CBÜ Beden Eğitimi ve Spor Bilimleri Dergisi
CBU Journal of Physical Education and Sport Sciences
Volume: 19, Issue: 2, 2024
E-ISSN: 2149-1046
DOI: 10.33459/cbubesbd.1399602
URL: https://dergipark.org.tr/tr/pub/cbubesbd

The Effect of Carbonhydrate Mouth Rinse on the Endurance Performance in Football Players*†

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Research Article
Received: 03/12/2023 Accepted: 02/03/2024 Published: 31/07/2024

Abstract

The presence of carbohydrates (CHO) in the mouth can enhance performance by stimulating the reward center of the brain. Mouth rinsing with CHO does not cause a potential side effect of gastrointestinal discomfort associated with CHO consumption. Numerous studies have demonstrated that using a carbohydrate solution via mouth rinsing can improve performance in endurance sports. However, research on football is limited, and the effectiveness of this approach in football is uncertain. This placebo-controlled and double-blind study was conducted to evaluate the impact of rinsing the mouth with a 15% CHO solution on endurance performance among football players. Twenty healthy male football players, aged between 20 and 25, participated in the study. Endurance performance was indirectly measured using the results of the Yo-Yo intermittent recovery (IR) test. Blood glucose and lactate levels of the football players were measured before and after the Yo-Yo IR test. They were given either a placebo or a 15% carbohydrate solution to rinse their mouths three times, including before warming up, before the Yo-Yo IR test, and in the middle of the test. There was no significant difference found in the levels of blood lactate, blood glucose, and VO2max values between the two groups (p> 0.05). The study concluded that rinsing the mouth with a 15% CHO solution had no significant impact on the endurance performance of football players.
Keywords: Football, CHO solution, Mouth rinse, Endurance

Futbolcularda Ağızda Karbonhidrat Çözeltisi Çalkalamanın Dayanıklılık Performansına Etkisi

Öz

Ağızda karbonhidrat (CHO) bulunması, beyin ödül merkezini uyararak performansı artırabilir. Ağızda CHO çalkalama, CHO tüketmenin potansiyel bir yan etkisi olan gastrointestinal rahatsızlığa neden olmaz. Birçok çalışma, ağızda çalkalama yoluyla karbonhidrat çözeltisi kullanmanın dayanıklılık sporlarında performansı artırabileceğini göstermiştir. Bununla birlikte, futbol üzerine yapılan araştırmalar sınırlıdır ve bu yaklaşımın futboldaki etkinliği belirsizdir. Bu çalışma plasebo kontrollü ve çift kör olarak, ağızda %15 CHO çözeltisi çalkalamanın futbol oyuncularının dayanıklılık performansı üzerindeki etkisini değerlendirmek için yapılmıştır. Çalışmaya 20 -25 yaş aralığında, 20 sağlıklı erkek futbol oyuncusu katılmıştır. Dayanıklılık performansı, Yo-Yo intermittent recovery (IR) testi sonuçları aracılığıyla endirekt olarak belirlenmiştir. Futbol oyuncularının kan glukozu ve laktat seviyeleri, Yo-Yo IR testinden önce ve sonra ölçülmüştür. Oyunculara, ısınmadan önce, Yo-Yo IR testinden önce ve testin ortasında olmak üzere üç kez ağızlarında çalkalamak için ya bir plasebo ya da %15 karbonhidrat çözeltisi verilmiştir. İki grup arasında kan laktat, kan glukozu ve VO^2max değerlerinde anlamlı bir fark bulunmamıştır (p>0.05). Çalışmada, ağızlarında %15 CHO çözeltisi çalkalamanın futbol oyuncularının dayanıklılık performansı üzerinde anlamlı bir etkisinin olmadığı sonucuna varılmıştır.
Anahtar Kelimeler: Futbol, CHO, Ağızda çalkalama, Dayanıklılık

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* This study is derived from the master's thesis titled "The Effect of Carbonhydrate Mouth Rinse on the Endurance Performance in Football Players" completed by the first author under the supervision of the corresponding author.

