Volume: 8 Issues: 53 [June, 2023] pp. 33 - 47
Journal of Islamic, Social, Economics and Development (JISED)
eISSN: 0128-1755
Journal website: www.jised.com
DOI: 10.55573/JISED.085304

THE FACTORS INFLUENCE ON THE INTERVENTION OF CARBOHYDRATE MOUTH RINSE IMPROVING ENDURANCE PERFORMANCE: A SYSTEMATIC REVIEW

Nadia Md Noor[1]
Al Hafiz Abu Bakar[2]*
Harris Kamal Kamaruddin[3]
Ahmad Dzulkarnain Ismail[4]
Ellail Ain Mohd Aznan[5]

[1]Faculty of Sports Science and Recreation, Universiti Teknologi MARA, Cawangan Perlis, Kampus Arau, 02600 Arau, Perlis, Malaysia, (E-mail: nadiamdnoor04@gmail.com)
[2]Faculty of Sports Science and Recreation, Universiti Teknologi MARA, Cawangan Perlis, Kampus Arau, 02600 Arau, Perlis, Malaysia, (E-mail: alhafizab@uitm.edu.my)
[3]Faculty of Sports Science and Recreation, Universiti Teknologi MARA, Cawangan Perlis, Kampus Arau, 02600 Arau, Perlis, Malaysia, (E-mail: harris540@uitm.edu.my)
[4]Faculty of Sports Science and Recreation, Universiti Teknologi MARA, Cawangan Perlis, Kampus Arau, 02600 Arau, Perlis, Malaysia, (E-mail: ahmad409@uitm.edu.my)
[5]Faculty of Sports Science and Recreation, Universiti Teknologi MARA, Cawangan Perlis, Kampus Arau, 02600 Arau, Perlis, Malaysia, (E-mail: ellailain@uitm.edu.my)

Article history

Received date	**:**	18-3-2023
Revised date	**:**	19-3-2023
Accepted date	**:**	10-5-2023
Published date	**:**	15-6-2023

To cite this document:
Md Noor, N., Abu Bakar, A. H., Kamaruddin, H. K., Ismail, A. D., & Mohd Aznan, E. A. (2023). The Factors Influence on The Intervention of Carbohydrate Mouth Rinse Improving Endurance Performance: A Systematic Review. *Journal of Islamic, Social, Economics and Development (JISED)*, 8 (53), 33 - 47.

***Abstract:** The ergogenic effects of carbohydrate (CHO) mouth rinse on exercise performance have been well-documented. A unique energy signalling pathway that can increase exercise effectiveness by stimulating different brain areas linked to reward, motivational, and motor control behaviour has been extensively cited as the mechanism underpinning CHO mouth rinse. There is, however, a paucity of research carefully reviewing the variables that affect the effectiveness of CHO mouth rinse. Therefore, the purpose of the study is to provide systematically review on the factors influence CHO mouth rinse on endurance performance. A systematic review was carried out by using online database (Google scholar and Scopus), as well as perhaps a conference proceeding related papers, were reviewed. Thirty-three related studies with CHO mouth rinse have been screened, however only 28 studies that eligibility accepted for reviewed in qualitative synthesis. The findings observed three main factors which criteria of athlete, intervention and concentration that influenced CHO mouth rinse during endurance exercise performance. Base from the review, the suitable criteria of participant that can be used as intervention experiment were elite and trained athlete. When considering the exercise routine, both cycling and running can be employed as an intervention for CHO mouth rinse as long as the speed and wattage modification are automated. While 6-6.4% of concentration in CHO shown a good enough to enhance exercise performance. Analyses all three factors that been reviewed can improved and provide a better idea for future experimental study of CHO mouth rinse.*

Volume: 8 Issues: 53 [June, 2023] pp. 33 - 47
Journal of Islamic, Social, Economics and Development (JISED)
eISSN: 0128-1755
Journal website: www.jised.com
DOI: 10.55573/JISED.085304

Keywords: *Carbohydrate, Mouth Rinse, Mouth Wash, Endurance Performance, Brain Activation*

Introduction

Carbohydrate (CHO) is the main source of energy during prolonged exercise by delaying fatigue and allowing an athlete to compete at higher levels for longer time (Janet Walberg-Rankin., 1996; Rollo & William., 2010; Jeukendrup et al., 2013; Muhamad et al., 2020). Mainly, CHO ingestion has been stated as a substrate for fuel metabolism during exercise and enhancing endurance capacity (Jeukendrup., 2011). CHO ingestion are assumed to include regulating blood glucose levels, CHO oxidation rates and protecting the liver and muscle glycogen (Jeukendrup et al., 2013). Few studies reported that ingestion of CHO before, during or after exercise may cause stomach upset and shown to impair exercise performance (Berkulo et al., 2016; Hawkins, Krishnan, Ringos, Garcia, & Cooper, 2017; Walsh, Noakes, Hawley, & Dennis, 1994). Since CHO was not swallowed during mouth rinse, this could be a decent technique and alternative for athlete to enhance athletic performance without causing gastrointestinal discomfort during exercise.

Over the past few years, CHO mouth rinse had shown the positive effect and revealed as a recent intervention to improve time trial of exercise either using cycling or running (Carter et al., 2004b; Chambers et al., 2009; Che Muhamed et al., 2014; Lane et al., 2013; Pottier et al., 2010; Sinclair et al., 2014) and distance covered during endurance exercise (Fraga et al., 2015; Rollo et al., 2010; Wright & Davison, 2013). The mechanism behind CHO mouth rinse has been widely supported by a novel energy mechanism that can enhance exercise efficiency by triggering brain and activating various regions associated to reward, motivational and motor control behaviour (Turner et al., 2014). Study by Chamber et al. (2009) reported that the mouth rinse containing glucose (sweet) and maltodextrin (non-sweet) can improve the performance compared to artificial sweetener. They also found five important brain regions activated during CHO mouth rinses which were insula/frontal operculum, dorsolateral prefrontal cortex (DLPC), orbitofrontal cortex, striatum and anterior cingulate cortex associated to reward, motivational and motor control behaviour. To date, there only several studies looking on systematic review of CHO mouth rinse in endurance performance (eSilva et al., 2014; Brietzke et al., 2018). Both studies are being explain general factors and result in simple terms. However, the study looking several factors which are the criteria of athletes, exercise protocol and concentration of CHO used to influence in specific terms using CHO mouth rinse in endurance performance remain unclear. In spite lack of review in factors that influence CHO mouth rinse on endurance performance, to close, the intention of this study is to review the factors influence CHO mouth rinse on endurance performance.

