https://jat.journals.ekb.eg/
Faculty of Physical Education, University of Sadat City
Journal of Theories and Applications of physical education sport sciences

Original Article

The Effect of Mouth Rinsing of Carbohydrate Solution on Physical Performance and Some Physiological Variables

Associate Prof. Taha A. Aljaser, Associate Prof. Mohammed Alkatan, Prof Dr. Salman H. Mohammad

Affiliations: Department of Physical Education and Sport, College of Basic Education, Public Authority for Applied Education and Training, Kuwait

E-mail address: taha1029@hotmail.com

Doi : **10.21608/jat.2024.322271.1027**

Abstract

This study investigated the effect of mouth rinsing of carbohydrate solution (CMR) on physical performance and some physiological variables during a workout. Seven (n = 7) collegiate athletes participated in the study. The physiological characteristics, in mean and standard deviation (M ± SD) of the sample, were Age (25.6 ± 4.3 y), weight (79.6 ± 22.7 kg), Height (172.3 ± 6.7 cm), BMI (26.6 ± 6.4 kg/m2), Percent of Body Fat (17.7 ± 6.9 %), and VO2 Max (49.5 ± 6.8 ml/min.kg-1). All subjects completed four experimental trials; the first visit was to collect baseline data and the subjects' physical characteristics. The three trials afterward were done in a crossover design. These trials consisted of a control test. Carbohydrate Mouth Rinsing (CMR) test: The subjects rinsed their mouths in (25 ml) of Carbohydrate (CHO) solution for (10 seconds) every (15 minutes). The third test was a placebo test, mouth rinsing in (25 ml) of colored water for (10 seconds). They ran on a treadmill to exhaustion throughout the three trials. There was a significant difference in the Maximum Heart Rate (Max HR) and Body Temperature at ($P \leq 0.05$). No significant differences were found in the physiological variables for the other variables. The use of CMR should be carefully considered as a protocol for enhancing sports performance. Appropriate dietary and fluid strategies should be prioritized during both training and competition. The study emphasizes the need for further research in this area, highlighting its importance and potential impact on sports performance enhancement.

Keywords: *Carbohydrate solution, Mouth Rinsing, Kuwaiti Athlete, Workout*

Introduction

Many sports nutritionists, coaches, and researchers agree that when planning nutrition for athletes, one of the most crucial points is the need to supply the body with substances that quickly oxidize during sports performance. A vital aspect of this is regenerating the glycogen depleted during physical activity. Glycogen stored in the muscles is depleted during anaerobic sports, while glycogen stored in the liver is used with fat in aerobic sports to increase glycogen reserves in the body for the athletes; this can be achieved through increasing carbohydrate consumption for several days before the sporting event. (Al-Sharifi, 2019), (Salama B. E.-D., 2002), (Fink, Mikesky, & Burgoon, 2012) Carbohydrates (CHO) are the body's primary source of energy production, playing a vital role in metabolic processes. The amount of CHO athletes should consume varies according to the nature and type of sports activity. The appropriate consumption of CHO positively affects an athlete's performance and can delay the onset of fatigue and stress; consuming CHO after intense sports activities helps speed up recovery. (Al-Beik, Abbas, & Khalil, 2009), (Al-Naga, 2018), (Fink, Mikesky, & Burgoon, 2012).

Upon digestion, CHO are converted into glucose, a simple sugar that serves as the direct energy source for the muscles. When glucose reaches the muscles and liver, it is further transformed into glycogen and stored until needed. The body's glycogen stores amount to approximately 450 grams. When the glycogen stored in the body decreases, the body can produce glucose from alternative food sources, such as protein. (Al-Sharifi, 2019), (Al-Naga, 2018), (McArdle, Katch, & Katch, 2015) CHO is a source of energy that helps delay central fatigue. However, consuming carbohydrates during short-term, high-intensity physical activities or within the first hour of exercise is not advisable due to the ample muscle glycogen stores. (Correia-Oliveira, Bertuzzi, Dal'Molin Kiss, & Lima-Silva, 2013), (Ferreira, et al., 2018), (Jeukendrup, 2014), (Torrens, Areta, Parr, & Hawley, 2016), (Winnick, et al., 2005).

Breaking down CHO begins in the mouth with saliva enzymes, which partially digest starch. Subsequently, hydrochloric acid in the stomach acts on starch and sucrose. Finally, pancreatic amylase takes over in the small intestine to complete the digestion process. (Sayed, 2014) However, rinsing the mouth with CHO solutions can help prevent a drop in blood sugar levels, maintain blood glucose levels, and delay the onset of fatigue. Low sugar levels can lead to fatigue and lethargy, negatively affecting athlete's performance. (Ali, C, Wilkinson, & Breier, 2017), (Duckworth, Backhouse, & Stevenson, 2013) One effective method to combat fatigue and enhance physical performance involves rinsing the mouth with CHO solutions. (Carter, Jeukendrup, & Jones, 2004), (Chiu, et al., 2022) This practice helps to sustain blood glucose levels, elevate CHO oxidation rates, and preserve muscle glycogen. These benefits are especially relevant for prolonged endurance activities with moderate intensity lasting over two hours. (Ali, C, Wilkinson, & Breier, 2017), (Duckworth, Backhouse, & Stevenson, 2013), (Jeukendrup A. , 2014)

According to (Ali, C, Wilkinson, & Breier, 2017), and (Pottier, Bouckaert, Gilis, Roeles, & Derave, 2010), swishing a CHO solution in the mouth and then spitting it out is called *(Carbohydrate Mouth Rinsing)*. This technique has significantly enhanced physical and temporal performance compared to swallowing the solution. The improved performance is attributed to the activation of oral receptors and stimulation of brain centers, which are associated with motivation. However, (Ispoglou, et al., 2015), (Beelen, et al., 2009), and (Whitham & McKinney, 2007) observed no notable effect on performance levels in their studies. This lack of effect may be linked to the amount of solution used, as small amounts of

CHO are more effective in energizing and stimulating the motivation centers in the brain, especially when glycogen levels are low. (Ali, C, Wilkinson, & Breier, 2017), (Beelen, et al., 2009), (Ispoglou, et al., 2015), (Pottier, Bouckaert, Gilis, Roeles, & Derave, 2010), (Whitham & McKinney, 2007), (Phillips, Findlay, Kavaliauskas, & Grant, 2014), and (Painelli, et al., 2011) have detailed the process of CHO mouthwash. This process triggers signals to the brain, reducing perceived fatigue and enhancing concentration. As a result, muscles can work more effectively without the discomfort of ingesting CHO, which can cause stomach heaviness and bloating.

