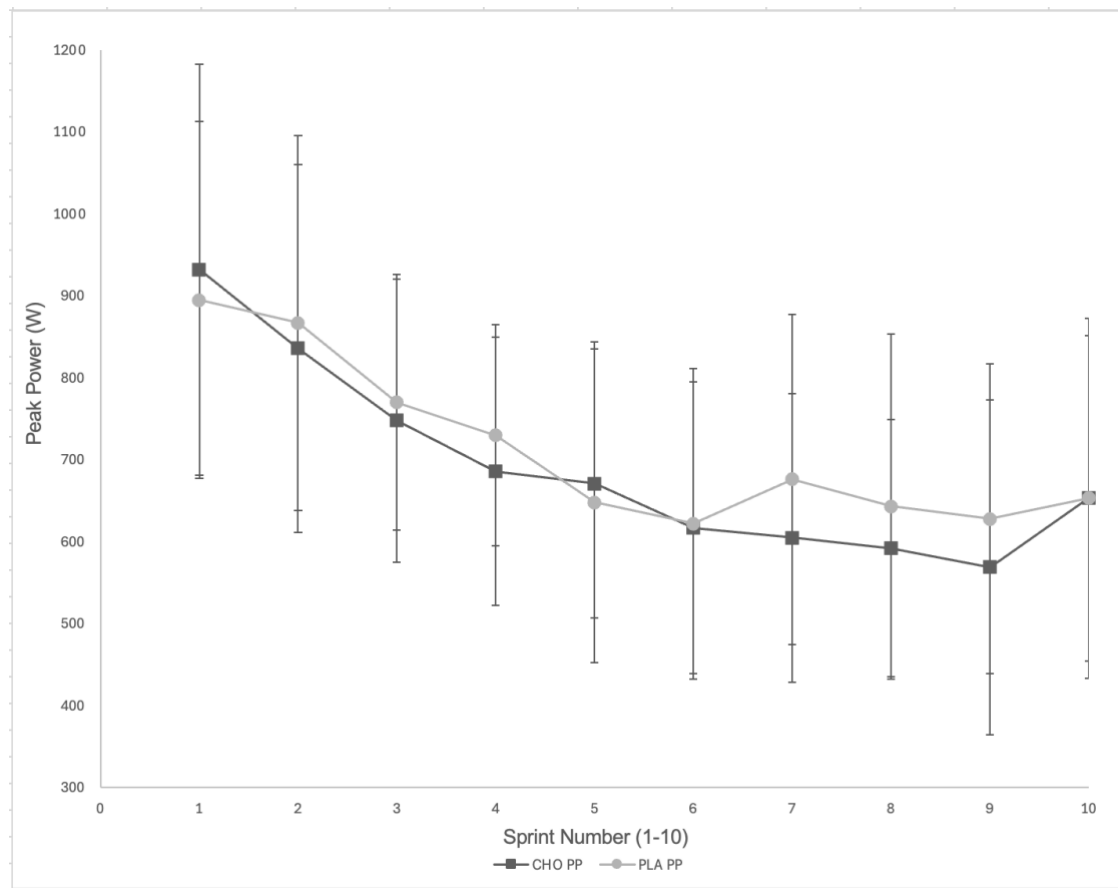


Figure 1: Mean ($\pm$ SD) Peak Power Output (W) across 10x6-second maximal sprints following CHO mouth rinse and placebo mouth rinse.

Two-way repeated measures ANOVA revealed no significant main effect of condition on peak power ($p = 0.480$, $F(1,6) = 0.568$, $\eta^2_p = 0.086$). However, a significant main effect of time was shown ($p < 0.001$, $F(1.89, 11.36) = 13.98$, $\eta^2_p = 0.700$) which indicates a clear decline in peak power across 10 repetitions. No significant condition*time interaction was observed ($p = 0.343$, $F(3.38, 20.26) = 1.18$) although a large effect size was shown ($\eta^2_p = 0.165$).

