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PERFORMANCE BENEFITS OF CARBONATED CARBOHYDRATE MOUTH RINSE

Muhammad Adi Asymawi Aminuddin, Ahmad Dzulkarnain Ismail[1], Harris Kamal Kamaruddin[*]

Faculty of Sport Science and Recreation, Universiti Teknologi MARA (UiTM), Arau 02600 Perlis Malaysia

Corresponding: Harris Kamal Kamaruddin, Email: harris540@uitm.edu.my

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ABSTRACT

A significant amount of research has been done on the benefits of consuming carbohydrates while exercising, especially for longer workouts when endogenous glucose levels are low. Consuming carbonated carbohydrates has the important effect of postponing exhaustion by preventing the body from using up its essential energy supply for activity. It is common knowledge among athletes that impact on the mouth's oral receptors by causing sharpness and acidity could give sensation to the mouthfeel. However, given the nature of the running, for example availability of fluids, it may be difficult for athletes to rehydrate in a true race situation. Carbohydrate mouth rinsing has been shown to improve extended exercise performance as an alternative to drinking. The fundamental process behind this enhancement has been linked to the stimulation of the brain behavioural centre and oral receptor, which both boost exercise performance and are related to rewards. The efficacy of carbohydrate mouth rinsing has been the subject of several investigations. Even though the results of these trials give strong support for the theory, more research is needed to light on the impact of carbohydrate mouth rinsing on prolonged exercise performance. These concerns include how the carbonated carbohydrate drinks could affect how well mouth rinsing with carbohydrates works for endurance activity.

Keywords: carbohydrate solution, carbonated, mouth rinse, exercise, performance

INTRODUCTION

Exercise performance and mouth rinsing with carbohydrates (CHO) have been related (MR). In a novel study, Carter et al., (2004) investigated the effects of CHO MR on cycling performance and discovered that, in comparison to water, the CHO MR intervention produced a notably faster cycling time trial. The scientists proposed that there is a specific class of oral receptors in the mouth that detects the calorie content of CHO solutions and triggers the activation of brain regions associated with motivation and motor control right away. (Carter et al., 2004). Furthermore, a functional magnetic resonance imaging (fMRI) (Chambers et al., 2009) study showed that CHO MR improved neural activation networks by stimulating the insula, striatum, dorsolateral prefrontal cortex (DLPFC) (Turner et al., 2014), and anterior cingulate cortex, which are regions of the brain linked to motor control, motivation, and reward. This study has confirmed that the presence of CHO in the mouth triggered a neural activation to the brain that may influence motor output. Since then, a number of studies have demonstrated that enhanced performance with CHO MR was more likely to be linked to perceived motivation, reward, and central drive (Durkin et al., 2021; Gavel et al., 2021; Kamaruddin et al., 2019; Luden et al., 2016; Takeuchi et al., 2020).

Additionally, CHO MR appears to have demonstrated that CHO rinse is more successful in lowering fatigue and improving performance when CHO is lacking (Beaven et al., 2013). CHO MR also can be utilised to improve performance by activating chemoreceptors and thermoreceptors, which raises brain activity levels overall (Durkin et al., 2021). Effect of CHO MR were rather than blood glucose levels fluctuating as the mechanisms controlling the ergogenic action of glucose ingestion/rinsing take place, it is more likely that aspartame-insensitive glucose-finding cells in the GI tract, including the mouth cavity, would be activated. (Chong et al., 2014). With the discovery that glucose in the mouth increases pituitary brain activity. Furthermore, data from functional magnetic resonance imaging (fMRI) studies indicate that although beverages containing CHO and artificially sweetened beverages activate similar brain taste pathways, especially in the frontal operculum/anterior insula, CHO elicits a stronger response and engages brain regions densely populated with dopaminergic neurons, such as the nucleus accumbent, ventral tegmental area, and striatum. These findings might help to explain studies that show that just gargling with CHO in the mouth helps improve a number of prolonged exercise-related symptoms (Watson et al., 2014). To guarantee high-quality recordings, electromyography (EMG) equipment standardisation is crucial. The 1999 IFCN Guidelines have been updated and expanded upon in this consensus report on "Standards of Instrumentation of EMG" (Tankisi et al., 2020).