(Ferreira, et al., 2018) found that rinsing the mouth with CHO solution without swallowing can generate energy. This effect was confirmed by other studies conducted by (Lane, Bird, Burke, & Hawley, 2013), (Fares & Kayser, 2011), (Pottier, Bouckaert, Gilis, Roeles, & Derave, 2010), (Chambers, Bridge, & Jones, 2009), (Rollo, Williams, Gant, & Nute, 2008), and (Carter, Jeukendrup, & Jones, 2004). The practical implications for athletes are significant as it showed improvement in performance during a one-hour training unit with relatively high intensity (75%). (Devenney, Mangan, Shortall, & Collins, 2018), (Turner, Byblow, Stinear, & Gant, 2014), and (Bortolotti, Altimari, Vitor-Costa, & Cyrino, 2014) also suggested that the absorption of CHO through the taste receptors in the oral cavity is the possible mechanism responsible for improving performance after gargling with CHO solution without swallowing.

Studies by (Ferreira, et al., 2018), and (Berkulo, et al., 2016) has highlighted the potential impact of gargling with a CHO solution without swallowing on the secretion of hormones associated with CHO consumption. Their findings have shed light on the unclear effects on hormones such as cortisol and insulin, adding a new dimension to the discussion.

During prolonged exercise (lasting one to two hours), a significant amount of glycogen is utilized in the muscles, reducing exercise performance. To sustain performance during exercises lasting 30-75 minutes or high-intensity exercise when there is no significant drop in blood glucose levels, mouth rinsing with CHO solution has been introduced. This underscores the importance of CHO intake in sustaining athletic endurance. The solution is swished in the mouth for 5-10 seconds and then spat out without swallowing, which delays fatigue and activates brain areas, as indicated in the study by (Brietzke, et al., 2020). This study provided valuable insights into how rinsing the mouth with a carbohydrate solution affects brain, cognitive, and perceptual responses. (Brietzke, et al., 2020), (Chambers, Bridge, & Jones, 2009), (Ferreira, et al., 2018), (Shirai, Wadazumi, Hirata, , Hamada , & Hongu, 2022), (Temesi, Johnson, Raymond, Burdon, & O'Connor, 2011)

The effectiveness of carbohydrate mouth rinse (CMR) in improving aerobic endurance and high-intensity exercise performance has been demonstrated in several studies (James, Ritchie , Rollo, & James , 2017), (Ataide-Silva, et al., 2016), (Phillips, Findlay, Kavaliauskas,

& Grant, 2014), (Beaven, Maulder , Pooley, Kilduff , & Cook, 2013). However, most research has concentrated on endurance-based activities like running and sprinting, with limited evidence of their effects on muscular strength and endurance (Clarke, Hammond , Kornilios, & Mundy, 2017), (Přibyslavská, et al., 2016), (Rollo, Homewood , Williams , Carter , & Goosey-Tolfrey, 2015). Studies indicate that significant glycogen depletion occurs during prolonged exercise lasting one to two hours, affecting exercise performance. Introducing CMR before and during prolonged exercise has been found to delay fatigue and activate specific brain areas, as stated in a study by (Brietzke, et al., 2020), providing valuable insights into its effects on brain, cognitive, and perceptual responses.

During prolonged exercise, rinsing the mouth with CHO solution for 5-10 seconds, referred to as CMR, has been shown to help maintain performance. This practice should be conducted before and during exercises lasting 30-75 minutes or high-intensity exercise when there is no significant drop in blood glucose levels. The CHO solution is then spat out without swallowing. This method has been found to delay fatigue and activate areas of the brain, as demonstrated in a study by (Brietzke, et al., 2020). The study provided valuable insights into the effects of this method on brain, cognitive, and perceptual responses.

Studies conducted by (James, Ritchie , Rollo, & James , 2017), (Ataide-Silva, et al., 2016), (Phillips, Findlay, Kavaliauskas, & Grant, 2014), (Beaven, Maulder , Pooley, Kilduff , & Cook, 2013), (Chryssanthopoulos, et al., 2018), and (Dolan, Witherbee , Peterson , & Kerksick , 2017), they all indicated that CMR has the potential to enhance aerobic endurance and high-intensity exercise performance significantly. However, most studies have focused on endurance-based exercise, running, and sprinting activities. There is a clear need for further research to understand its effects on muscular strength and endurance fully.

In previous studies, researchers identified discrepancies in investigations examining the effects of CHO mouth rinsing on exercise performance. This method may reduce fatigue and effort by influencing muscle glycogen, which supplies energy to the body. The studies involved moderate-intensity and long-duration exercises (lasting over an hour) and high-intensity exercises (lasting less than an hour). Some studies suggested that the variability in performance improvement from rinsing the mouth with CHO solutions may be due to differences in fasting duration before the experiment, duration of mouth rinsing, type of activity, exercise protocols, and sample size. (Silva, et al., 2013) confirmed these factors, sparking further interest in the need for more research on rinsing the mouth with a CHO solution on physical performance.

Materials and Method

Participants

Convenience sample: ten collegiate athletes from the Physical Education Department at the College of Basic Education in Kuwait participated in the study (N = 10). However, three subjects were excluded as they needed to complete all the necessary measurements, resulting in a final sample of seven (n = 7). The physiological characteristics, in mean and standard deviation (M ± SD) of the sample, were as follows: Age (25.6 ± 4.3 y), weight (79.6 ± 22.7 kg), Height (172.3 ± 6.7 cm), BMI (26.6 ± 6.4 kg/m2), Percent of Body Fat (17.7 ± 6.9%), and VO2 Max (49.5 ± 6.8 ml/min.kg-1). One of the criteria for participation in this study was engaging in physical activities 3-5 days a week, totaling 1.5-5 hours per week. Table 1 shows the physical characteristics of all the subjects involved and the type of sports they engaged in.