† This study has presented as oral presentation on 3th International Congress on Multidisciplinary Approach to Sports and Social Sciences at 10-11 November 2022, Istanbul, Türkiye

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INTRODUCTION

Nutrition is crucial for maximizing the physical and mental performance of elite athletes during both training and matches, as well as maintaining their overall health throughout a prolonged season. The quality, quantity, and timing of the food, fluids, and supplements that athletes consume have a significant impact on their performance and recovery during and between matches (Collins et al., 2020; Thomas et al., 2016).

To enhance athletic performance, one of the most extensively researched ergogenic aids is the intake of carbohydrates (CHO) before and during exercise (Thomas et al., 2016; Valleser et al., 2020). While the underlying mechanism of the performance enhancement of CHO consumption during exercise is not entirely clear, one possible explanation is that it helps to maintain high rates of CHO oxidation through the use of exogenous CHO (Gungor, 2014; Jeukendrup, 2014; Newell et al., 2018). However, a study has found that during high-intensity exercise, only 5-15 grams of externally consumed CHO are actually utilized within the first hour of exercise. Due to the relatively small amount of externally consumed CHO that is oxidized compared to the total amount of CHO that is oxidized during exercise, it has been suggested that this may not be sufficient to enhance exercise performance (Jeukendrup et al., 1997). Furthermore, the metabolic mechanisms underlying the performance-enhancing effects of orally consumed CHO have not been fully elucidated. In a study where an infusion of 20% glucose-containing solution was administered to cyclists via intravenous route to eliminate the possible effects of externally consumed CHO on the central nervous system, although the glucose levels in the blood and glucose uptake in skeletal muscles were increased, there was no improvement in performance (Carter et al., 2004b). All these findings have led to the suggestion that CHO mouth rinse before and during exercise may enhance performance without changing metabolic responses (Carter et al., 2004a; Carter et al. 2004b; Clarke et al., 2017; Clarke et al., 2016; Kasper et al., 2016; Rollo et al., 2015). Furthermore, it has been concluded that the role of CHO in short-term endurance performance is regulated via the central nervous system rather than through metabolic mechanisms (Carter et al., 2004b). Based on these findings, it was demonstrated for the first time in a study that using mouth rinsing with a maltodextrin (MD) solution, which eliminates the metabolic effects of CHO, improved exercise performance by 2.8% (Carter et al., 2004a).

Mouth rinsing with a CHO solution is more practical and advantageous compared to consuming CHO during exercise, as it does not cause gastrointestinal disturbances (Collins et al., 2020; Gungor, 2014). Therefore, it raises the question of how the use of mouth rinsing with a CHO solution, which has emerged as a sports nutrition strategy for endurance athletes in the last decade, might affect performance in sports with interval loads at both high-and low-intensity.

As a result of our research, we have found that there is only one study (Karayigit et al., 2017) that has examined the effects of mouth rinsing with CHO on high-intensity interval loads in football. In this study by Karayigit et al., the effects of CHO mouth rinsing on the intermittent sprint performance of football players were investigated, and it was concluded that this technique did not significantly improve the intermittent sprint performance in football players (Karayigit et al., 2017).

Studies have shown that mouth rinsing with a CHO solution can increase self-selected running speed, suggesting potential benefits in sprint performance during interval training (Collins et al., 2020; Rollo et al., 2015). Although the implications of CHO mouth rinsing on endurance performance in football are still unclear, the use of a CHO solution as a mouth rinse during game breaks (e.g., half-time, overtime, injury interruptions) is thought to potentially improve performance when CHO consumption is limited due to gastrointestinal concerns (Collins et al., 2020; Dorling and Earnest, 2013).

Although most of the research on carbohydrate mouth rinsing has focused on cycling races and marathon running, there is limited research on team sports such as football, leaving the effect of this practice for football unclear. The aim of this study was to investigate the impact of rinsing a 15% CHO solution on endurance performance, blood lactate, and blood glucose values in 20 healthy male football players aged 20-25 years.

Hypothesis:
Rinsing carbohydrate solution in the mouth affects endurance performance in football players.