A study by Ataide-silva et al., (2016), investigate the effects of a CHO (CHO) mouth rinse on cycling performance, fuel oxidation rates, and neuromuscular activity at varying starting endogenous CHO availability levels. This study looked at how different initial levels of endogenous CHO availability, which were controlled by prior fasting and exercise, affected neuromuscular activity (EMG), metabolic responses (plasma glucose and lactate, fat and CHO oxidation rates), and exercise performance when using CHO mouth rinse. Therefore, as a result showed the continuous load exercise went on, the plasma glucose levels were maintained higher by the CHO mouth rinse. CHO mouthwash improved the decreased EMG activity during continuous load exercise in the combined exercise-depleted muscle glycogen condition with the placebo. Additionally, in the combined exercise-depleted muscle glycogen condition with placebo, power output and EMG activity during sustained exercise were decreased however, both were recovered with CHO mouth rinse. When natural CHO availability is insufficient exercise performance is impacted by the CHO mouth rinse and the most significant influencing mechanism may be an enhanced central motor drive (Ataide-silva et al., 2016).

Furthermore, it was shown that the subjective, behavioural, and electrophysiological effects can be neutralised by combining solutions, such as a series of MR methods using maltodextrin and caffeine (Cutsem et al., 2017) or glucose and maltodextrin (Evans et al., 2021). However, the carbonated type of solution still remains unexplored.

MECHANISTIC IMPROVEMENT OF MOUTH RINSE

The term "mouthfeel" describes the range of tactile or physical feelings that are connected to different meals and drinks in the mouth. Similar to taste and smell, mouthfeel influences the flavour of food (Simons et al., 2019). Carbonated solutions are created when carbon dioxide (CO_2) and acidity are in balance. This can have an impact on the mouth's oral receptors by causing sharpness and acidity (Steen et al., 2016). According to study by Steen et al., (2016) some drinks are made sharper or more acidic by adding organic acids like malic or citric acid. Given that carbonated water contains CO_2 gas at a significantly higher pressure, CO_2 bubbles have the power to activate mechanosensitive neurons (Takeuchi et al., 2020). After carbonic anhydrase activity reduces CO_2 to carbonic acid, the tongue reacts with the carbonic acid, causing a trigeminal feeling or oral irritation (Barker et al., 2021). Numerous research conducted since then have shown the impact of the carbonated review on workout performance. (Murray et al., 1987; Zachwieja et al., 1992).

Based on previous study, it has been shown that consuming CHO during exercise enhances performance, even at high intensities (>75% VO_{2max}) and for a short amount of time (1~hr). Similar performance gains have been demonstrated by rinses containing CHO. This suggests that the advantages of consuming CHO when exercising may extend beyond their usual metabolic benefit and might potentially act as a positive afferent signal that may influence motor activity (Jeukendrup et al., 2010). Another study by Carter et al., (2004) investigate that oral receptors have an impact on the way a person performs during cycling. The results show that using a mouth rinse containing CHO improves performance during a one-hour time trial. Rather than having a metabolic basis, the mechanism behind the improvement in high-intensity exercise performance with exogenous CHO appears to include an increase in cerebral drive or want to achieve. Long-term exercise and resistance training tests conducted by MR also looked at whether regular CHO rinses may improve neuromuscular performance during taxing, high-intensity contractions (Bazzucchi et al., 2017). Based on investigation by Bazzucchi et al., (2017), indicates that by rinsing CHO, reduce the neuromuscular decline in performance caused on by tiredness resulting from intense isokinetic exercise. Rinsing with CHO-containing liquids, both sweet and non-sweet, can enhance neuromuscular function during an isokinetic intermittent fatigue test. In summary, unidentified receptors in the mouth cavity detect CHO, and this has been connected to benefits in exercise performance (Jeukendrup et al., 2010).