Methodology

Search Strategy

In a well-organized and transparent process, a systematic review aims to systematically discover, search, and synthesize literature linked to previous studies or research, utilizing replicable procedure at each step. A systematic review may be known as a meta-narrative review or a mixed studies review (Wong, Greenhalgh, Westhorp, Buckingham, & Pawson, 2013). This method allows for the evaluation of a variety of research designs in a single exercise (qualitative and quantitative). These reviews might include research of various designs and concepts (Wong et al., 2013). It is also significant to the researchers' claims, as it promotes research accuracy and help in the identifying of gaps, trends, and needed directions for future study.

Resources

Google Scholar and Scopus, two major reference databases (Table 1), were used for this review. These two of databases are regarded as the most significant citation indexing systems. Google scholar is a literature scientific citation that can available been accessed for all people who search the citation research while Scopus comprises of a wide range of topic areas and document formats, including scientific journals, books, and conference proceedings, among others. The main function of these databases, it has been chosen to review great quality of research paper.

Table 1: Keywords and Search Strings

Databases	Keywords used
Scopus	TITLE-ABS-KEY (("CHO mouth rinse*" OR "mouth rinse*" OR "mouth rinses*" OR "CHO rinses "OR "carbohydrate mouth rinse*" AND ("endurance" OR "endurance performance" OR "exercise"))
Google scholar	Carbohydrate mouth rinse, CHO mouth rinse, endurance performance

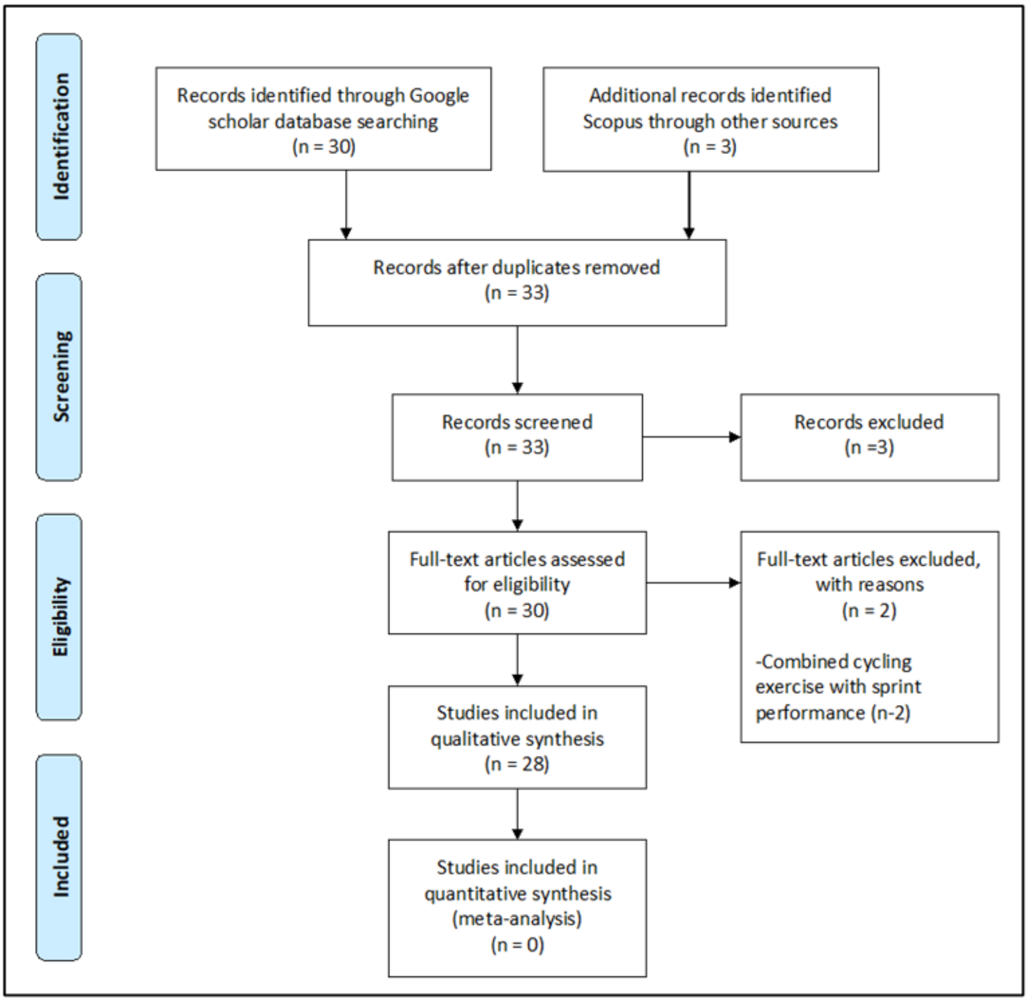

Figure 1.1: PRISMA Flow Diagram of The Study Selection Process (Page et al., 2021)

Volume: 8 Issues: 53 [June, 2023] pp. 33 - 47
Journal of Islamic, Social, Economics and Development (JISED)
eISSN: 0128-1755
Journal website: www.jised.com
DOI: 10.55573/JISED.085304

Systematic Review Process (Identification)

Figure 1.1 show the PRISMA flow diagram of the study selection process. Identification is the first step in the systematic review. The procedure included identifying keywords in Scopus used CHO mouth rinse, mouth rinse, mouth rinses, CHO rinses, carbohydrate mouth rinse, endurance and endurance performance, while for google scholar the keywords used carbohydrate mouth rinse, CHO mouth rinse and endurance performance for the purpose of searching for information (Table 1). By suing dictionaries and keywords from previous research, it was easier to put keywords in Google Scholar as well as other relevant information sources to find the related journal. There were 30 documents found from Google Scholar and 3 documents from Scopus databases as a consequence of this review research. The process consists of few steps which read research abstracts and study, second is check for duplication, thirds is read the papers thoroughly and lastly simply having two independent researchers check for exclusion criteria and double-check the reference lists.