Table 1. Physical characteristics and the type of sports for each subject. (N=7)

Subjects	Age	Weight	Height	BMI	Sports
1	23	61	167	21.9	Soccer
2	25	99.5	186	28.8	Jiu-Jitsu
3	22	58	166	21	Soccer
4	21	67.5	171	23.1	Volleyball
5	32	70	170	24.2	Soccer
6	25	81.5	172	27.5	Handball
7	31	120	174	39.6	Judo
Mean	**25.6**	**79.6**	**172.3**	**26.6**	
SD	**4.3**	**22.7**	**6.7**	**6.4**	

Before participating in this study, all subjects must submit medical clearance from their physician regarding their physical health and their dentist regarding their oral and gum health. They completed a health and training history questionnaire and read and signed written informed consent forms. Procedures and protocols were approved by the Research Committee at the Public Authority for Applied Education & Training – Kuwait (PAAET) and the Department of Physical Education and Sport at the College of Basic Education.

Procedures

Protocol and devices

At the beginning of the study, a meeting was held for the subjects participating. In this study, a full explanation was given of the nature of this study and the vital role the participants play in improving physical fitness and enhancing and contributing to sports science in Kuwait. All questions or inquiries related to this study were answered in this meeting. The participants also read and viewed the informed consent to participate as subjects in this study. After the explanation, the consent form was signed, and all the subjects who participated in this study had to present and sign a health medical examination form from their doctor or clinic stating that the subject was fit to participate in the study.

All subjects completed four experimental trials; the first visit was to collect baseline data and the subjects' physical characteristics. The three trials afterward were done in crossover design; each of these trials was separated by 7 – 10 days (Dolan, Witherbee , Peterson , & Kerksick , 2017). All trials have been done in the same laboratory under the same environmental conditions and simultaneously for each subject (Zaher, 2011), (Salama B. E.-D., 2000), (Carter, Jeukendrup, & Jones, 2004), (Duckworth, Backhouse, & Stevenson, 2013). The subjects were instructed to refrain from strenuous physical activities and asked to abstain from caffeine, tobacco, and consumption for 24 hours before each trial (Duckworth, Backhouse, & Stevenson, 2013). They should also have repeated their recorded diet for 24 hours, as close as possible, before the first visit for every trial (Chambers, Bridge, & Jones, 2009). All trials should be done at the same time of day and at least three hours from the last meal consumed by each subject for each trial. (Salama B. E.-D., 2000), (Salama B. E.-D., 2002), (Kumar, Wheaton, Snow, & Millard-Stafford, 2016). All subjects kept an exercise diary for 48 hours before each test for repetition before each test. (Zaher, 2011)

In the study, at the first visit, every subject was familiarized with the test procedures, protocol, purpose, and benefits of this study before the test. Before beginning any procedures, the researchers clarified any questions or inquiries by the subjects about data gathering. Each subject signed a subject consent form. The date, time, and body temperature were recorded during this first visit. Age was recorded to the nearest one year, height to the nearest 0.5 cm, and body weight to the nearest 0.5 kg. Body composition was recorded using (Bodystat 1500, Isle of Man, British Isles), according to manufacturer instructions specified in the user's manual. At this visit, each subject undertook a continuous incremental test to exhaustion on a treadmill to determine the maximum oxygen consumption (VO2 max); T 150 with controller unit (*Cosmed et al.*), Quark B2: (Breath by breath pulmonary gas exchange measuring device Gas analysis:(*Cosmed, Rome, Italy*), was used to measure expired-air. ECG monitored and recorded (*Cosmed, Rome, Italy*). Borg's 20-point scale of perceived exertion (RPE) was used to determine the workout intensity every 10 min. through the trails. (Zaher, 2011).

For the following trials, upon arrival of the subjects, a Polor short-range radio telemetry heart rate monitor was fitted to subjects (Polar Vantage NV, Polar Electro, Oy, Finland). The subjects were required to sit quietly in a quiet place for 30 minutes. After this 30 min., the resting value for the following measurements was taken: resting heart rate (RHR), resting blood glucose (RBG), using (Accu –Chek Performa, Roche Diagnostics GmbH, Mannheim, Germany), and the resting blood lactate (RBL) using (Accutrend et al.).

Before every test, the subject was asked if he liked to use the bathroom to empty his bladder before any testing began. Then, the subject was allowed 15 minutes of self–selected worm–, which included jogging at various speeds and many types of stretching. The test took place at the end of the worm–up section.

Experimental Design

- **First Trial:** In this stage of the study, the subjects received no substance except drinking water if they need it (Control Test). They ran on a treadmill at 75- 85% of their Maximum Heart Rate (HR max) to exhaustion.

- **The Second Trial**: At this stage, carbohydrate Mouth Rinsing (CMR) was used; the subjects rinsed their mouths in (25 ml) of CHO solution of 6.4 g. of colorless and odorless Maltodextrin dissolved in (93.6 ml) of water. The mixtures were then adjusted to 6.4% Maltodextrin solution for the subjects to rinse it in their mouths for (10 seconds) then the mouth-rinsed solution was spat out and collected in a graded beaker. This mouth rinsing was done at the per-test, and after every (15 minutes) during the workout; after every mouth rinse, the subjects were instructed not to drink any water for (5 minutes) to avoid diluting the CHO solution. (Bastos-Silva, et al., 2017), (Chiu, et al., 2022), (Kamaruddin, Ooi , Abu Bakar , & Che Muhamed, 2017), (Lane, Bird, Burke, & Hawley, 2013), (Yang, et al., 2024)