CENTRAL RESPONSE ACTIVATION

The advantages of C-CHO MR during exercise were positively influenced by the ergogenic CHO solution. The mechanism underlying this effect is probably connected to the sharp sensitivity of the oral receptors for thirst and brain activity, which are closely tied to elevated levels of self-arousal and motivation in prolonged exercise (Kamaruddin et al., 2019). The exertion of ergogenic effects on CHO MR was demonstrated by the fMRI, which was employed to assess the activation of brain areas, via stimulation of mouth receptors and activation of certain neural pathways (Chambers et al., 2009; Salle et al., 2013). Studies utilising functional magnetic resonance imaging are commonly employed to investigate activation effects in subject populations (Beckmann et al., 2003). In previous study also showed that during physical exercise, oral glucose signalling can boost activation of neural networks involved in sensory perception and increase activation within the primary sensorimotor cortex (Turner et al., 2014). According to research on exercise, the taste of CHO stimulates brain areas that can improve an individual's ability to complete an activity. Oral exposure to glucose activated reward-related brain areas, such as the striatum and anterior cingulate cortex, which were not sensitive to the sugar, according to the associated fMRI investigation (Chambers et al., 2009). The results of the study demonstrated that the presence of CHO in the mouth activates an exclusive energy signalling pathway that can enhance human performance. Furthermore, it may be discovered that rinsing a sweeter fluid with a greater caloric content may cause the insula/liontal operculum and DLPC to expand.

Despite following consumption of bitter mouth rinses is probably necessary to boost performance, oral exposure to both bitter tasting and caffeine may have an ergogenic effect on endurance performance, which is because MR with CHO appears to improve endurance performance (Best et al., 2020). CHO mouth rinse improves neuromuscular recruitment during a given whole body exercise task when training begins with decreased endogenous CHO availability, according to the results report, which build on past studies (Ataide-Silva et al., 2016). Based on Ataide-Silva et al., (2016), examine the effects of various early amounts of endogenous CHO availability on neuromuscular activity, fuel oxidation rates, and cycling performance while examining the mouth rinse response to CHO. Therefore, CHO and fat oxidation rates were computed, and EMG activity was recorded. When paired with exercise depletion, there is a significant increase in the EMG amplitude and a corresponding rise in power output with CHO mouth rinse. This confirms that the CHO mouth rise procedure is more effective the more CHO reserves are reduced. During the 20-kilometer time trial, the combined exercise-depleted condition with placebo resulted in a reduction in power production and EMG activity. Yet these parameters were recovered after using CHO mouth rinse. This study shown that when endogenous CHO availability is limited, CHO mouth rinse affects exercise performance. The primary influencing mechanism could involve an increased central motor drive (Ataide-Silva et al., 2016). It is also possible, as suggested by earlier research (Jeukendrup et al., 2010), that during physical activity, the positive central responses to an oral CHO stimulus could balance out the negative physical, metabolic, and thermal sensations coming from joints, muscles, and core temperature receptors. These signals could either consciously or unconsciously lead to central fatigue and an inhibition of motor drive to the exercising muscles. Thus, the favourable benefits of a CHO mouth rinsing on exercise performance may have a molecular explanation because it has been observed that many of these higher brain areas are activated by oral CHO rather than non-nutritive sweeteners (Chambers et al., 2010).

Based study from Gam et al., (2016) some mechanisms were administered using a combined mouth rinse and ingestion protocol to activate as many throughout the oral cavity, soft palate, epiglottis, and upper oesophagus as possible Because there is evidence that the greatest concentration of T2Rs and the taste of bitterness occur at the back of the tongue and oral cavity. In addition, taste gave the signals have the potential to alter the corticomotor pathway by activating a number of brain locations, also in previous study from Gam et al., (2015) said that ergogenic impact was attributed to brain activation by sensory taste signals rather than a metabolic or hormonal action brought on by the gut absorption of the CHO. The sprint was conducted right after CHO mouth rinsed. The chemogenic nature of the tongue irritation caused by carbonated water is independently confirmed by this evidence. The current observations are consistent with the theory that carbonated water stimulates lingual nociceptors by a mechanism that is dependent on carbonic anhydrase, which in turn stimulates neurons in Vc that are most likely involved in signalling feelings of oral irritation (Simons et al., 1999).