Screening Process (Inclusion and Exclusion)

This is the process which some journals need to exclude based on the criteria established by the writers with the help of particular databases (Table 2). In this stage, eligible, inclusion and exclusion were focused to main access publications include in the systematic review process. All journal has been chosen from 2004-2019 and studies that uses CHO mouth rinse on endurance performance. While non-English language document and combine endurance with sprint performance has been excluded as criteria on this systematic review. Type of exercise as non-aerobic also been excluded in this review.

Table 2: The Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Year	Between 2004-2019	<2004
Document Type	Article Journals, Review articles	Books, chapter in books, conference proceedings
Language	English	Non-English
Type of exercise	Aerobic	Non-aerobic

Data Extraction Process

The data were conducted independently by two researchers. It also been review as extracted data process such as title, type of publications from original journal or review, data of journal (authors, year publication) and design and methods that been used on the studies such as criteria has been uses in study criteria of athlete, concentration of CHO used, intervention, (cycling or running), and main results in the study. For main results, the data will be taken using final result in mean either in min, distance or using power output. All this data will be shown the significant result of the study either have improvement or not in percentage.

Data Analysis

In this systematic review, the current study used mean and standard deviation as final results (time to complete or distance covered with different solutions) in percentage either result in power output, minutes or duration. Since studies that uses minutes has been the most often reported result, an overall mean difference analysis was conducted using mean minutes rather

Volume: 8 Issues: 53 [June, 2023] pp. 33 - 47
Journal of Islamic, Social, Economics and Development (JISED)
eISSN: 0128-1755
Journal website: www.jised.com
DOI: 10.55573/JISED.085304

than other indicator like time to completion for a given distance or task, time to fatigue, or power output as 1-hour time trial.

Results

Performing a preliminary database search, there are only a few journals that been chosen and met the criteria on this systematic review. Twenty-eight studies have been chosen from 33 studies. The factors and main findings can been review from previous studies are in Table 3.

Volume: 8 Issues: 53 [June, 2023] pp. 33 - 47
Journal of Islamic, Social, Economics and Development (JISED)
eISSN: 0128-1755
Journal website: www.jised.com
DOI: 10.55573/JISED.085304

Table 3: Summary of The Studies Investigating the Factors of Carbohydrate Mouth Rinse on Performance During Exercise

Authors	Criteria of athletes	Intervention	Concentration of CHO used	Main results (mean ± SD)	Result / significant of performance
Carter et al., 2004	7 male & 2 female endurance-trained	Cycling Time-trial ~1 hr	6.4% MALT (maltodextrin) vs. WA (Water)	Power output (W) (MALT) 259 ± 16 W vs (PLA) 252 ± 16 W	Yes (+) significant for 2.7% with CHO vs WA
Whitham & McKinney, 2007	7 male recreational athletes	Running time trial 45 min	6% MALT (maltodextrin-97% polysaccharide, 2% disaccharide, 1% glucose + 3% lemon juice) vs. PLA (3% lemon juice)	Distance (m) (CHO) 9333 ± 988 vs. (PLA) 9309 ± 993	Ns (-) for 0.26% with CHO vs PLA
Rollo et al., 2008	10 endurance-trained men	30 min treadmill run	6% CHO (glucose solution vs Placebo (taste-matched placebo)	Distance (m) (CHO) 6584 ±520 vs. (PLA) 6469 ± 515	Yes (+) significant for 1.78% with CHO
Chambers et al., 2009	8 male recreational cyclists	Cycling ~75% Wmax	1) 6.4% CHO (glucose) vs. PLA (saccharin) 2) 6.4% MALT (maltodextrin + saccharin and aspartame) vs. PLA (saccharin)	1) Time (min) (CHO) 60.4 ± 3.7 vs. (PLA) 61.6 ± 3.8 2) Time (min) (MALT) 62.6 ± 4.7 vs. (PLA) 64.6 ± 4.9	1) Yes (+) significant for 1.99% with GLU vs PLA 2) Yes (+) significant 3.19% with MALT vs PLA
Beelen et al., 2009	14 male endurance-trained cyclists	Cycling Time-trial ~1 hr	6.4% MALT (maltodextrin) vs. PLA (Water)	Power output (W) (MALT) 265 ± 5 vs. (PLA) 266 ± 5 W	Ns (-) for 0.37% with CHO vs PLA
Rollo et al., 2010	20 male endurance trained runners	Running Time-trial ~1-hr ~60% VO2max	6.4% CHO-E (CHO-electrolyte beverage) vs. PLA (a color tasted-matched placebo)	Distance (m) (CHO) 14298 ± 685 vs. (PLA) 14086 ± 732	Yes (+) significant for 1.50% with CHO vs PLA
Pottier et al., 2010	12 endurance-trained triathletes	Cycling Time-trial ~1 hr	6% CHO-E (100-ml isotonic CES) vs. PLA (aspartame)	Power output (W) (CHO-E) 265 ± 30.6 vs (PLA) 256.5 ± 34.3W)	Yes (+) significant for 3.20% with CHO vs PLA
Rollo & Williams, 2011	10 endurance-trained male runners	Running Time-trial ~1-hr ~60% VO2max	1) 4% CHO-E (mouth rinse without intake) vs. PLA (artificial sweetener -aspartame) (mouth rinse + intake)	1) Distance (m) (CHO-E + without intake) 14283 ± 758 vs. (PLA) 14190 ± 800 2) Distance (m)	1) Ns (-) for 0.65% with CHO-E + without intake vs PLA

Volume: 8 Issues: 53 [June, 2023] pp. 33 - 47
Journal of Islamic, Social, Economics and Development (JISED)
eISSN: 0128-1755
Journal website: www.jised.com
DOI: 10.55573/JISED.085304