Sub-Hypotheses:

1. Rinsing carbohydrate solution in the mouth affects endurance performance in football through VO^2max, blood lactate and glocose levels.
2. Rinsing carbohydrate solution in the mouth does not affect endurance performance in football through VO^2max, blood lactate and glocose levels.

METHODS

Study Design

The study was carried out following a rigorous experimental design incorporating both placebo-controlled and double-blind methodologies. At the onset of the investigation, the athletes' body compositions were assessed, followed by the collection of food intake records spanning a period of one week preceding the commencement of the study. To mitigate potential confounding factors that could influence performance in relation to variables such as total energy intake, carbohydrate, fat, protein, and water consumption assessed during participants' pre-test food intake, a standardized one-week nutritional regimen was devised by the dietitian. The athletes were instructed to adhere to this prescribed program. The athletes were categorized into two groups: the placebo group (PLA), which utilized a sweetener-solution for mouth rinsing during the initial test day, and the rinse group (CHO), which employed a solution containing 15% CHO during the subsequent test day. The assessment of the players' endurance performances was conducted indirectly through the utilization of VO_{2max} outcomes derived from the Yo-Yo IR test. Blood glucose and lactate levels were assessed at both the commencement and conclusion of the test. Following the measurement of blood glucose and lactate on the day of testing, participants were instructed to engage in a 15-minute warm-up session. Subsequently, prior to the warm-up phase, immediately preceding the initiation of the Yo-Yo IR test, and once during the mid-point of the test (upon completion of the 1000-meter lap), the athletes executed mouth rinses for a duration of 5 seconds, totaling three rinses throughout the entire test. Upon the termination of the test, blood glucose and lactate measurements were reiterated (Figure 1).

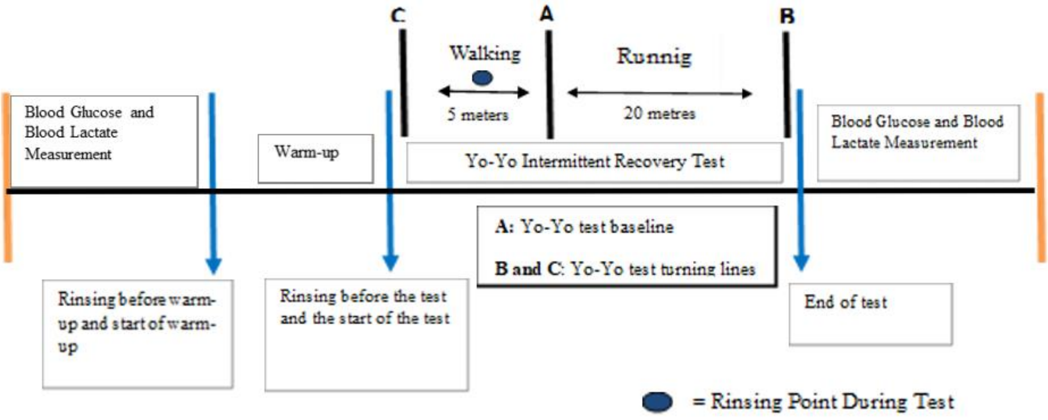

Figure 1. Study design

Participants

The study was conducted on a sample of 20 male football players, aged between 20 and 25, who were actively participating in the Regional Amateur League and exhibited good health status. To determine the sample size, power analysis was conducted using the G*Power (3.1.9.4) program. The power of the study is indicated as 1-β (β = Type II error probability). Based on the results of Cogan and Coyle's (1987) study on reversing fatigue during prolonged exercise through carbohydrate infusion or ingestion, lactate values were found to be 1.7 ± 0.1 in the group infused with carbohydrate (n = 7) and 2.0 ± 0.2 in the group ingesting carbohydrate (n = 7). For calculations aiming to achieve 95% power at α=0.05 level, with an effect size (d) of 1.8973666, it was determined that there should be a minimum of 8 individuals in each group. Ethical approval for the study was obtained from the Clinical Trials Ethics Committee of Marmara University Faculty of Medicine (No: 09.2021.331), adhering to the ethical principles outlined in the Declaration of Helsinki. Prior to the study, participants were provided with information about the objectives of the study, study design, training programs, measurement methods, study responsibilities, and expected medical conditions, and they were asked to sign an informed consent form.