FACTORS AFFECTING THE EFFECTIVENESS OF MOUTH RINSE

DURATION OF RINSING

According to Sinclair et al., (2014) and 10 seconds of mouth rinse with 6.4 percent CHO affected 30 minutes of self-selected cycling performance have significant differences. The study revealed that the distance cycled during the 10-second mouth rinse trial was much greater than that observed for PLA trials. There was no difference between the 5 and 10 second trials. However, ten out of eleven subjects cycled further in the 5 seconds trial than in the PLA, and eight cycled further in the 10 seconds trial than in the 5 seconds trial. Sinclair et al. (2014) observed that, despite the improvement in distance cycled in the 5 seconds trial when compared to PLA (Taylor, et al., 2015), it was only significant with 10 seconds, implying a dosage response to MR time.

Improvement in exercise performance with 10 seconds of mouth rinsed inspired other researchers to use this method in their research (Chambers et al., 2009a; Fraga et al., 2015; Lane et al., 2013; Rollo et al., 2015). Although (Sinclair et al., 2014) finding encourages the usage of 10 seconds MR length during a 30-minute cycling event, this may be difficult for a race that requires a greater breathing rate. During a high-intensity event, MR for 5 seconds proved to be a more practical method than 10 seconds, as breathing could be interrupted while rinsing the solution around the mouth (Sinclair et al., 2014). As a result, many researchers have maintained to use a 5 second MR duration in their research (Carter et al., 2004; Che Muhamed et al., 2014; Jeffers et al., 2015; Rollo et al., 2011; Whitham & McKinney et al., 2007).

FED AND FASTED STATUS

However, the efficacy of CHO MR in fasted or fed states may not be significant regulation in improving exercise performance. Whitham and McKinney et al., (2007) found that CHO MR had no ergogenic impact on those who fasted overnight after time-trial running, however Pottier et al., (2010) found that CHO MR improved performance despite a meal 2 hours before exercise. Indeed, three research investigated the effects of fed and fasted states on exercise performance using CHO mouth rinse (Fares & Kayser et al., 2011; Lane et al., 2013; Trommelen et al., 2015). There was a significant improvement effect on TTE at 60% maximal workload in both fed and fasted modes, with 3.5 and 11.6 percent performance increase, respectively (Lane et al., 2013; Trommelen et al., 2015). According to Lane et al., (2013) discovered a similar result when they investigated fed and fasted athletes after a 1 hour cycling time-trial performance with maltodextrin and PLA. Both circumstances claimed performance advantages. However, the extent of improvement was much greater among those who fasted (3.3%) than among those who fed (1.8%). A subsequent study, however, found no benefit of CHO mouth rinse in both fasted and fed stages after a 1-hour cycling time trial (Trommelen et al., 2015). The pre-prandial state part is predicted to have a significant impact on exercise performance with CHO MR, as studies have shown that the effect of CHO MR is greatest when fasted versus fed (Lane et al., 2013). CHO mouth rinse has no effect on power output during glycogen-reduced cycling (Trommelen et al., 2015).

The difference between the reported positive and zero effect of CHO mouth rinse on high-intensity exercise endurance is controlled by the pre-exercise meal. A several of research found that starting exercise after an overnight fast was beneficial (Chambers et al., 2009; Che Muhamed et al., 2014; Rollo et al., 2008). or to remain post-prandial for up to 4 hours (Carter et al., 2004; Rollo et al., 2011). One reason for the failure of research to detect the ergogenic effect of CHO mouth rinse is that patients received a CHO pre-meal 2 - 3 hours before exercise (Beelen et al., 2009). Comparable findings have also indicated that CHO feeding had no influence on high-intensity running and cycle exercises after consuming a CHO-rich lunch hours before the events (Desbrow et al., 2004; Rollo & Williams, 2010).