			2) 6.4% CHO-E (mouth rinse + intake) vs. PLA (artificial sweetener - aspartame) (mouth rinse + intake)	(CHO-E + intake) 14515 ± 756 vs. (PLA) 14190 ± 800	2) Yes (+) significant for 2.29% with CHO-E + intake vs PLA
Fares & Kayser, 2011	13 healthy non-athletic males	Cycling ~60% Wmax	1) 6.4% CHOFS (maltodextrin) vs. PLAFS (water) 2) 6.4% FCHO (maltodextrin) vs. FPLA (water)	1) Time (min) (CHOFS) 56.6 ± 12.2 vs. (PLAFS) 54.7 ± 11.3 2) Time (min) (FCHO) 53.9 ± 12.8 vs. (FPLA) 48.3 ± 15.3	1) Yes (+) for 3.47% with CHOFS vs PLAFS 2) Yes (+) significant for 11.59% with FCHO vs FPLA
Lane et al., 2013	12 competitive male cyclists	Cycling time trial ~1-hr	10% MALTFS (maltodextrin) vs. PLAFS (placebo)	Power output (W) Fast Stated 1) (MALTS) 286 ± 6 W vs. (PLA) 281 ± 5 Power output (W) Fed Stated 2) MALTS) 282 ± 6 W vs. (PLA) 273 ± 6 W	1) Yes (+) significant for 1.8% with MALTFS vs PLA in fast stated 2) Yes (+) significant 3.4% with MALTS vs PLA in fed stated
Wright & Davison, 2013	7 active male university students	90 min treadmill running	Placebo, 6% or 12% CHO-E, (maltodextrin 95%, dextrose, 3% and maltose 2%) vs PLA (saccharin)	Distance (m) (CHO-E trials 6%) 14.6 ± 1.7 km; (CHO-E 12%) 14.9 ± 1.6 km vs (PLA) 13.9 ± 1.7 km	Yes (+) significant for 4.79% with CHO-E vs PLA
Gam et al., 2013	10 male cyclists	Cycling Time-trial ~1 hr	6.4 % CHO (maltodextrin) or Water (WA) or No solution (CON)	Power output (W) (CHO) 250 ± 9.50 W and (WA) 254 ± 11.19 W than in (CON) 258. ± 9.69 W	Yes (+) significant for 1.57% with CHO vs WA
Sinclair et al., 2014	11 healthy active male reactional cyclists	30 min cycling time trial	6.4% MALT (maltodextrin) vs. PLA (water bolus)	1) Power Output (W) -5s (MALT 153 ± 17 vs. (PLA) 146 ± 13 2) Power Output (W) -10s (MALT) 156 ± 17 vs. (PLA) 146 ± 13	1) Yes (+) significant for 4.34% rinse 5 s with CHO vs PLA 2) Yes (+) significant for 6.36% rinse for 10 s with CHO vs PLA

Volume: 8 Issues: 53 [June, 2023] pp. 33 - 47
Journal of Islamic, Social, Economics and Development (JISED)
eISSN: 0128-1755
Journal website: www.jised.com
DOI: 10.55573/JISED.085304

Che Muhamed et al., 2014	9 trained adolescent male cyclists	Preloading cycle at 65% rate of oxygen consumption	6% CHO electrolyte beverage (Gatorade, PepsiCo, Chicago) or PMR (aspartame)	Time (min) (CMR) 12.9 ± 1.7 and (PMR) 12.6 ±1.7 vs. (NOR) 16.8 ± 1.6 min	Yes (+) significant for 23.21% with CMR vs NOR
Ara & Uckworth, 2015	7 trained male cyclists	1-hr simulated cycling time trial	Non-CHO placebo (aspartame) and 4, 6, and 8% CHO solutions (sucrose & glucose)	Power output (W) (0%, 4%, 6%, 8%) 251± 28, 248± 28, 246 ± 31, and 247 ± 33 *W*	Ns (-) for 1.19% with non-CHO placebo vs CHO
Kulaksiz et al., 2016	9 recreational active males	20 km cycling time trial	3, 6, 12 % MD solution (maltodextrin) or PLA (placebo + aspartame)	Time (min) (3, 6, 12 % MD) 40.2 ± 4.0 40.1 ± 3.9, 40.1 ± 4.4, and (PLA) 39.3 ± 4.2 min	Ns (-) for 1.99% with MD vs PLA
Devenney et al., 2016	12 recreational active males	Cycling Time-trial ~1 hr	6% and 16% CHO (maltodextrin) vs PLA	Power Output (W) (6% CHO) 174 ± 20 W vs (16% CHO) 163 ± 23 W and (PLA) 177 ± 23W	Yes (+) significant for 1.69% with CHO vs PLA
Clarke et al., 2016	15 healthy males	5 km running time trial	0, 3, 6, or 12% (Maltodextrin with water and energy-free sweetener)	Time (min) (0% CHO) 26:34 ±4:07min:s; (3% CHO) 27:17 ±4:33min:s; (6% CHO) 27:05 ±3:52min:s; (12% CHO) 26:47 ± 4.31min:s	Ns (-) for 3% with 0%, 3%, 6% or 12% CHO
Fraga et al., 2017	6 endurance trained male	Time to exhaustion on treadmill	8% CHO solution (dextrose) or a non-caloric sweetener (PLA) & 6% CHO solution to ingest (ING)	Distance (m) (MR) 2583 ± 686 s (ING) 2625 ± 804 s (PLA) 1935 ± 809 s	Yes (+) significant for 1.6% with CHO vs PLA
Ali et al., 2017	9 moderately trained male cyclist	Cycling ~75% Wmax	15% CHO (CHOR), 7.5% (CHOI), Placebo mouth rinse; aspartame (PLAR), Placebo ingestion; aspartame (PLAI)	Time (min) (CHOI) 65.3 ± 4.8 min; (CHOR) 68.4 ± 3.9 min; (PLAI) 68.7 ± 5.3 min; (PLAR) 68.3 ± 5.2 min	Yes (+) significant for 3.46% with CHOI vs CHOR, PLAR, PLAI
Kamaruddin et al., 2017	12 male endurance-trained runners	Time to exhaustion on treadmill	6% CHO (glucose) vs PLA (Placebo; sucralose, Diabetasol)	Time (min) (CHO) 81.2 ± 4.1 min vs (PLA) 76.8 ± 3.9 min	Yes (+) significant for 5.6% with CHO vs PLA

Volume: 8 Issues: 53 [June, 2023] pp. 33 - 47
Journal of Islamic, Social, Economics and Development (JISED)
eISSN: 0128-1755
Journal website: www.jised.com
DOI: 10.55573/JISED.085304

