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Original article

The effects of carbohydrate mouth rinsing on upper body strength and muscular endurance performance

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Abstract. The purpose of this research was to examine the effect of rinsing of carbohydrate in the mouth on bench press strength and endurance performance in resistance-trained athletes. 15 men (Age: 21.6 ± 1,3 years, Height: 181.2 ± 10,0 cm, Body Weight: 83.3 ±14.4 kg), who performed upper-body resistance training at least 5 days a week for the last 1 year, participated in this research. After the familiarization test day, participants took part in a total of 2 test days with a randomized, counterbalanced, crossover study design: 6% (1.5 gr) weight / volume (w/v) carbohydrate mouth rinsing (cho) with 25 ml water or mouth rinse with water (PLA). After a 10-hour night fasting, with olympic barbell bar, one repetition maximum (1RM) of participants was determined to evaluate upper body strength, immediately before 1RM attempt participants rinsed the solution. Muscular endurance was measured by lifting 40% of 1RM until exhaustion in 3 sets. 3 min of passive rest was allowed between sets and at the beginning of each minute mouth rinsing was applied. During the test protocol heart rate (HR), lactate (LA), glucose (GL), arousal (AR) and ratings of perceived exertion (RPE) were measured. Paired Samples T-test and two-way repeated measures ANOVA were used for data analysis. No significant differences were detected between the trials in the values of upper-body strength (p=0.43), muscular endurance (for repetition number, p=0.57; for total kg, p=0.43), HR (p=0.71), LA (p=0.42), GL (p=0.36), AR (p=0.19) and RPE (p=0.51).

Key words: Supplement, Mouth rinse, Ergogenic aid, Strength

Introduction

Carbohydrate (Cho) ingestion improves long-term (>2 hours) endurance exercises by mechanisms of optimizing blood glucose concentration, sparing muscle glycogen storages for later use through the end of exercise and increasing exogenous cho oxidation (1). However, subsequent studies have shown that Cho ingestion is not a risk factor for the performance decline of metabolic factors, and increases short-term high-intensity exercise performance. (2). By hypothesizing that the ergogenic mechanisms of Cho ingestion may be central not only metabolic, it was reported that the effect of 10-second rinsing with 6.4% Cho solution on time-trial performance was examined in elite runners and significantly increased the performance (3). Chambers et al. (4) by using functional magnetic resonance imaging (fMRI) technique reported that rinsing maltodextrin or glucose in the mouth increased the activation of the brain areas responsible for motor control and reward (insula/operculum frontal, orbitofrontal cortex, and striatum). Researches have stated that rinsing Cho for 5-10 seconds independently of taste (glucose or maltodextrin) in the mouth during endurance exercise decreased the rating of perceived exertion (RPE) and, increased muscle activation and mental performance (5,6).

For the athletes with gastrointestinal problems due to Cho ingestion before and/or after exercise, Cho mouth rinsing without ingestion is becoming increasingly common as an alternative method. There are studies reporting that it may lead to improve short-term high-intensity exercise performance besides increasing endurance exercise performance (7). It is known that Cho mouth rinsing improves the performance of maximal voluntary contraction of the elbow flexors by increasing corticomotor excitability (8). Increasing the skeletal muscle power production in this way has the potential to improve performance also during resistance exercises in which high power output is needed. Bastos-Silva et al. (9), reported that Cho mouth rinsing significantly increased the number of repetitions of bench press exercise at 80% of 1RM in elite resistance-trained subjects. It is also stated that the muscular endurance performance of bench press and squat exercises at 60% of 1-RM during the early morning hours significantly increased by Cho rinsing (10). Contrary to these results, Painelli et al. (11) found that Cho mouth rinse did not increase the performance of 1RM strength and a 6-set muscular endurance at 70% of 1-RM in strength-trained young men. They asserted that even though Cho mouth rinse was able to stimulate the reward and/or motivation centers in the brain, this stimulus was not strong enough to improve strength performance. Also, it was reported that being the resistance-trained of the participants might affect the results. It is known from the previous studies that there are almost no neural activation deficits during maximal voluntary contraction in resistance-trained athletes (12). Cho mouth rinse might enhance motivation more, which was able to increase the neural drive to the muscle, in untrained subjects (11). In another study conducted on recreationally resistance-trained men, it was detected that Cho mouth rinse did not improve the 1RM strength and muscular endurance performance at 40% of 1RM (13).