The influence of a pre-exercise fasting interval is likely to modify the brain response to an oral stimulus. Following an overnight fast (12 hours) and the intake of a 700-kcal liquid meal, the CHO solutions exposed in the mouth appeared to elicit cerebral reactions (Haase et al., 2009). When compared to the post-prandial state, there was increased activity in brain regions such as the ventral striatum, amygdala, and hypothalamus following a prolonged fast (Haase et al., 2009). These cerebral responses are capable of influencing motor output, which may be affected by pre-exercise nutritional status.

HEAT STRESS ENVIRONMENT

The effect of CHO mouth rinse on endurance exercise performance in a heat stress condition has not been well studied. Che Muhamed et al., (2014) discovered no difference in power output between CHO-e and PLA mouth rinse during 10 km time-trial cycling in heat stress conditions (32 °C and 75% relative humidity). When compared to the no-rinse condition, MR with either CHO or PLA solution had ergogenic benefits. Similarly, Watson et al., (2014) discovered that CHO mouth rinse did not improve time-trial cycling performance under a hot stress situation of 30 °C, while Cramer et al., (2015) found that performance remained stable throughout 40 km of self-paced cycling in the heat (35°C and 60% relative humidity). As a result, time and mean power output were similar in the CHO and PLA trials, suggesting that CHO MR did not improve 1 hr trial performance in hot and humid conditions (Cramer et al., 2015).

The explanation for the reduced efficiency of CHO mouth rinse on performance in a hot setting has not been determined (Watson et al., 2014). Heat stress may mask or overpower signals from CHO receptors in the mouth, dampening any potential benefit in performance (Watson et al., 2014). Another argument is that the high level of heat and cardiovascular strain, especially near the end of the time trial, may have completely eliminated any potential ergogenic benefit of CHO MR (Cramer et al., 2015).

A study by Kamaruddin et al., (2023) determine of CHO mouth rinse improved tropical natives' endurance running performance in a warm-humid (30°C and 70% relative humidity) environment. Twelve endurance male runners went through three time-to-exhaustion (TTE) trials at 70% VO_{2max} while swilling 25 ml of a 6% CHO (CHO) or taste-matched placebo (PLA) mouth rinse, as well as no mouth rinse in the control (CON) trial. The current study investigated the effect of CHO MR on running endurance in a warm-humid environment among dehydrated and heat acclimated tropical native runners. The key finding is that, regardless of solution type (CHO or PLA), MR enhanced TTE running performance when compared to no rinsing. However, rinsing a CHO solution had no ergogenic benefit when compared to a placebo solution (Kamaruddin et al., 2023).

CARBONATED SOLUTION AS POTENTIAL MOUTH RINSING

Soft drinks are frequently made to taste like fruit, especially orange or lemon, or like spices and herbs, such in cola drinks. A balanced mixture of sweetness and astringency will form the base flavour, and flavour and colour will be added to provide the desired product attributes. To improve the keeping quality, ingredients like preservatives and antioxidants may be added characteristics of the goods (Ashurst & Ashurst et al., 2016).

As the sparkling drink was substantially more popular than the non-carbonated (NC-CHO) drink, the carbonation did increase consumer psychological preference for the taste. As a evidence from Barker et al., (2021) that study find out how they perceive fruit juices carbonated beverages on a sensory and emotional level. Thus, consumers' preference for the taste was enhanced by the carbonation since they preferred the sparkling juice much more than the NC-CHO beverage. All tastes had better mouthfeels when they were carbonated, and the sparkling beverages had much better mouthfeels than their NC-CHO counterparts (Barker et al., 2021). However, carbonated beverage still does not discover towards psychological mentality in enhancing prolonged exercise. The fluid that has been swallowed is only retained in the mouth cavity for a brief period of time before moving into the oesophagus and stomach.

The human circulatory system is subject to significant regulatory demands during prolonged exercise in hot conditions because blood volume must meet demands for both blood flow to working muscles and the thermoregulatory effector mechanisms of increased circulation to the skin and sweating (Hickey et al., 1994). In fact, a variety of substances included in food, drink, and spice blends have the ability to chemically activate nerve fibre receptors that transmit heat, burning, chilling, tingling, or touch sensations (Simons et al., 2019).