- **The Third Trial:** was the (placebo test), where the subjects rinsed their mouths in (25 ml) of colored water for (10 seconds) at the pre-test and every (15 minutes); the placebo solution was drinking water with food coloring, which contains (0 calories), and sweetened with (0.34 g of artificial sweetener (Canderel Tablets)) it is made to look like the CMR solution in color. The mouth-rinsed solution was spat out and collected in a graded beaker, and subjects were instructed not to drink any water for (5 minutes) after every rinse. (Bastos-Silva, et al., 2017), (Chiu, et al., 2022), (Kamaruddin, Ooi , Abu Bakar , & Che Muhamed, 2017), (Lane, Bird, Burke, & Hawley, 2013), (Yang, et al., 2024)

This study was a crossover design where all subjects completed three experimental trials in a random order. The subjects ran on a treadmill at 75- 85% of the heart rate max (HR max) to exhaustion, and all trials were separated by 7–10 days each. Throughout the three trials, a bottle of water (0.800 ml) was available for subjects throughout the workout, and if the subject needed water, another bottle was provided. All the amounts of water consumed were recorded (Correia-Oliveira, Bertuzzi, Dal'Molin Kiss, & Lima-Silva, 2013), (Shirai, Wadazumi, Hirata, , Hamada , & Hongu, 2022) .The control panel was completely covered throughout all the trials, so the subjects could not compare their performance from one trial to another regarding the distance or time of the workout. All these trials were conducted in the same laboratory and under the same environmental conditions (23 C).

Statistical Analysis

All data were analyzed using SPSS for Windows version 22.0 (SPSS, Inc., Chicago, IL. USA). One–way ANOVA with repeated measures to analyze the overall differences in the physiological responses and the subject's performance in the trials. Significance differences were set at the ($P \leq 0.05$) confidence level; descriptive statistics' results were presented as a (mean ± standard deviation).

Results and Discussion

1.Heart Rate Measurements (HR)

The statistics showed no significant difference in the physiological variables between Control test and (CMR) and (PMR) at the ($P \leq 0.05$) level; in one-way ANOVA repeated test for Heart Rate (HR) measurement, and these finding consistent with the finding of (Beelen, et al., 2009) in their study. Figure (1) shows HR values in different stages.

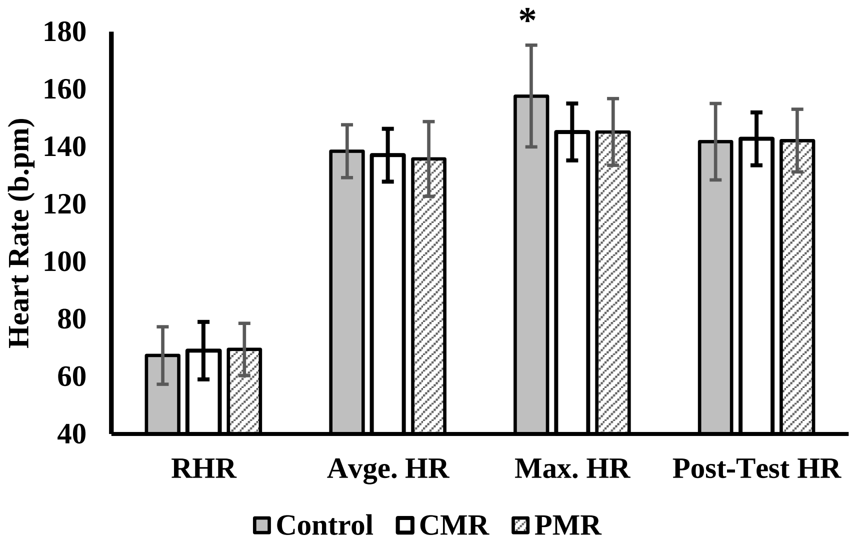

Figure (1): The Heart Rate Values in different stages of the tests in (Mean ± SD) (N= 7)
Resting Heart Rate (RHR), Average Heart Rate (Avge. HR), Maximum Heart Rate (Max. HR), PostTest Heart Rate (Post-Test HR)

There was no significant difference in the Heart Rate (HR) measurements in all the tests between the three conditions at the different stages of the tests at ($P \leq 0.05$) confidence level; in the one-way ANOVA repeated test, for Heart Rate (HR) measurement the (Mean ± SD) for the Resting Heart Rate (RHR) for Control test was (67.3 ± 10.0 b.pm), the CMR was (69.0 ± 10.0 b.pm), and PMR was (69.4 ± 9.1 b.pm). The same held for the Average HR (Avg. HR) where the control test was (138.4 ± 9.2 b.pm), the CMR was (137.0 ± 9.2 b.pm), and the PMR was (137.0 ± 9.2 b.pm) F value the Avge.HR was [$F(2,12) = 0.275$, $P = 0.76$, $\eta\rho2 = 0.126$)], but there was a significant difference in the Maximum Heart Rate (Max HR) tests at ($P \leq 0.05$); the value of the (Mean ± SD) for the control test was (157.6 ± 17.7 b.pm), the CMR was (145.1 ± 9.9 b.pm), and at the PMR was (145.1 ± 11.6 b.pm). Moreover, the F value is the Max.HR was [$F(2,12) = 3.774$, $P = 0.05$, $\eta\rho2 = 0.180$)]; These finding of the Max. HR is in agreement with the findings of (Chambers, Bridge, & Jones, 2009), (James, Ritchie , Rollo, & James , 2017), and (Phillips, Findlay, Kavaliauskas, & Grant, 2014), in their investigations of the CMR effects on performance. On the other hand, there was no significant difference in the Post-Test Heart Rate (PHR), where the (Mean ± SD) for the Control test was (141.7 ± 13.3 b.pm), for the CMR was (142.7 ± 9.2 b.pm), and the PMR was (142.1 ± 10.9 b.pm).