Data Collection

To assess the physical attributes of the participants, their body compositions were assessed. Additionally, the Yo-Yo IR test was conducted to determine their maximal oxygen uptake (VO_{2max}). To examine the potential impact of carbohydrate (CHO) solution on performance, a comprehensive 24-hour food intake record was meticulously maintained. Based on the data derived from these records, participants adhered to individually tailored standardized nutritional regimens devised by a qualified dietitian prior to the commencement of the study. Blood glucose and blood lactate measurements were conducted to assess the physiological responses to exercise.

Evaluation of Body Composition

Height measurement was conducted using a stadiometer (Holtain, England) with a precision error margin of ±1 mm. Body weight, body fat percentage, and fat free mass were assessed using a bioelectrical impedance analyzer (Tanita, TBF 300, Germany) with a precision of ±100 g. Body Mass Index (BMI) was computed by dividing body weight (in kilograms) by the square of height (in meters). The formula for BMI is BMI = Body weight (kg) / $Height^2$ (m).

Assessment of Blood Glucose and Lactate Levels

Dual measurements of blood glucose and lactate levels were conducted for each athlete, encompassing both pre- and post-performance test time points. Blood glucose levels were assessed using a portable blood glucose meter (Accu-chek Performa Nano), whereas blood lactate levels were determined by analyzing blood samples obtained from the fingertip using a portable blood lactate meter (Roche Accutrend).

Dietary Intake Assessment Form

The athletes were instructed to maintain a comprehensive food consumption log for both the week preceding the initiation of the study and throughout its duration. The recorded food consumption data were subsequently analyzed utilizing the BeBIS Nutrition Information System (BeBiS 8-Ebispro for Windows, Germany; Turkish version). This dataset was utilized for assessing the impact of energy intake and the quantities of macro- and micronutrients consumed by athletes on their performance, taking into account both similarities and differences in pre-test conditions. Furthermore, these records served as a basis for informing the development of the nutrition program.

Nutrition Program

Tailored nutrition programs have been formulated with a focus on individual athletes, accounting for their respective training regimens. The determination of daily energy needs entailed the summation of the basal metabolic rate (BMR) computed using the Harris-Benedict formula and the energy expenditure associated with football training (Roza & Shizgal, 1984).

Daily nutrition plans were devised with the consideration that approximately 55-60% of the total daily energy requirement is derived from carbohydrates, less than 30% from fats, and protein intake of 1.5-2 g per kg body weight (constituting 12-15% of energy intake) to mitigate the risk of muscular tissue deterioration (Kerksick et al., 2018; TUBER, 2016).

Yo-Yo Intermittent Recovery Test Protocol

In this study, the assessment of endurance performance was conducted using the Yo-Yo AT1 test, a field-based evaluation tool that has been specifically designed for this purpose (Beelen et al., 2009). At the end of each run of 40 meters, including shuttle run in a distance of 2x20 meters at gradually increasing speeds, the players walked for 10 seconds in the active recovery zone and waited at the baseline. Upon auditory cue, the athletes initiated the subsequent running phase. The test protocol concluded either when the athletes voluntarily withdrew from the test or when they were unable to reach the finish line on two consecutive occasions (Bangsbo et al., 2008).

Determination of Maximum Oxygen Consumption ($VO_{2\,max}$)

The maximal oxygen consumption (VO_2max) value of the participants was estimated according to the AT1 test results with the formula given below:

VO_2max ($mL * kg^{-1} * min^{-1}$) = [AT 1 running distance (m) × 0,0084]+ 36,4 (Bangsbo et al., 2008)

Administration of Placebo and Carbohydrate (CHO) Solution

A solution containing 15% carbohydrate was prepared by adding 75 g of dextrose (proteinocean) in powder form into drinking water (500 ml) of the same brand. The placebo group was provided with a mouth-rinsing solution prepared by combining a sweetening agent with 500 ml of drinking water. Prior to warm-up, prior to initiating the yo-yo IR test, and during the midway point of the test, CHO group rinsed their mouths with 50 ml of a carbohydrate solution containing 15% dextrose and PLA group with a placebo substance that exhibited similar color and taste attributes, achieved through the use of an artificial sweetener.