Before packing, carbon dioxide (CO_2) gas must be pumped into the liquid product in order to create a carbonated beverage. The gas dissolves quickly in water, with its soluble content rising as the temperature decreases. Products get their characteristic sharp and acidic taste from the carbonic acid that is produced when CO_2 is dissolved in water. Soft drinks are usually designed to give the user a flavour of fruit, like lemon or orange, or herbs and spices, like in cola. A well-balanced combination of sweetness and sharpness will be the underlying flavour, with additional flavour and colour added to fulfil the specifications for the product. Preservatives and antioxidants are examples of ingredients that can be added to improve a product's keeping power (Steen et al., 2016). The mouthfeel and pleasure of liquids, especially soft drinks, are enhanced by the tingling feeling that is often associated with carbonated drinks (Simons et al., 2019). Carbonated water converts CO2 to carbonic acid, which stimulates the lingual nociceptor. Trigeminal neurons, which are involved in signalling oral irritation, are also stimulated by the ingestion of carbonated water in a way that requires based on carbonic anhydrase (Dessirier et al., 2000). Previous investigation by Zachwieja et al., (1992) carbonated increases in heart rate and VO^2 during a 15-minute performance bike were indicative of increased effort expended when fizzy drink was added to CHO. A prior study that employed both single and multiple timepoints of ingestion shown that the consumption of carbonated beverages might improve muscle endurance after receiving sodium bicarbonate. Thus, the beverage has a stimulating effect and a mildly acidic taste when consumed slowly. The many components and physical characteristics of carbonated beverages might alter these perceptions. Cooler liquids produce the most pleasant taste response, albeit this is subject to individual variation. The temperature of the beverage also affects how it tastes (Cuomo et al., 2009). The tingling sensation associated with carbonated beverages is highly desired and contributes to the mouthfeel and enjoyment of beverages such as beer, champagne, and soft drinks. Carbonation has recently been shown to improve the thirst-quenching properties of water (Simons et al., 2019). In previous preview also said that, (Simons et al., 2019) the tingle sensation associated with carbonated beverages is frequently misattributed to the bursting of CO_2 bubbles on oral tissues, which results in the activation of tactile pathways.

Previous studies has found that the majority of existing evidence have focused on the immediate effects of carbonated water on swallowing performance, which may be brought on by thermal, chemogenic, or mechanical stimulation (CO_2 bubbles) in the water (Takeuchi et al., 2020). According to Dhaka et al., (2006) All of these stimulation modalities open large cation channels on peripheral neurons to directly activate transient receptor potential vanilloid-1 (TRPV1) channels (Takeuchi et al., 2020) and revealed that citric acid significantly outperformed sucrose in its ability to facilitate spontaneous swallowing (Pelletier & Lawless et al., 2003; Takeuchi et al., 2020). However, if this neutralising impact of acidic taste or urea on acids could be a factor in the physiological anti-caries advantages. By raising blood bicarbonate concentration, a buffer that can support maintaining extracellular and intracellular pH, sodium bicarbonate causes ergogenic effects. Acute sodium bicarbonate ingestion has been the subject of several meta-analyses that looked at how it affected different aspects of exercise performance (such as single and repeated sprint performance and intermittent exercise performance), but none of these meta-analyses specifically looked at the results of muscular strength or muscular endurance (Grgic et al., 2020). This finding is relevant to research on satiety and food choice. The brain's overall processing of signals linked to sweetness, particularly those derived from sucrose, decreased when carbonation was present. The combination of CO2 and sucrose may enhance the consumption of sucrose, although these findings may be suitable for dietary programmes that include noncaloric drink (Salle et al., 2013).

CONCLUSION

In recent years, there has been an increase in the practise of using CHO MR to enhance endurance exercise performance. This is based on a large body of scientific evidence showing that rinsing a CHO solution activates brain areas connected to reward and pleasure perception, which in turn increases the desire to exercise. It is also suggested that CHO MR be used instead of fluids to reduce the risk of gastrointestinal issues while exercising. Therefore, among amateur and skilled athletes, the practise of CHO MR continues to grow in popularity.

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