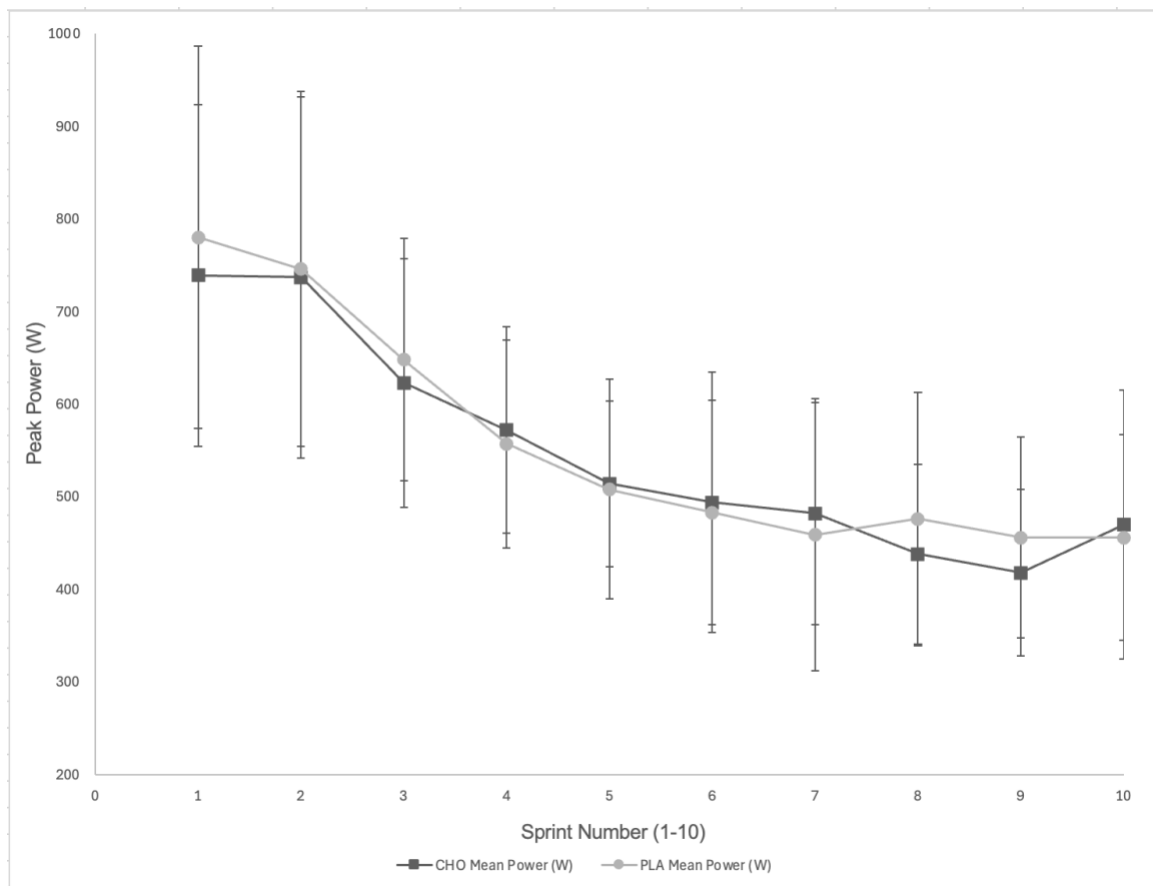


Figure 2: Mean ($\pm$ SD) Average Power Output (W) across 10x6-second maximal sprints following CHO mouth rinse and placebo mouth rinse.

For average power output, two-way repeated measures ANOVA showed no significant main effect of condition ($p = 0.437$, $F(1,6) = 0.694$, $\eta^2_p = 0.104$) or time ($p = 0.236$, $F(1.05, 6.27) = 1.733$, $\eta^2_p = 0.224$). The condition*time interaction was non-significant ($p = 0.358$, $F(1.02, 6.12) = 0.995$) but demonstrated a large effect size ($\eta^2_p = 0.142$), mirroring the trend seen in peak power output.