James et al., 2017	11 competitive male cyclists	Cycling ~75% Wmax	7 %, 14% CHO (maltodextrin) vs PLA (fruit juice)	Time (min) (7% CHO) 57.3 ± 4.5 min (14% CHO) 57.4 ± 4.1 min vs (PLA) 59.5 ± 4.9 min	Yes (+) significant for 3.69% with CHO vs PLA
Murray et al., 2018	8 male athletes	40 km cycling time-trial	6.4% CHO (glucose), vs PLA (water solution)	Time (min) (CHO) 67.1 ± 1.1 min vs (PLA) 67.9 ± 1.0 min	Yes (+) significant for 1.1% with CHO vs PLA
Bataineh et al.,2018	18 sub-elite male runners	Time to exhaustion on treadmill	7.5% CHO (Sucrose), PLA (a flavour and taste matched placebo solution), no rinse (CON)	Time (min) (CHO) 1282.0 ± 121.3 s; (PLA) 1258.1 ± 113.4 s; (CON) 1228.7 ± 98.5 s;	Yes (+) significant for 1.86% with CHO vs PLA
Ferreira et al., 2018	11 trained male cyclists	30 km cycle ergometer	6% CHO (unflavoured maltodextrin solution) vs PMR (Placebo mouth rinse) vs DAL (Drinking "ad libitum)	Time (min) (CMR) 54.5 ± 2.9 min (PMR) 54.7 ± 2.9 min (DAL) 54.5 ± 2.5 min	Ns (-) for 0.3% with CMR vs PMR
Bavaresco Gambassi et al., 2019	21 physically active healthy men	Cycling exercise until volitional exhaustion	6.4% MRCS (maltodextrin) vs 0% PLA	Time (min) (CONT) 43.0 ± 27.5min (PLA) 57.4 ± 30.6min (MRCS) 70.9 ± 30.3 min	Yes (+) significant for 19.0% with MRCS vs PLA
Baltazar-Martins & Del Coso, 2019	16 well trained male cyclists	Cycle ergometer (25.3 km)	6.4% CHO (carbohydrate concentration) vs PLA (Sports Drink zero)	Power output (W) (PLA) 238 ± 46 vs (CHO) 248 ± 47w	Yes (+) significant for 4.0% with CHO vs PLA
Kamaruddin et al., 2019	12 well-trained male runners	Time to exhaustion on treadmill	6% CHO (glucose) vs PLA (artificial sweeteners; Sucralose, Diabetasol)	Time (min) (CHO) 78.2 ± 4.3 vs. (PLA) 76.9 ± 3.8 min	Yes (+) significant for 3–5% with CHO vs PLA

Note **GLU —glucose; MALT —maltodextrin; CHO —carbohydrate; PLA —placebo; WA-water; CHO-E —electrolyte carbohydrate solution; Ns—non-significant; CHOFS—carbohydrate rinse in fasted state; PLAFS—placebo in fasted state; FCHO—carbohydrate rinse in fed state; FPLA—placebo in fed state; MALTFS—maltodextrin rinse in fed state; FMALT—maltodextrin rinse in fast state; PLAFS—placebo in fed state; FPLA—placebo in fed state; MRCS—mouth rinse carbohydrate solution.

Discussions

The objectives of this review were to analyze the factors that influence CHO mouth rinse on endurance performance. The current study revealed 28 studies investigating the effect of CHO mouth rinse on endurance exercise performance. Most of the studies found that mouth rinses with glucose and maltodextrin enhancing endurance exercise performance. Carter et al. (2004b), conducted the first experiment on CHO mouth rinse, finding that exercise performance was improved when rinsing with CHO rather than ingesting. The ergogenic action of CHO mouth rinse does not appear to be due to its absorption, as it has been observed that CHO mouth rinse does not cause changes in blood glucose levels. The mechanism of CHO mouth rinse shows brain part activation in insula/frontal operculum, orbitofrontal cortex, and striatum (Chambers et al., 2009). While Bakar et al. (2017), proved that using high caloric content and sweeter, which is glucose has been shown to activate a larger magnitude of the insula/frontal operculum region of the brain. Based on Table 3, three main factors that influenced CHO mouth rinse on endurance performance which are the criteria of athletes, intervention and concentration of CHO. Based on the current study finding, 21 of the studies showed significant in result of endurance performance, while 7 other studies did not show any significant in endurance performance (Whitham & Mckinney, 2007; Beelen et al, 2009; Rollo & Williams, 2011; Ara & Uckworth, 2015; Kulaksiz et al, 2016; Clarke et al, 2016; Ferreira et al, 2018).

Criteria of Athletes

Most of the studies of CHO mouth rinse had been used recreational athlete, well trained runners and elite athlete male as their main criteria of the experiment. It been showed 20 studies used elite and trained athletes as their criteria of athletes and 3 of the studies did not show any positive result probably due to the fed state condition (Beelen et al., 2009; Ara & Uckworth., 2015; Ferreira et al., 2018) compare with another 20 studies that used fasted state that shown positive result. While 8 studies used recreational athlete for the criteria in endurance performance and 3 studies did not show any positive result (Whitham & Mckinney., 2007; Kulaksiz et al., 2016; Clarke et al., 2016). Whitham & Mckinney, (2017) employed a manually adjusted treadmill during exercise testing, which could have an impact on an athlete's performance during the trial. While study from Kulaksiz et al. (2016) and Clarke et al. (2016) did not show any improvement because of they used different concentration for their mouth rinse protocol. According to the data, elite or trained athletes were more frequently used for cycling or running rather than recreational athletes. However, utilising recreational athletes is also feasible because they can cope the exercise routine (Murray et al., 2018). It had been demonstrated that an athlete's degree of fitness was crucial for obtaining an experiment's meaningful results. It can be concluded that, because of physiological variables, used elite or trained athletes perform better than recreational athletes. In comparison to recreational athletes that are able to maintain and sustain the endurance protocol, it has been demonstrated that elite and trained athletes have larger stroke volumes, left ventricular masses, and left ventricular wall thickness (Degens, Hans, et al. 2019).

Intervention

The majority of research results in current finding have used cycling as an experiment intervention rather than running. The intervention of cycling been used in study which 17 studies used cycling time trial and only 1 study used cycling until volitional exhaustion protocol. 14 studies showed significant in result by using cycling as an intervention. While 4 of the studies did not shown significant in cycling exercise (Beelen et al., 2009; Ara & Uckworth., 2015; Kulaksiz et al., 2016; Ferreira et al., 2018). Studies by Chambers et al. (2009); Ali et al. (2017); James et al. (2017), used 75% Wmax cycling time trial as the intervention of the experiment and as a result of the athlete cycling under the strain that was applied to the programme, the results improved. Similar to this, Fares & Kayser (2011) used 60% of their cycling's Wmax as an intervention and saw an improvement in their results. While, study by Bavaresco Gambassi et al. (2019) showed the positive result in cycling until volitional exhaustion.