Limitations of the study

Limitations of the study include the small sample size due to the research being conducted on only one club, the inability to assess athletes' glycogen storage levels before the tests, the lack of investigation into factors such as enzyme activities and hormonal changes in athletes. Additionally, considering that the improvement in performance resulting from rinsing the carbohydrate solution in the mouth is thought to be regulated through the central nervous system, examining the athletes' mood states before the test could have been beneficial.

Research Ethics

Ethical approval was given by the ethics committee of Marmara University, Faculty of Medicine, Clinical Trials Ethics Committee (Project code: 09.2021.331) and written consent was obtained from all participants in the study.

Data Analysis

All data were analyzed with SPSS (statistical package for social sciences) for Windows 22 program. The suitability of the data for a normal distribution was assessed using the Shapiro-Wilk test, along with consideration of other assumptions such as kurtosis and skewness values, as well as examination of a histogram graph. The comparison of two independent groups was conducted using the Mann-Whitney U test and Independent Sample t-test, while the comparison of two dependent groups utilized the Paired Sample t-test and Wilcoxon test. The significance level of 0.05 was employed as a threshold for determining the significance of the obtained values.

RESULTS

Table 1. Descriptive characteristics of the participants

Variables	Min.	Max.	$\overline{X}$±S
Age (years)	20,0	25,0	22,65±1,90
Height (cm)	167,0	189,0	180,15±6,00
BW (kg)	60,0	88,0	73,95±7,48
BMI (kg/m^2)	19,6	25,4	22,74±1,47
Fat percentage (%)	9,0	15,0	11,95±1,76
FFM (kg)	54,6	75,7	64,81±5,63
Duration of football playing (years)	4,0	15,0	10,50±5,23
Weekly training duration (hours)	5,0	21,0	11,30±3,69

Minimum: Minimum, Max: Maximum, X: Mean, S: Standard Deviation BW: Body Weight, FFM: Fat Free Mass, BMI: Body Mass Index

Age, height, body mass, BMI values, body fat percentage and FFM of the athletes (n=20) were 22.65±1.90 years, 180.15±6.00 cm, 73.95±7.48 kg, 22.74±1.47 kg/m2, 11.95±1% and 64.81±5.63 kg, respectively. The mean duration of football playing experience among the athletes was reported as 11.50±5.23 years, whereas the weekly training duration amounted to 11.30±3.69 hours (Table 1).

Table 2. Analysis of nutritional consumption prior to the Yo-Yo test

	PLA Group (n:20)		CHO Group (n:20)		t	p
	Med (Min.-Max.)	$\overline{X}$±S	Med (Min.-Max.)	$\overline{X}$±S		
Energy (kcal)	2000 (1470,15-3359,73)	2244,86±692,82	1834,38 (1256,88-2913,36)	2048,77±528,05	0,70	0,49
CHO (g)	153,68 (95,82-364,30)	197,79±96,78	186,25 (95,03-289,90)	190,94±66,73	0,18	0,86
Protein (g)	89,37 (72,98-131,69)	97,40±20,50	79,35 (58,26-121,50)	80,89±21,09	1,73	0,10
Fat (g)	110,00 (68,99-157,07)	115,77±30,40	101,52 (68,40-154,06)	106,48±30,33	0,67	0,51

* p< 0.05, Main: Minimum, Max: Maximum, X: Mean, S: Standard Deviation, P: Paired Sample t test.

Upon analyzing the dietary intake of athletes prior to the performance test, no statistically significant disparity was found between the two groups across the evaluated variables (p> 0.05; Table 2). Consequently, it was concluded that the athletes received equivalent energy intake before the test and consumed similar proportions of carbohydrates, water, protein, and fat.