2. Blood Glucose & Blood Lactate

Figure (2) shows the values of the Blood Glucose and Blood Lactate values in all the stages of the tests; there was no significant difference in blood glucose measurements in all the test between the three conditions at the different stages of the tests at ($P \leq 0.05$) confidence level; in one-way ANOVA repeated test, were the values in the (Mean ± SD) for the three tests at the resting stage was for the Blood Glucose test at resting state, for the Control test was (C-G) was (5.3 ± 0.4 mmol/L)), for the CMR was (5.1 ± 0.2 mmol/L), and for the PMR was (5.3 ± 0.4 mmol/L). There was no significant difference for the Blood Glucose post-test at ($P \leq 0.05$), were the F value was [$F(2,12) = 0.54$, $P = 0.6$, $\eta\rho2 = 0.034$)], the values the Blood Glucose Post-test was at the Control test was (C-G) was (5.0 ± 0.4 mmol/L)), for the CMR was (5.2 ± 0.5 mmol/L), and for the PMR was (5.1 ± 0.4 mmol/L). As is shown from the values of the Blood Glucose at all the stages, there is no significant difference in the one-way ANOVA repeated test at ($P \leq 0.05$) level; these findings agree with what (Ispoglou, et al., 2015), and (Whitham & McKinney, 2007) in their studies.

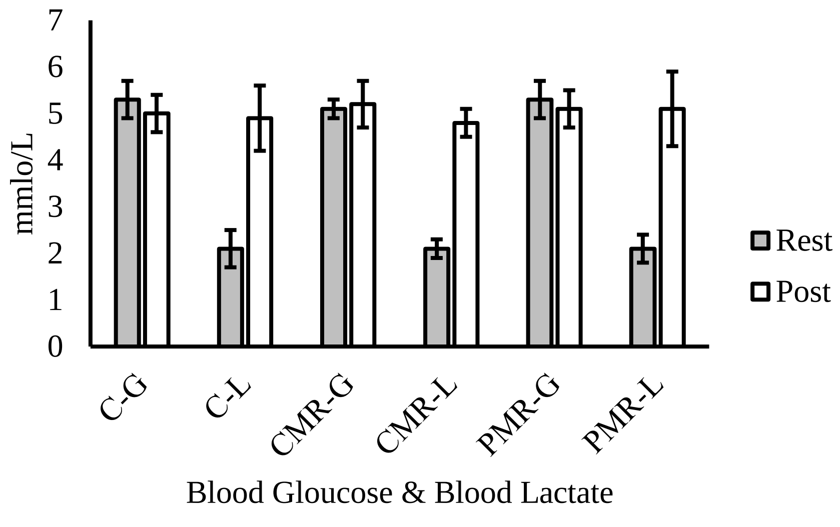

Figure (2): The Blood Glucose and blood Lactate values at different stages of the tests in (Mean ± SD) (N= 7)

Control Glucose (C-G), Control Lactate (C-L), Carbohydrate Mouth Rinsing Glucose (CMR-G), Carbohydrate Mouth Rinsing Lactate (CMR-L), Placebo Mouth Rinsing Glucose (PMR-G), Placebo Mouth Rinsing Lactate (PMR-L)

For the Blood Lactate test, there was no significant difference in one-way ANOVA repeated test at ($P \leq 0.05$) confidence level for the Blood Lactate value during the pre-test or the post-test, the values for the pre-test for the Control resting was (C-L) (2.1 ± 0.4 mmol/L), CMR was (2.1 ± 0.2 mmol/L), and for the PMR was (2.1 ± 0.3 mmol/L). While at the Post-test, the values were for the Control were (4.9 ± 0.7 mmol/L), the CMR was (4.8 ± 0.3 mmol/L), and the PMR was (5.1 ± 0.8 mmol/L). There was no significant difference in one-way ANOVA repeated test at ($P \leq 0.05$) confidence level for the post-test Blood lactate where the F value was [F (2,12) = 0.813, P = 0.5, ηρ2 = 0.054)].

3. Rate Perceived Exertion (RPE)

The Rate of Perceived Exertion (RPE) is one way to assess the feeling of exertion during workouts. (14). Our finding in this study indicated that there was no significant difference in the one-way ANOVA repeated test at ($P \leq 0.05$) confidence level for test the Rate Perceived Exertion (RPE) test, were the values in the (Mean ± SD) for the three tests, for the Control trial was (15.4 ± 2.5), for the CMR was (15.4 ± 2.4), and for the PMR was (15.3 ± 2.7), therefor there was no significant difference in one-way ANOVA repeated test at ($P \leq 0.05$) confidence level for both test the Rate Perceived Exertion (RPE) test, the F value was [F (2,12) = 0.109, P = 0.9, ηρ2 = 0.0009)]. These findings were consistent with the findings of (Beelen, et al., 2009), and (Whitham & McKinney, 2007) in their studies.

4. Body Temperature (B.Temp. °C)

There was a significant difference in Body Temperature (B.Temp) measurements in the one-way repeated measures ANOVA test. The value of (F) is the F value was [F (2,12) = 36.5, P = 0.01, ηρ2= 0.749)]. Post hoc test showed that CMR influence (B.Temp.) were the (mean ± SD) for the Control trial was (38.1 ± 0.4 °C), compared to the CMR trail (38.1 ± 0.4 °C), and the PMR trail was (36.8 ± 0.3 °C). correspond with what (Lane, Bird, Burke, & Hawley, 2013), (Fares & Kayser, 2011), and (Dolan, Witherbee , Peterson , & Kerksick , 2017) they found in their researches.

5. Water Consumption (ml)

Similar to what (Whitham & McKinney, 2007) had found in their study, that there was no significant difference in the one-way ANOVA repeated test at ($P \leq 0.05$) confidence level for water consumption measurements, where the values in the (Mean ± SD) for the three trials, for the Control trial, was (625.0 ± 247.1 ml), for the CMR was (578.6 ± 210.2 ml), and for the PMR was (716.4 ± 304.5 ml), therefor there was no significant difference in one-way ANOVA repeated test at ($P \leq 0.05$) confidence level for both test the water consumption measurements, the F value for the water consumption was [F (2,12) = 0.1.211, P = 0.3, ηρ2 = 0.0548)]. The total amount of mouth rinsing solution volume used in (Mean ± SD) by the subjects during the workout was for the CMR (154.7 ± 32.3 ml), and for the PMR trial was (165.4 ± 40.5 ml). From that, the amount of mouth-rinsed solution spat out for the CMR trial was (135.6 ± 33.2 ml), and for the PMR trial was (143.1 ± 34.9 ml).