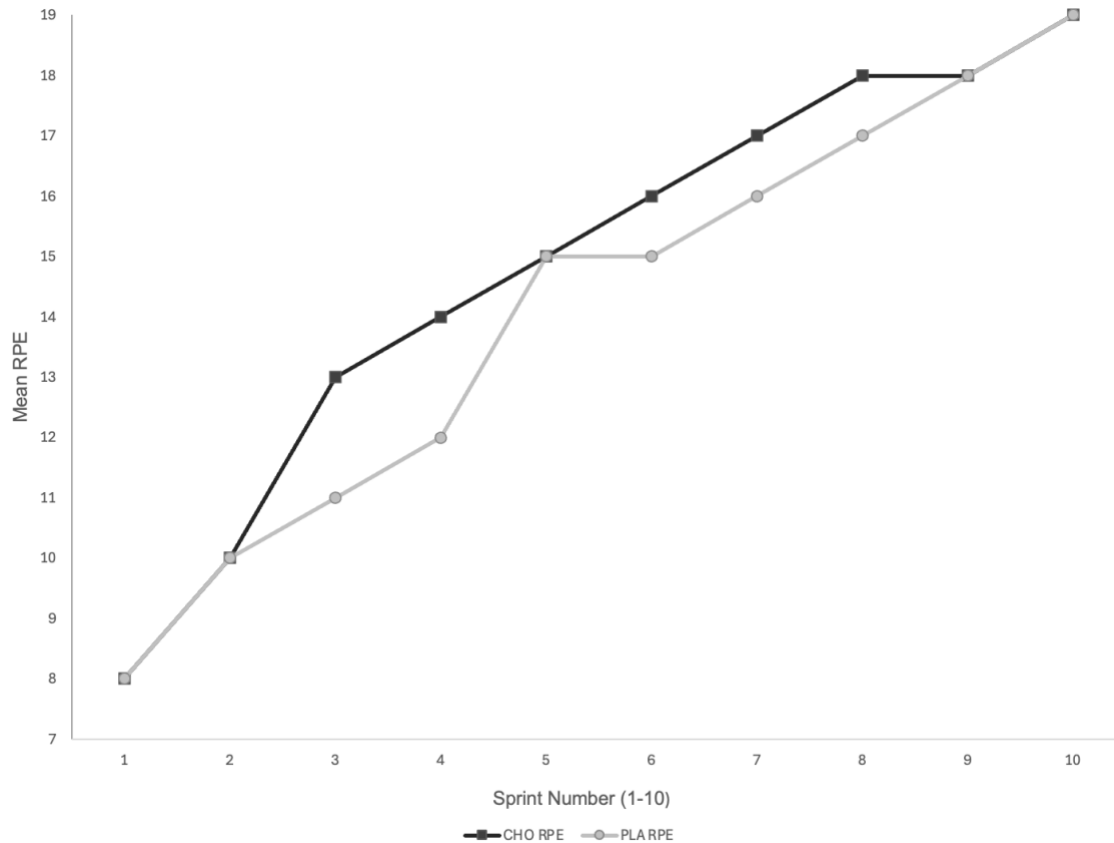


Figure 3: Mean RPE Scores across 10x6s Maximal Sprints Following CHO Mouth Rinse and PLA Mouth Rinse.

RPE scores increased progressively throughout both trials, with a two-way repeated measures ANOVA indicating a significant main effect of time ($p < 0.001$, $F(1.72, 10.33) = 68.10$, $\eta^2_p = 0.919$). A significant main effect of condition was also observed ($p = 0.048$, $F(1,6) = 6.165$) alongside a large effect size ($\eta^2_p = 0.507$). Mean RPE was consistently higher in the CHO condition compared to PLA. (Figure 3). No significant interaction of condition*time was found ($p = 0.734$, $F(2.43, 14.59) = 0.373$), supported by a small effect size ($\eta^2_p = 0.059$).