Table 3. Findings regarding the comparison of performance based on groups

	PLA Group (n:20)		CHO Group (n:20)		t	p
	Med (Min.-Max.)	$\overline{X}$±S	Med (Min.-Max.)	$\overline{X}$±S		
Yo-Yo test (m)	2970 (1480-3660)	2859,0±705,18	3000 (1500-3640)	2866,00±695,55	0,02	0,97
VO_{2maks}	61,35 (48,83-67,14)	60,45±5,90	61,77 (49,00-66,98)	60,51±5,85	0,02	0,97

* p< 0.05, Main: Minimum, Max: Maximum, X: Mean, S: Standard Deviation, P: Paired Sample t test

Upon comparing the groups based on the mean running distance achieved in the Yo-Yo performance test, it was determined that there was no statistically significant distinction between them (p>0.05; Table 3). Likewise, no significant discrepancy was observed between the groups in terms of the indirectly calculated VO_{2max} values derived from the results of the Yo-Yo performance test.

Table 4. Findings regarding the comparison of blood lactate values based on groups

		Pre-Test		Post-Test			p
		Med (Min.-Max.)	$\overline{X}$±Ss	Med (Min.-Max.)	$\overline{X}$±Ss		
Blood Lactate (mmol)	**PLA Group**	2,80 (1,60-6,80)	3,21±1,89	5,90 (3,10-8,90)	5,87±2,01	*t:-2,29	0,05
	CHO Group	2,00 (1,40-6,00)	2,55±1,47	5,85 (2,20-7,60)	5,38±1,87	*z:-2,91	0,01
		**z:-1,55 p:0,12		**t:0,54 p:0,59			

* p <0.05, Min: Minimum, Max: Maximum, X: Mean, S: Standard Deviation *t: Paired Sample t test **t:Independent Sample t test *z: Wilcoxon test **z:Man Whitney-U test

For the PLA group, there is a statistically significant difference between pre-test and post-test lactate values (t=-2.29; p<0.05). Upon examining the mean values, it was determined that pre-test blood lactate values (3.21±1.89) were lower than the post-test values (5.87±2.01).

The significant difference observed exhibits a large effect size (Cohen's d: 0.763). For the CHO group, there is a statistically significant difference between pre-test and post-test lactate values (z=-2.91; p<0.05). Upon analyzing the median values, it was found that pre-test lactate values (Median: 2) were lower than the post-test values (Median: 5.85). The significant difference observed exhibits a large effect size (r: 0.92). There is no statistically significant difference between pre-test and post-test lactate values among the groups (p>0.05; Table 4).

Table 5. Findings regarding the comparison of blood glucose values based on groups

		Pre-Test		Post-Test			***p***
		Med (Min.-Max.)	**$\bar{X}$±Ss**	**Med (Min.-Max.)**	**$\bar{X}$±Ss**		
Blood Glucose (mg /dl)	**PLA Group**	100 (90-124)	101,33±11,59	105 (94-130)	105,89±12,52	**t:-5,25	*0,01
	CHO Group	92 (81-113)	93,80±10,02	95,50 (89-115)	98,50±8,30	**t:-6,71	*0,01
		***t:1,52 p:0,14		***t:1,53 p:0,14			

* p< 0.05, Min: Minimum, Max: Maximum, X: Mean, S: Standard Deviation **t: Paired Sample t test ***t:Independent Sample t test

For the PLA group, there is a statistically significant difference between pre-test and post-test glucose values (t=-5.25; p<0.05). Upon examining the mean values, it was found that pre-test glucose values (101.33±11.59) were lower than the post-test values (105.89±12.52). The significant difference observed exhibits a large effect size (Cohen's d: 1.75). For the CHO group, there is a statistically significant difference between pre-test and post-test glucose values (t=-6.71; p<0.05). Upon analyzing the mean values, it was determined that pre-test glucose values (93.80±10.02) were lower than the post-test values (98.50±8.30). The significant difference observed exhibits a large effect size (Cohen's d: 2.23). There is no statistically significant difference between pre-test and post-test glucose values among the groups (p>0.05; Table 5).