6. Total Distance (km)

There was no significant difference in one-way ANOVA repeated test at ($P \leq 0.05$) confidence level total distance for the three trials, where the values in the (Mean ± SD) for the three trials, for the Control trial was (10.8 ± 1.4.km), for the CMR was (10.2 ± 2.8 km), and for the PMR was (11.3 ± 3.6 km), therefor there was no significant difference in one-way ANOVA repeated test at ($P \leq 0.05$) confidence level in the total distance for the three trials, the F value for the total distance was [F (2,12) = 0.689, P = 0.5, ηρ2= 0.0383)]. These finding agree with what (Beelen, et al., 2009), (Ispoglou, et al., 2015) had found in their studies.

7. Total Time Exhaustion (m: s)

There was no significant difference in the one-way ANOVA repeated test at ($P \leq 0.05$) in total time to exhaustion for the three trials, where the values in the (Mean ± SD) for the three trials, for the Control trial, was (83.6 ± 19.1 m:s), for the CMR was (77.1 ± 21.7 m:s), and for the PMR was (86.3 ± 27.0 m:s), therefor there was no significant difference in one-way ANOVA repeated test at ($P \leq 0.05$) confidence level in the total time for the three trials, the F value for the total times to exhaustion was [F (2,12) = 0.788, P = 0.9, ηρ2 = 0.0325)]. This finding corresponds with the finding of (Beelen, et al., 2009). (Ispoglou, et al., 2015)), and (Whitham & McKinney, 2007) in their studies.

The findings of this study showed that CMR did not result in any performance increases compared with the Control trial nor PMR. We found no significant differences between the three conditions tested regarding physiological variables for heart rate measurements in all the different stages except for the Max HR test, and these findings correspond with what (Beelen, et al., 2009), and (Whitham & McKinney, 2007). On the other hand, there was a significant difference found in heart rate measurements in some studies of CMR. (Black, et al., 1993), (Gam, Guelfi, & Fournier, 2013), (Lane, Bird, Burke, & Hawley, 2013) Similarly, the results of the Blood Glucose and Blood Lactate have no significant differences, and that is consistent with the finding of a similar study that found no difference between the Blood Glucose and Blood Lactate test. (Beelen, et al., 2009), (Chong, Guelfi, & Fournier, 2014), (Ispoglou, et al., 2015) In contrast, some studies found a significant difference in blood lactate and blood glucose tests. (Fares & Kayser, 2011), (Gam, Guelfi, & Fournier, 2013), (Lane, Bird, Burke, & Hawley, 2013), (Phillips, Findlay, Kavaliauskas, & Grant, 2014)

While (Fares & Kayser, 2011), (Gam, Guelfi, & Fournier, 2013), and (Ispoglou, et al., 2015), in their studies found that there are significant differences between RPE test in CMR compare to PMR, in contrast to our finding. Our findings did not find a difference in RPE, but there was a significant difference in Body Temperature (B. Temp) measurements in the one-way repeated measures ANOVA test. The value of (F) is the F value was [F (2,12) = 36.5, P = 0.01, ηρ2= 0.749)]. Post hoc test showed that CMR influence (B.Temp.) were the (mean ± SD) for the Control trial was (38.1 ± 0.4 °C), compared to the CMR trail (38.1 ± 0.4 °C), and the PMR trail was (36.8 ± 0.3 °C). These findings are consistent with another study. (Beaven, Maulder , Pooley, Kilduff , & Cook, 2013), (Chong, Guelfi, & Fournier, 2014), (Rollo, Homewood , Williams , Carter , & Goosey-Tolfrey, 2015) Regarding the performance in the form of total time and the total distance of the test, we did not find a significant difference in total time nor the total distance, corresponding with other study findings. (Black, et al., 1993), (Chong, Guelfi, & Fournier, 2014), (Ispoglou, et al., 2015) On the other hand, some studies found that CMR increases performance and has significant differences. (Beaven, Maulder , Pooley, Kilduff , & Cook, 2013), (Chong, Guelfi, & Fournier, 2014), (Phillips, Findlay, Kavaliauskas, & Grant, 2014)

Conclusion

This study showed that CMR did not influence the total time or distance of the test and did not affect the physiological variables tested, such as blood glucose, blood lactate, and RPE. However, this seems to have had some effect on body temperature and Max HR; these differences in findings between our study finding, and other research may be due to the methodology used in each study, such as dosage more or less, the time for rinsing (5 s), (10 s), (15 s), as well as the frequency of mouth rinsing, in addition to CHO concentration in the solution. (Beaven, Maulder , Pooley, Kilduff , & Cook, 2013), (Chong, Guelfi, & Fournier, 2014), (Fares & Kayser, 2011), (Kumar, Wheaton, Snow, & Millard-Stafford, 2016), (Lane, Bird, Burke, & Hawley, 2013), (Phillips, Findlay, Kavaliauskas, & Grant, 2014).

Recommendation

From this study finding, we recommend that mouth rinsing for longer duration (i.e., 10 seconds) or higher and more frequent (i.e., 5 minutes) be more effective than the shorter duration during work-out. However, mouth rinsing more frequently and for longer durations may not be practical in many athletic settings. Alternatively, ad libitum water intake alongside CHO mouth rinsing protocols may be more effective than mouth rinsing alone; however, this is still to be confirmed. In conclusion, coaches and practitioners should be skeptical of adopting a conventional mouth rinsing protocol to optimize sports performance; however, other options may exist. Consequently, mouth rinsing as a practical strategy for coaches and athletes must be more credible under specific conditions and carefully considered before its inclusion. Emphasis should be focused on appropriate dietary and fluid strategies during training and competition

References

Al-Beik, A. F., Abbas, E. E.-D., & Khalil, M. A. (2009). *Metabolism and Anaerobic and Aerobic Energy Systems* (1 ed.). Alexandria: Al-Ma'arif facility.