However, several studies included a running intervention in their research, including 4 other studies that employed the protocol for running till exhaustion and 6 studies that used the running time trial methodology. As a result, 8 out of 10 studies had positive findings, although two of them found no appreciable improvement in the running exercise (Whitham & Mckinney., 2007; Clarke et al., 2016). A 2007 study by Whitham and Mckinney found no increase and no evidence of improvement in time trial running. Unfortunately, this had drawbacks because the runners could manually adjust the speed of their treadmill and had direct control over it. It might impact how people feel throughout exercise. Meanwhile, study from Rollo et al. (2010), used self-selected speed where used treadmill belt and it shown positive result. Besides, study by Fraga et al. (2015); Kamaruddin et al. (2017); Baitaneh et al. (2018); Kamaruddin et al. (2019), also had been shown significant improvement in time to exhaustion on treadmill. Though solely in terms of physiological changes, time to exhaustion is incompatible with genuine mimics like competition (Kamaruddin et al., 2019).

The results showed that cycling time trials produced better results than either time trials or running till exhaustion. While in cycling, the advantage to perform appears to be achieved by reducing the power output during time trial, the running protocol can be improved by increasing self-selected running tempo during CHO mouth rinsing (Rollo et al., 2010). Runners usually sustain their self-selected running pace for most of the time trial, then sprint towards the ending. It can be concluded that, using cycling time trial as intervention was shown a positive result between running performance in CHO mouth rinse study because the protocol had been used same as actual mimics in competition with CHO mouth rinse while exercise. But study for running still needed in future by protocol from Rollo et al. (2010), which uses treadmill belt with automated treadmill in running protocol. However, the intervention of exercise depends on purpose of the study.

Concentration of CHO Used

The findings studies on cycling and running exercise used glucose and maltodextrin as their concentration CHO mouth rinse either 20–25 mL of 6%, 6.4%, 7%, 8%, 10% and 12%. Most trials utilized CHO mouth rinse with a 6% or 6.4% concentration, and they found that it significantly improved exercise performance. While study by Whitman & Mckinney. (2007), Beelen et al. (2009) and Ferreira et al. (2018) did not show any improvement in concentration that been used in 6-6.4% of CHO mouth rinse. It was thought that the technique utilized in both trials was inappropriate because it required the runners to manually adjust the treadmill's speed, which could have an impact on the primary finding.

Although some research improved their results with concentrations of 8% and 10% of CHO mouth rinse, Wright & Davison's study in 2013 found that 6.4% was sufficient to produce a noticeable improvement in activity. In contrary, Kulaksiz et al. (2016) found no significant differences in exercise while using 50 mL of 3%, 6%, or 12% of CHO mouth rinse in a 20 km cycling time trial comparing PLA that contain aspartame. They postulated that this was because a 50 mL bolus was used to increase the contact between a CHO source and the CHO sensing receptors in the mouth without lengthening the rinsing duration, which has been associated with disrupting respiration rhythm and, as a result, reducing exercise power output. Similar to a study by Clarke et al. (2016), which used varied concentrations of CHO (0, 3, 6, or 12%) but found no significant changes from a caloric placebo because it might not be beneficial due to the intervention of exercise that less than 30 minutes.

Chamber et al. (2009) found that both CHO mouth rinses (glucose and maltodextrin) boosted exercise performance because both solutions include calories and sweets (or flavourless maltodextrin) that trigger the brain activities. When rinsed in a higher calorie of CHO, there was more activation in the brain region (Chamber et al, 2009; Bakar et al, 2017). But both of the studies only do in fMRI study but not in the performance trial. However, only study by fMRI shown positive result in brain activation that trigger in insula/frontal operculum, orbitofrontal cortex and striatum using high caloric of CHO (Bakar et al., 2017). But there is no data reported on using 18% of CHO concentration to show positive result in exercise performance. Additionally, mouth rinse with a 6.4% maltodextrin solution was demonstrated to improve whole-body, moderate-intensity exercise performance and maintained electromyographic activity (Bastos-Silva et al., 2016). It can be concluded that most studies have employed 6–6.4% of CHO mouth rinse as their main concentration, either glucose, maltodextrin, or sucrose, and it was good enough to improve performance. However, other researchers believe that using a mouth rinse with a higher concentration will result in a larger saturation of the oral receptors, which will then stimulate the reward pathway more strongly for performance changes (Chamber et al. 2009, Turner, 2014).

Conclusion

CHO mouth rinse would be advantageous and helpful to coaches, athletes, or any organization in providing a potent technique for mouth rinse to form for athletes during competition or activity. To sum-up, the study has reviewed the variables that affect CHO mouth rinse performance in endurance sports. All these factors such as criteria of athlete, intervention and concentration of CHO used were being connected to influence the result of experiment. Elite or trained athletes are suitable for the criterion of an athlete due to physiological variables. Besides, intervention of exercise also has been important factors that will make significance result in the experiment either cycling or running that suitable with the subject. In addition, concentration of CHO can also influence of the exercise because of the caloric either concentration of CHO. Thus, the findings suggest other researchers to observe and learn more about factors such as criteria that suitable of subject, intervention and concentration that can uses in their future study. By enhancing the elements that have been discussed, CHO mouth rinse can boost endurance performance. Future studies on the effects of CHO mouth rinse on endurance performance can use this review as the basis for their research.