DISCUSSION

In our investigation, which aimed to explore the impact of mouth rinsing with a CHO solution compared to a placebo solution on endurance performance among football players, no statistically significant difference was observed in the analysis of blood lactate, blood glucose, and VO_{2max} values between the groups. Our study findings demonstrated that the utilization of a 15% CHO solution for rinsing had no discernible impact on endurance performance, as evaluated through the Yo-Yo IR test, among soccer players.

In studies showing that rinsing with a carbohydrate solution (6.4%) in the mouth improves exercise performance (Carter et al., 2004a, Chambers et al., 2009; Pottier et al., 2010; Rollo et al., 2010; Rollo et al., 2008), it has been stated that this improvement in performance may be related to activating the reward part of the brain. Several investigations investigating the influence of mouth rinsing with CHO solution on exercise performance have reported enhancements in exercise performance (Carter et al., 2004a; Chambers et al., 2009; Pottier et al., 2010, Rollo et al., 2010; Rollo et al., 2008), whereas other studies have observed no significant improvements (Bender et al., 2009; Che Muhammed et al., 2014; Chong et al., 2011). The lack of significant impact on endurance performance from mouth rinsing with CHO solutions could potentially be attributed to various factors, coyleincluding the specific sport engaged in, the applied protocol, participants' VO_{2max} levels, the relatively low exercise intensity, the duration of fasting, discrepancies in food consumption and resting values among participants before the tests, as well as the sample size.

In studies that assert improvements in exercise performance through the mouth rinsing of CHO solutions, running (Rollo et al., 2010; Rollo et al., 2008) or cycling exercises (Beelen et al., 2009) were predominantly employed as the performance tests (Carter et al., 2004a; Chambers et al., 2009) In our investigation, the Yo-Yo Intermittent Recovery Test was employed as the performance test to assess the athletes' performance levels under football-specific conditions and to capture the branch-specific physical and physiological parameters. Furthermore, VO_{2max} levels were indirectly estimated through the test. Another contributing factor to the absence of a significant effect on endurance performance in our study is believed to be the variation in the performance test utilized.

In contrast to previous research, our study aimed to investigate the potential impact of increasing the concentration of the carbohydrate solution (15%) on endurance performance. However, administering a hypertonic solution did not yield a statistically significant alteration in endurance performance.

The mean VO_{2max} of the participants in our study was determined to be 60.45±5.90 ml/min/kg. In studies investigating the impact of CHO solution rinsing on performance that reported higher VO_{2max} values among athletes compared to our study, some studies demonstrated performance improvements (Carter et al., 2004a; Chambers et al., 2009; Pottier et al., 2010), whereas other studies did not find similar outcomes (Rollo et al. 2010; Whitham & McKinney, 2007). Given the satisfactory VO_{2max} availability level observed among the athletes in our present study, it can be inferred that the intensity of the exercise does not exert an influence on the outcomes.

In a study investigating the impact of carbohydrate solution rinsing on performance while considering the states of full and hunger, significant enhancements in performance were observed in both conditions (full or hungry), with the athletes having a mean VO_{2max} value of 31±7 ml/min/kg (Fares & Kayser, 2011). In our investigation, upon evaluating the dietary intakes of the athletes as well as their resting blood lactate and glucose levels, it was noted that there were no substantial differences in the resting values within the preceding 24 hours and the quantities of macronutrients and micronutrients consumed in their meals. In contrast to previous studies (Carter et al., 2004a; Chambers et al., 2009; Pottier et al., 2010; Rollo et al., 2010; Rollo et al., 2008) indicating the beneficial impact of mouth rinsing with a CHO solution on exercise performance, our investigation demonstrated that mouth rinsing with a 15% concentration CHO solution had no discernible effect on blood lactate, VO_{2max}, and blood glucose values. These findings suggest that the lack of impact is unrelated to resting values and the retrospective 24-hour food consumption.