Ali, A. M., C, Y. M., Wilkinson, A., & Breier, B. H. (2017). Effect of mouth rinsing and ingestion of carbohydrate solutions on mood and perceptual responses during exercise. *Journal of the International Society of Sports Nutrition, 14*, 1-10. doi:doi.org/10.1186/s12970-017-0183-4

Al-Naga, E. G. (2018). *The Scientific Encyclopedia of Nutrition* (1 ed.). Cairo: Modern Book Center.

Al-Sharifi, A. H. (2019). *Basics of Sports Physiology.* Kuwait, Kuwait: Al-Sharifi.

Ataide-Silva, T., Ghiarone, T., Bertuzzi, R., Stathis, C. G., Leandro, C. G., & Lima-Silva, A. E. (2016). CHO mouth rinse ameliorates neuromuscular response with lower endogenous CHO stores. *Medicine and Science in Sports and Exercise, 48*(9), 1810-1820.

Bastos-Silva, V. J., Araujo, , G. G., Franco, , S. D., Melo, , A. D., Learsi,, S. K., Lima-Silva,, A. E., & Bertuzzi, , R. (2017). Carbohydrate mouth rinse reduces rating of perceived exertion but does not affect performance and energy systems contribution during a high-intensity exercise. *Motriz: Revista de Educação Física, 23*, e101785.

Beaven, C. M., Maulder , P., Pooley, A., Kilduff , L., & Cook, C. (2013). Effects of caffeine and carbohydrate mouth rinses on repeated sprint performance. *Applied Physiology, Nutrition, and Metabolism, 38*(6), 633-637. doi:https://doi.org/10.1139/apnm-2012-0333

Beelen, M., Berghuis, J., Bonaparte, B., Ballak, S. B., Jeukendrup, A. E., & Van Loon, L. J. (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. doi:https://doi.org/10.1123/ijsnem.19.4.400

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. doi:https://doi.org/10.1080/17461391.2015.1009495

Black, A. E., Prentice, A. M., Goldberg, G. R., Jebb, S. A., Bingham , S. A., Livingstone , M. B., & Coward, A. (1993). Measurements of total energy expenditure provide insights into the validity of dietary measurements of energy intake. *Journal of the American Dietetic Association, 93*(5), 572-579.

Bortolotti, H., Altimari, L. R., Vitor-Costa, M., & Cyrino, E. S. (2014). Mouth rinse with carbohydrate drink and performance: Hypothesis of its central action. *International Sport Med Journal, 15*(1), 84-95.

Brietzke, C., Franco-Alvarenga, P. E., Canestri, R., Goethel, M. F., Vínicius , I., Painelli, V. D. S., , V. D., & Pires, F. O. (2020). Carbohydrate mouth rinse mitigates mental fatigue effects on maximal incremental test performance, but not in cortical alterations. *Brain Sciences, 10*(8), 493. doi:https://doi.org/10.3390/brainsci10080493

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

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

Chiu, C. H., Chen, C. H., Yang, T. J., Chou, K. M., Chen, B. W., Lin, Z. Y., & Lin, Y. C. (2022). Carbohydrate mouth rinsing decreases fatigue index of taekwondo frequency speed of kick test. *Journal of Physiology Investigation, 65*(1), 46-50. doi:doi.org/10.1007/s12576-021-00847-0

Chong, E., Guelfi, K. J., & Fournier, P. A. (2014). Combined glucose ingestion and mouth rinsing improves sprint cycling performance. *International journal of sport nutrition and exercise metabolism, 24*(6), 605-612.

Chryssanthopoulos, C., Ziaras , C., Oosthuyse , T., Lambropoulos , I., Giorgios , P. P., Zacharogiannis, E., & Maridaki, M. (2018). Carbohydrate mouth rinse does not affect performance during a 60-min running race in women. *Journal of Sports Sciences, 36*(7), 824-833. doi:https://doi.org/10.1080/02640414.2017.1346262

Clarke, N. D., Hammond , S., Kornilios, E., & Mundy, P. D. (2017). Carbohydrate mouth rinse improves morning high-intensity exercise performance. *European Journal of Sport Science, 17*(8), 955-963. doi: https://doi.org/10.1080/17461391.2017.1333903

Correia-Oliveira, C. R., Bertuzzi, R., Dal'Molin Kiss, M. A., & Lima-Silva, A. E. (2013). Strategies of dietary carbohydrate manipulation and their effects on performance in cycling time trials. *Sports Medicine, 43*, 707-719.

Devenney, S., Mangan, S., Shortall, M., & Collins, K. (2018). Effects of carbohydrate mouth rinse and caffeine on high-intensity interval running in a fed state. *Applied Physiology, Nutrition, and Metabolism, 43*(5), 517-521. doi: https://doi.org/10.1139/apnm-2017-0458

Dolan, P., Witherbee , K. E., Peterson , K. M., & Kerksick , C. M. (2017). Effect of carbohydrate, caffeine, and carbohydrate + caffeine mouth rinsing on intermittent running performance in collegiate male lacrosse athletes. *he Journal of Strength & Conditioning Research, 31*(9), 2473-2479. doi:https://doi.org/10.1519/JSC.0000000000001730

Duckworth, L. C., Backhouse, S. H., & Stevenson, E. J. (2013). The effect of galactose ingestion on affect and perceived exertion in recreationally active females. *Appetite*, 252-580. doi:doi.org/10.1016/j.appet.2013.08.017

Fares, E. J., & Kayser, B. (2011). Carbohydrate mouth rinse effects on exercise capacity in pre- and postprandial states. *Journal of Nutrition and Metabolism, 1*, 385962. doi:https://doi.org/10.1155/2011/385962

Ferreira, A. M., Farias-Junior, L. M., Elsangedy, T. A., Marcadenti, A., Lemos, T. M., & Fayh, A. P. (2018). The effect of carbohydrate mouth rinse on performance, biochemical and psychophysiological variables during a cycling time trial: a crossover randomized trial. *Journal of the International Society of Sports Nutrition, 15*, 15-23.