4. DISCUSSION

This study aimed to investigate the effect of mouth rinsing with a 6% maltodextrin solution on 10x6s maximal repeated sprints in fasted participants. Findings revealed a dissociation between perceptual and performance measures. While rinsing with a CHO solution

significantly increased RPE ($p=0.048$) it failed to elicit any improvements in PPO or MPO. However, individual performance improvements in three participants ($n=3$) suggest that CHO MR efficacy should be tested on an individual basis (Gough *et al.*, 2022).

Many studies have reported ergogenic benefits with CHO MR, with the prediction that CHO triggers oral cavity receptor cells and stimulates reward centres in the brain, leading to reduced perception of effort and improved motor output (Chambers, Bridge and Jones, 2009). Beaven *et al.*, (2013) reported ergogenic benefits, including increased PPO and MPO, using a similar 6s protocol, contradicting observed results in the present study. This discrepancy may be explained through differences in total workload volume and rinsing frequency. Beaven *et al.*, (2013) utilised only 5 sprints, whereas the current 10-sprint protocol may have introduced cumulative metabolic and respiratory fatigue that decreased the efficacy of CHO MR (Dorling and Earnest, 2013).

Furthermore, Beaven administered rinses prior to every sprint (5 rinses, 5 sprints), whereas the present study rinsed only before sprint 1 and 6 (2 rinses, 10 sprints). This suggests CHO MR may require frequent dosing to maintain a heightened central drive and achieve ergogenic effects (Small *et al.*, 2007; Rollo *et al.*, 2010; Painelli, 2011). The reward stimulus may have attenuated between rinses in the current study, potentially leaving most sprints without ergogenic effect (Matsumoto, 2013; Suen *et al.*, 2025; Pires *et al.*, 2024). Consequently, the intermittent rinsing in the current study may have been insufficient for maintaining the sustained neurological stimulus required for power output enhancements in repeated sprints.

Despite group-level non-significance ($n=7$), three participants ($n=3$) improved power output under the CHO condition. This variability is characteristic of CHO MR research and may be influenced by participants fasted or fed state (Painelli, 2022; Deng *et al.*, 2025). Although fasting typically increases oral receptor sensitivity, this limited group of responders suggests that inter-individual differences, such as receptor sensitivity and density, might determine the level of ergogenic response (Hartley *et al.*, 2024; Haase, Cerf-Ducastel and Murphy, 2009; Malik *et al.*, 2008). For these participants, rinsing at sprint 1 and 5 provided a sufficient stimulus to improve performance, reinforcing the recommendation by Gough *et al.*, (2022) for personalised, dose-response protocols.

The lack of ergogenic effect may be linked to the specific fatigue aetiology associated with the mode of exercise chosen (Pires *et al.*, 2024). Tomazin, Morin and Millet (2017) demonstrated that repeated sprint cycling is primarily limited by peripheral factors (metabolic byproduct accumulation and impaired muscle contraction), whereas central fatigue is more prominent in running. Given that CHO MR is a centrally-mediated intervention, its effectiveness may be

dependent on the amount of central fatigue present (Chambers, Bridge and Jones, 2009; Black *et al.*, 2018). In the current protocol, the 'reward' stimulus from oral CHO sensing may have been insufficient to overcome peripheral exhaustion (Tomazin, Morin and Millet, 2017). This may further explain the dissociation between significantly elevated RPE ($p = 0.048$) and lack of performance enhancement, as the muscles may have reached a 'physical ceiling' while the brain perceived a higher level of stress.

Repeated sprint performance research suggests that accumulated metabolic fatigue may overrule CHO MR's ergogenic influence. Physiological factors occurring during high-intensity exercise, including phosphocreatine (PCr) depletion and intramuscular phosphate accumulation, generates inhibitory signals to the central nervous system (Dorling and Earnest, 2013; Reilly, Drust and Clarke, 2008; Bogdanis *et al.*, 1996). Jeukendrup and Chambers (2010) suggested these mechanisms of fatigue may nullify subtle reward stimuli sensed by oral receptors, explaining why power output failed to improve despite a large effect size ($\eta^2_p = 0.165$, $\eta^2_p = 0.142$). Consequently, metabolic fatigue from maximal sprinting may desensitise brain reward centres to a CHO stimulus, further explaining the dissociation between power output and significantly elevated RPE ($p = 0.048$) (Tornero-Aguilera *et al.*, 2022).