References

Abu Bakar, A. H., Mat Isa, S., Mohd Rasli, M. H., Shuaib, I. L., Singh, R., Derbyshire, S., Che Muhamed, A. M. (2017). The effects of varying level of glucose and fructose on brain activation during mouth rinse. *International Conference on Movement Health and Exercise*, *58*, 111– 116. https://doi.org/10.1186/s12970-016-0161-8

Ali, A., Moss, C., Yoo, M. J. Y., Wilkinson, A., & Breier, B. H. (2017). Effect mouth rinsing and ingestion of carbohydrate solutions on mood and perceptual responses during exercise. *Journal of the International Society of Sports Nutrition*, *14*(1), 1–10. https://doi.org/10.1186/s12970-016-0161-8

Baltazar-Martins, G., & Del Coso, J. (2019). Carbohydrate mouth rinse decreases time to complete a simulated cycling time trial. *Frontiers in Nutrition*, *6*(May), 1–8.

https://doi.org/10.3389/fnut.2019.00065

Bataineh, M. F., Al-Nawaiseh, A. M., Abu Altaieb, M. H., Bellar, D. M., Hindawi, O. S., & Judge, L. W. (2018). Impact of carbohydrate mouth rinsing on time to exhaustion during Ramadan: A randomized controlled trial in Jordanian men. *European Journal of Sport Science*, *18*(3), 357–366. https://doi.org/10.1080/17461391.2017.1420236

Bavaresco Gambassi, B., Gomes de Santana Barros Leal, Y., Pinheiro Dos Anjos, E. R., Antonelli, B. A., Gomes Gonçalves E Silva, D. C., Hermes Pires de Mélo Montenegro, I., Di Cássia de Oliveira Angelo, R., Suruagy Correia Moura, I., & Schwingel, P. A. (2019). Carbohydrate mouth rinse improves cycling performance carried out until the volitional exhaustion. *Journal of Sports Medicine and Physical Fitness*, 1–5. https://doi.org/10.23736/S0022-4707.17.07980-4

Berkulo, M. A., Bol, S., Levels, K., Lamberts, R. P., Daanen, H. A., & Noakes, T. D. (2016). Ad-libitum drinking and performance during a 40-km cycling time trial in the heat. *European journal of sport science*, *16*(2), 213-220. https ://doi.org/10.1080/17461 391.2015.10094 95

Beelen, M., Berghuis, J., Bonaparte, B., Ballak, S. B., Jeukendrup, A. E., & van Loon, L. J. C. (2009). Carbohydrate mouth rinsing in the fed state: lack of enhancement of time-trial performance. *International Journal of Sport Nutrition and Exercise Metabolism*, *19*(4), 400–409. https://doi.org/10.1123/ijsnem.19.4.400

Carter, J. M., Jeukendrup, A. E., Mann, C. H., & Jones, D. A. (2004a). The effect of glucose infusion on glucose kinetics during a 1-h time trial. *Medicine and Science in Sports and Exercise*, *36*(9), 1543-1550. https://doi.org/10.1249/01.mss.0000139892.69410.d8

Carter, J., Jeukendrup, A., & Jones, D. (2004b). The effect of carbohydrate mouth rinse on 1-h cycle time trial performance. *Medicine & Science in Sports & Exercise*, *36*(12), 2107-2111. https://doi.org/10.1249/01.mss.0000147585.65709.6f

Chambers, E. S., Bridge, M. W., & Jones, D. A. (2009). Carbohydrate sensing in the human mouth: effects on exercise performance and brain activity. *The Journal of physiology*, *587*(8), 1779-1794. https ://doi.org/10.1113/jphysiol.2008.164285

Che Muhamed, A. M., Mohamed, N. G., Ismail, N., Aziz, A. R., & Singh, R. (2014). Mouth rinsing improves cycling endurance performance during Ramadan fasting in a hot humid environment. *Applied Physiology, Nutrition, and Metabolism*, *39*(4),458-464. https://doi.org/10.1139/apnm-2013-0276

Clarke, N. D., Thomas, J. R., Kagka, M., Ramsbottom, R., & Delextrat, A. (2017). No dose-response effect of carbohydrate mouth rinse concentration on 5-km running performance in recreational athletes. *Journal of strength and conditioning research*, *31*(3), 715-720. https://doi.org/10.1519/JSC.0000000000001531

De Ataide e Silva, T., Di Cavalcanti Alves de Souza, M., De Amorim, J. F., Stathis, C.G., Leandro, C. G., & Lima-Silva, A. E. (2014). Can carbohydrate mouth rinse improve performance during exercise? A systematic review. *Nutrients*, *6*(1), 1-10. https://doi.org/10.3390/nu6010001

Devenney, S., Collins, K., & Shortall, M. (2016). Effects of various concentrations of carbohydrate mouth rinse on cycling performance in a fed state. *European Journal of Sport Science*, *16*(8), 1073–1078. https://doi.org/10.1080/17461391.2016.1196735

Fares, E. J. M., & Kayser, B. (2011). Carbohydrate mouth rinse effects on exercise capacity in pre- and postprandial states. *Journal of Nutrition and Metabolism*, *2011*. https://doi.org/10.1155/2011/385962

Ferreira, A. M. J., Farias-Junior, L. F., Mota, T. A. A., Elsangedy, H. M., Marcadenti, A., Lemos, T. M. A. M., Okano, A. H., & Fayh, A. P. T. (2018). The effect of carbohydrate mouth rinse on performance, biochemical and psychophysiological variables during a

Volume: 8 Issues: 53 [June, 2023] pp. 33 - 47
Journal of Islamic, Social, Economics and Development (JISED)
eISSN: 0128-1755
Journal website: www.jised.com
DOI: 10.55573/JISED.085304

cycling time trial: A crossover randomized trial. *Journal of the International Society of Sports Nutrition*, *15*(1), 1–9. https://doi.org/10.1186/s12970-018-0225-z

Fraga, C., Velasques, B., Koch, A. J., Machado, M., Paulucio, D., Ribeiro, P., & Pompeu, F. A. M. S. (2017). Carbohydrate mouth rinse enhances time to exhaustion during treadmill exercise. *Clinical physiology and functional imaging*, *37*(1), 17-22. https://doi.org/10.1111/cpf.12261

Gam, S., Guelfi, K. J., & Fournier, P. A. (2013). Opposition of carbohydrate in a mouth-rinse solution to the detrimental effect of mouth rinsing during cycling time trials. *International Journal of Sport Nutrition and Exercise Metabolism*, *23*(1), 48–56. https://doi.org/10.1123/ijsnem.23.1.48

Hawkins, K. R., Krishnan, S., Ringos, L., Garcia, V., & Cooper, J. A. (2017). Running Performance with Nutritive and Nonnutritive Sweetened Mouth Rinses. *International journal of sports physiology and performance*, *12*(8), 1105-1110. https ://doi.org/10.1123/ijspp .2016-0577

Ispoglou, T., O'Kelly, D., Angelopoulou, A., Bargh, M., O'Hara, J.P.and Duckworth, L.C. (2015) Mouth rinsing with carbohydrate solutions at the postprandial state fail to improve performance during simulated cycling time trials. The Journal of Strength & Conditioning Research 29, 2316-2325. https ://doi.org/10.1519/JSC.0000000000000882

Jeukendrup, A. E., & McLaughlin, J. (2011). Carbohydrate ingestion during exercise: effects on performance, training adaptations and trainability of the gut. In *Sports nutrition: More than just calories-triggers for adaptation* (Vol. 69, pp. 1-18). Karger Publishers. https://doi.org/10.1159/000329268

Jeukendrup, A. E., Rollo, I., & Carter, J. M. (2013). Carbohydrate mouth rinse: performance effects and mechanisms. *Sports Science Exchange*, *26*(118), 1-8.