Fink, H. H., Mikesky, A. E., & Burgoon, L. A. (2012). *Practical Applications in Sport Nutrtion.* Burlington, Massachusetts: Jones & Bartlett Learning LLC.

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.

Ispoglou, T., O'Kelly, D., Angelopoulou, A., Bargh, M., O'H, O'Hara, J. P., & Duckworth, L. C. (2015). Mouth rinsing with carbohydrate solutions at the postprandial state fails to improve performance during simulated cycling time trials. *The Journal of Strength & Conditioning Research*, 2316-2325.

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), 25-33. doi:https://doi.org/10.1123/ijsnem.2016-0111

Jeukendrup, A. (2014). A step towards personalized sports nutrition: carbohydrate intake during exercise. *Sports Medicine, 44 (suppl 1)*, 25-33.

Jeukendrup, A. (2014). Oral carbohydrate rinse: Placebo or beneficial? *Current Sports Medicine Reports, 12*(4), 222-227. doi:doi.org/10.1249/JSR.0b013e31829a677f

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 3rd International Conference on Movement, Health and Exercise: Engineering Olympic Success: From Theory to Practice. *58*, pp. 121-128. Springer: the International Federation for Medical and Biological Engineering (IFMBE).

Kumar, N., Wheaton, L. A., Snow, T. K., & Millard-Stafford, M. (2016). Carbohydrate ingestion but not mouth rinse maintains sustained attention when fasted. *Physiology Behavior, 153*, 33-39.

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, 8*(2), 134-139. doi:doi.org/10.1139/apnm-2012-0300

McArdle, W. D., Katch, F. I., & Katch, V. L. (2015). *Exercise Physiology Nutrition, Energy and Human Performance* (8 ed.). Philadelelphia, Pennsylvania: Wolters Kluwer Health/ lippincott Williams & Wilkins.

Painelli, V. S., Roschel, H., Gualano, B., Del-Favero, S., Benatti, F. B., Ugrinowitsch, C., & Lancha, A. H. (2011). The effect of carbohydrate mouth rinse on maximal strength and strength endurance. *European Journal of Applied Physiology, 111*, 2381-2386. doi:doi.org/10.1007/s00421-011-1865-8

Phillips, S. M., Findlay, S., Kavaliauskas, M., & Grant, M. C. (2014). The influence of serial carbohydrate mouth rinsing on power output during a cycle sprint. *Journal of Sports Science & Medicine, 13*(2), 252-258. doi:doi.org/10.52082/jssm.2014.252

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

Přibyslavská, V., Scudamore , E. M., Johnson , S. L., Green , J. M., Stevenson Wilcoxson , M. C., Lowe, J. B., & O'Neal, E. K. (2016). Influence of carbohydrate mouth rinsing on running and jumping performance during early morning soccer scrimmaging. *European Journal of Sport Science, 16*(4), 441-447. doi:https://doi.org/10.1080/17461391.2015.1060268

Rollo, I., Homewood , G., Williams , C., Carter , J., & Goosey-Tolfrey, V. L. (2015). The influence of carbohydrate mouth rinse on self-selected intermittent running performance. *International Journal of Sport Nutrition and Exercise Metabolism, 25*(6), 550-558. doi:https://doi.org/10.1123/ijsnem.2015-0031

Rollo, I., Williams, C., Gant, N., & Nute, M. (2008). he 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. doi:https://doi.org/10.1123/ijsnem.18.6.585

Salama, B. E.-D. (2000). *Food health and organ functions* (1 ed.). Cairo: Dar Al-Fikr Al-Arabi.

Salama, B. E.-D. (2002). *Sports Health and Physiological Determints of Sports Activity*. (1, Ed.) Cairo: Dar Al-Fikr.

Sayed, A. N.-D. (2014). *Principles of Sports Physiology*. Cairo, Egypt: Modern Book Center.

Shirai, A., Wadazumi, T., Hirata, , Y., Hamada , N., & Hongu, N. (2022). Carbohydrate mouth rinse and spray improve prolonged exercise performance in recreationally trained male college students. *Sports, 10*(4), 51. doi:https://doi.org/10.3390/sports10040051

Silva, T. D., de Souza , M. C., De Amorim , J. F., Stathis , C. G., Leandro , C. G., & Lima-Silva , A. E. (2013). Can carbohydrate mouth rinse improve performance during exercise? A systematic review. *Nutrients, 6*(1), 1-10. doi:https://doi.org/10.3390/nu6010001

Temesi, J., Johnson, N. A., Raymond, J., Burdon, C. A., & O'Connor, H. T. (2011). Carbohydrate ingestion during endurance exercise improves performance in adults. *The Journal of Nutrition, 141*(5), 890-897. doi:https://doi.org/10.3945/jn.110.137075

Torrens, S. L., Areta, J. L., Parr, E. B., & Hawley, J. A. (2016). Carbohydrate dependence during prolonged simulated cycling time trials. *European Journal of Applied Physiology, 116*, 781-790.

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. doi:https://doi.org/10.1016/j.appet.2014.05.020

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

Winnick, J. J., Davis, J. M., Welsh, R. S., Carmichael, M. D., Murphy, E. A., & Blackmon, J. A. (2005). Carbohydrate feedings during team sport exercise preserve physical and CNS function. *Medicine & Sicence in Sports & Exercise, 37*(2), 306-315.

Yang, T. J., Shiu, Y. J., Chen , C. H., Yu , S. Y., Hsu, Y. Y., & Chiu, C. H. (2024). Carbohydrate Mouth Rinses before Exercise Improve Performance of Romanian Deadlift Exercise: A Randomized Crossover Study. *Nutrients, 16*(8), 1248.

Zaher, A. R. (2011). *Encyclopedia of Sports Physiology* (1 ed.). Cairo: Al-Kitab Publishing Center.