The literature encompasses varying outcomes in studies investigating the effects of mouth rinsing with a carbohydrate solution on performance, depending on the duration of fasting. For instance, a study that examined the impact of mouth rinsing with a CHO solution on running performance following a four-hour fasting period (Whitham & McKinney, 2007)) did not reveal any performance enhancement. Conversely, Pottier et al. (2010) demonstrated an improvement in endurance performance during tests conducted after a two-hour fasting period. Despite the aforementioned studies, it is important to note that pre-exercise fasting state could potentially influence the central neural responses associated with the perception of carbohydrates in the oral cavity. In a study conducted by Lane et al. (2013), the effects of mouth rinsing with a carbohydrate solution were compared between participants in a fed and fasted state. A 10% hypertonic carbohydrate solution was utilized, and performance improvements were observed in the tests conducted following overnight fasting. However, this study reported that rinsing a 10% CHO solution in the mouth after a 2-hour fasting period did not have any impact on performance (Lane et al., 2013). In our study, athletes engaged in the exercise protocol after a 2-hour fasting period. Therefore, we posit that the state of hunger did not significantly impact the outcomes of the study.

There is a disparity in findings concerning the effects of rinsing a carbohydrate solution on exercise termination time. In a study investigating the impact of rinsing an isotonic carbohydrate solution at a 6.4% concentration during a 1-hour cycling exercise, it was observed that it had no influence on the duration of exercise completion (Beelen et al., 2009). In a separate study (Carter et al., 2004a), the workload during a cycling exercise was maintained constant, and it was reported that mouth rinsing with a carbohydrate solution had a beneficial impact on exercise completion times. However, our study findings demonstrated no effect of oral rinsing with a carbohydrate solution on endurance performance, contradicting previous studies that suggested improved exercise completion times with CHO solution mouth rinsing.

In the investigation conducted by Sinclair et al. (2014), the impact of rinsing an isotonic carbohydrate solution in the mouth for varying durations (5 or 10 seconds) on performance was examined. The study reported that rinsing CHO in the mouth for 5 seconds did not result in a significant improvement in average power output.

In this study, upon examining the blood lactate and glucose values measured before and after exercise in relation to rinsing the mouth with a 15% carbohydrate, no statistically significant difference was observed. Nevertheless, as anticipated, there was a significant increase in blood glucose and lactate levels during the exercise tests, which can be attributed to the exercise itself. In the study conducted by Pottier et al. (2010), it was observed that mouth rinsing with a carbohydrate solution resulted in elevated blood lactate levels compared to the placebo solution; however, no statistically significant difference was observed between the tests when considering blood glucose levels. In line with our study, previous research (Gam et al., 2013; Whitham & McKinney, 2007) also reported no significant impact of rinsing the mouth with a CHO solution on blood glucose and lactate levels. According to Chambers et al. (2009), it was indicated that the oral rinsing of carbohydrate solutions containing maltodextrin and glucose activates brain regions associated with reward and leads to performance enhancement.

In conclusion, despite previous explanations of the positive effects associated with carbohydrate presence in the oral cavity, such as performance enhancement, reduced perceived exertion, mitigation of motor skill inhibition, and alleviation of central fatigue, the current study revealed that the mouth rinsing of a 15% carbohydrate solution had no significant impact on VO_{2max}, blood lactate, and blood glucose levels in football players.

Future investigations may consider assessing the athletes' glycogen storage levels prior to conducting the tests. Furthermore, a more comprehensive experimental protocol can be conducted to elucidate factors such as enzyme activities and hormonal changes that provide insights into the observed phenomena. Given that the enhancement in performance associated with mouth rinsing of carbohydrate solution is mediated by the central nervous system, it may be worthwhile to assess the emotional states of participating athletes prior to the test in future studies.

Acknowledgements
The authors would like to thank all athletes who participated in the study, and sports club for their collaboration.

Disclosure statement
No potential conflict of interest was reported by the author(s).

Author Contributions
BM and MKY designed the study research design. MKY supervised the study BM collected and analysed the data. All authors prepared and approved the final manuscript.

Additional information
This study was supported by a research grant from Marmara University Scientific Research Projects Coordination Unit (BABKO) with Project code: TYL-2021-10297.

Ethics Committee Approval
Committee Name: Marmara University, Faculty of Medicine, Clinical Trials Ethics Committee, Istanbul.
Date: 15.03.2021
Protocol number: 09.2021.331

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