Methodological limitations must be considered when interpreting the current findings. A small sample size ($n = 7$) reduced the statistical power of the study and increased the risk of type II error, where large effect sizes ($\eta^2_p = 0.142-0.165$) were insufficient to reach statistical significance (Knudson and Lindsey, 2014). The absence of a familiarisation session likely introduced 'learning effects' and technical variability between the two trials, potentially masking any subtle ergogenic benefits (Hopker *et al.*, 2009; Capriotti, Sherman and Lamb, 1999). Furthermore, the primarily male, recreationally active participants limits generalisability. Future research should prioritise female populations and investigate hormonal variations throughout the menstrual cycle which may affect responses to CHO MR (Helm, McGinnis and Basu, 2021). Effects should also be investigated in elite athletes who may present with enhanced central efficiency and altered responses to CHO MR (Deng *et al.*, 2025; Suen *et al.*, 2025).

Perfect sensory matching for 6% maltodextrin solution is difficult, potential unblinding may have introduced 'nocebo' and expectancy effects, contributing to the significantly elevated RPE ($p = 0.048$) (Gough *et al.*, 2022). Future research should include supplement detection questionnaires to verify blinding efficacy (Gough *et al.*, 2022; Planès, Villier and Mallaret, 2016; Shabir *et al.*, 2018). Additionally, the requirement to rinse for 10s within a short recovery window of 26s imposed a respiratory and cognitive burden, potentially explaining the lack of

power output improvement (Gam, Guelfi and Fournier, 2013). This is evident when compared to lower-volume protocols where performance enhancements were recorded, but the level of cumulative ventilatory distress would likely be less (Beaven *et al.*, 2013). Future research should investigate alternative delivery formats, such as atomised sprays, and optimise rinse timing towards the end of recovery periods when heart rate and breathing have further stabilised (Shirai *et al.*, 2022).

5. ETHICAL CONSIDERATIONS AND CONCLUSION

This study evaluated the effect of a 6% maltodextrin mouth rinse during a 10x6-second repeated sprint protocol. Results demonstrated a dissociation between performance and perception of effort, where CHO MR failed to significantly enhance PPO ($p = 0.480$) or MPO ($p = 0.437$) yet significantly increased RPE ($p = 0.048$). Despite the lack of statistical significance, the large effect sizes observed in the condition* time interaction (PPO $\eta^2_p = 0.165$; MPO $\eta^2_p = 0.142$) suggests a potentially meaningful, but inconsistent, impact on power output. Individual responders ($n = 3$) highlight that ergogenic benefits may depend on individual characteristics such as receptor sensitivity (Hartley *et al.*, 2022).

The lack of performance gain may be due to the peripheral nature of sprint-cycling fatigue, which appears to overrule the centrally-mediated 'reward' stimulus from oral CHO sensing (Tomazin, Morin and Millet, 2017). Furthermore, the increased RPE in the CHO condition suggests that in higher volume protocols the distraction and respiratory burden of rinsing may outweigh subtle benefits. Practically, CHO MR may not be the primary recommendation for short duration maximal sprints due to risks of increased respiratory distress and elevated RPE without guaranteed performance enhancements (Gam, Guelfi and Fournier, 2013). However, it remains a strategy to be explored for athletes prone to GI discomfort, as maltodextrin complies with World Anti-Doping Agency (WADA) regulations, making it an ethical and non-invasive ergogenic aid to use (WADA, 2026). Future research should investigate alternative delivery methods, such as atomised spray, to minimise distraction while further exploring individual responses to CHO MR. (Shirai *et al.*, 2022; Gough *et al.*, 2022).

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