James, R. M., Ritchie, S., Rollo, I., & James, L. J. (2017). No dose response effect of carbohydrate mouth rinse on cycling time-trial performance. *International journal of sport nutrition and exercise metabolism*, *27*(1), 25-31. https://doi.org/10.1123/ijsnem.2016-0111

Kulaksız, T. N., Koşar, Ş. N., Bulut, S., Güzel, Y., Willems, M. E. T., Hazir, T., & Turnagöl, H. H. (2016). Mouth rinsing with maltodextrin solutions fails to improve time trial endurance cycling performance in recreational athletes. *Nutrients*, *8*(5), 2–15. https://doi.org/10.3390/nu8050269

Kamaruddin H.K., Ooi C.H., Abu Bakar A.H., Che Muhamed A.M. (2017) Carbohydrate Mouth Rinse Enhances Time to Exhaustion of Running Performance Among Dehydrated Subjects. In: Ibrahim F., Cheong J., Usman J., Ahmad M., Razman R., Selvanayagam V. (eds) 3rd International Conference on Movement, Health and Exercise. MoHE 2016. IFMBE Proceedings, vol 58. Springer, Singapore. https://doi.org/10.1007/978-981-10-3737-5_25

Kamaruddin, H. K., Ooi, C. H., Mündel, T., Aziz, A. R., & Muhamed, A. M. C. (2019). The ergogenic potency of carbohydrate mouth rinse on endurance running performance of dehydrated athletes. *European journal of applied physiology*, *119*(8), 1711-1723. https://doi.org/10.1007/s00421-019-04161-2

Lane, S. C., Bird, S. R., Burke, L. M., & Hawley, J. A. (2013). Effect of a carbohydrate mouth rinse on simulated cycling time-trial performance commenced in a fed or fasted state. *Applied Physiology, Nutrition and Metabolism*, *38*(2), 134–139. https://doi.org/10.1139/apnm-2012-0300

Murray, K. O., Paris, H. L., Fly, A. D., Chapman, R. F., & Mickleborough, T. D. (2018). Carbohydrate mouth rinse improves cycling time-trial performance without altering plasma insulin concentration. *Journal of Sports Science and Medicine*, *17*(1), 145–152.

Muhamad, A. S., Puad, N. F. R. M., & Kuan, G. (2020). Effects of Carbohydrate Mouth Rinsing on Salivary Lysozyme, Mood States and Running Performance Among Recreational Runners. *The Malaysian Journal of Medical Sciences: MJMS*, *27*(1), 87. https://doi.org/10.21315/mjms2020.27.1.9

Page, M. J., Moher, D., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., . . . McKenzie, J. E. (2021). PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. *372*, n160. doi:10.1136/bmj.n160 %J BMJ

Pottier, A., Bouckaert, J., Gilis, W., Roels, T., & Derave, W. (2010). Mouth rinse but not ingestion of a carbohydrate solution improves 1-h cycle time trial performance. *Scandinavian Journal of Medicine and Science in Sports*, *20*(1), 105–111. https://doi.org/10.1111/j.1600-0838.2008.00868.x

Rollo, I., Williams, C., Gant, N., & Nute, M. (2008). The influence of carbohydrate mouth rinse on self-selected speeds during a 30-min treadmill run. *International journal of sport nutrition and exercise metabolism*, *18*(6), 585-600. https://doi.org/10.1123/ijsnem.18.6.585

Rollo, I. A. N., Cole, M., Miller, R., & Williams, C. (2010). Influence of mouth rinsinga carbohydrate solution on 1-h running performance. *Medicine and science in sports and exercise*, *42*(4), 798-804. https://doi.org/10.1249/MSS.0b013e3181bac6e4

Rollo, I., & Williams, C. (2011). Effect of Mouth-Rinsing Carbohydrate Solutions on Endurance Performance. 41(6), 449–461. https://doi.org/10.2165/11588 730-00000 0000-00000

Sinclair, J., Bottoms, L., Flynn, C., Bradley, E., Alexander, G., McCullagh, S., ... & Hurst, H. T. (2014). The effect of different durations of carbohydrate mouth rinse on cycling performance. *European journal of sport science*, *14*(3), 259-264. https://doi.org/10.1080/17461391.2013.785599

Turner, C. E., Byblow, W. D., Stinear, C. M., & Gant, N. (2014). Carbohydrate in the mouth enhances activation of brain circuitry involved in motor performance and sensory perception. *Appetite*, *80*, 212-219. https://doi.org/10.1016/j.appet.2014.05.020

Walsh, R. M., Noakes, T. D., Hawley, J. A., & Dennis, S. C. (1994). Impaired high-intensity cycling performance time at low levels of dehydration. *International journal of sports medicine*, *15*(07), 392-398. https://doi.org/10.1055/s-2007-1021076

Walberg-Rankin, J. (1995). Dietary carbohydrate as an ergogenic aid for prolonged and brief competitions in sport. *International Journal of Sport Nutrition and Exercise Metabolism*, *5*(s1), S13-S28. https://doi.org/10.1123/ijsn.5.s1.s13

Whitham, M., & McKinney, J. (2007). Effect of a carbohydrate mouthwash on running time-trial performance. *Journal of Sports Sciences*, *25*(12), 1385–1392. https://doi.org/10.1080/02640410601113676

Wright, B. F., & Davison, G. (2013). Carbohydrate mouth rinse improves 1.5 h run performance: is there a dose-effect?. *International journal of exercise science*, *6*(4), 328.