The results of the studies in the literature differ due to methodological diversity. Various factors such as the measurement accuracy of the tests, the lack of control of the eccentric-concentric contraction speeds in the bench press endurance test in many studies, differences in the set number, in intensity of endurance test (40-60-70% of 1RM) and in training status of the participants may explain the diversity of findings. In addition to these factors, duration, dose and number of Cho mouth rinse can be considered as determinants of the ergogenic effect (14). Sinclair et al. (15) tested the effects of mouth rinse with 6.4% Cho solution for 5 or 10 seconds on the 30-minute time trial cycling performance and found a significant difference in 10-second mouth rinse. Also, 60-70% of 1RM was used in muscular endurance protocols in the applied researches and significant effect was not found. As in aerobic endurance tests, it can be suggested that the effect size of Cho mouth rinsing may increase by reducing the intensity of the muscle endurance tests (20-40% of 1RM) and extending the duration of protocol (16). In another study, Cho was rinsed in the mouth only one time before the strength and muscular endurance measurements and significant effect was not observed (17). It is known that increasing the frequency of cho mouth rinsing before the test improves high-intensity exercise performance (18).

This study was designed as an extension of the literature investigating the effects of Cho mouth rinsing on exercise performance. The intensity of the upper body muscular endurance test (40% of 1RM) was reduced and the duration of the test was extended by increasing the number of sets. Further, the frequency of cho mouth rinsing during rest periods between sets was increased. Exercise velocities were standardized as 2-second eccentric and 2-second concentric contractions. The purpose of this study was to examine the effect of Cho mouth rinsing on upper body strength and endurance performance. The hypothesis that Cho mouth rinsing improves strength and muscular endurance was tested.

Method

Research Group

15 men (Age: 21.6 ± 1,3 years, Height: 181.2 ± 10,0 cm, Body Weight: 83.3 ±14.4 kg) who perform resistance training 2 hours a day at least 5 days a week in the last 1 year participated in this study. They corresponded to intermediate strength-trained athlete's classification of the National Strength and Conditioning Association (19). After informing participants about the test protocol and potential risks, written

informed consent was obtained. The study was approved by the Ankara University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee (decision no. 13-916-18).

Research Design

Before strength and endurance tests, body composition measurements were taken and familiarization tests were applied to eliminate the learning effect. The participants were instructed not to consume alcohol and caffeine, and to avoid performing physical activity in the last 24 hours. They were asked to record their diets in the last 24 hours before the familiarization test and asked to repeat this diet in the last 24 hours before the next test days. In the test morning, whether they accord with the protocol of the last 24 hours was orally asked and confirmed. All tests were performed in the morning (07:00-09:00) after night-long fasting. There were 2-5 days between the test days. Subjects participated in a total of 2 test days with a randomized, counterbalanced, crossover and single-blind study design: 1) CHO: 6% weight/volume (1.5 gr) maltodextrin mouth rinse (Fantomalt, Nutricia, UK), 2-) PLA: placebo (water) rinse. Solutions were prepared in 25 ml water by masking with sucralose (200 mg). To measure the amount of maltodextrin and sucralose in the solutions, an electronic scale with a precision of 1 milligram was used. For upper body strength measurement, 1RM on the bench-press exercise was determined. As for the muscular endurance value (a-) repetition number and b-) repetition number x weight), it was determined by maintaining to lift weight at 40% of 1RM until exhaustion. The test protocol is schematically as in Figure 1.

Muscular Endurance Measurement

After 5-min warming-up on the treadmill, the 1RM bench press of participants was determined by the protocol of Earle and Baechle (20). According to the protocol, participants performed 10 repetitions with the weightless bar (Eleiko, Halmstad, Sweden) and rested for 1 minute. By increasing the load (Eleiko Olympic Disc) by 10%, 3 repetitions were performed and a 2-min rest was allowed. Then, a weight close to the estimated maximal of the participant was selected and 2 repetitions were performed, and 3 minutes rest was given. Weight was increased by 5-10% and the participant was asked to perform 1RM attempt. When the participant could lift the weight with the right technique, the weight was increased by 5-10% again, and 1RM attemp was performed and 3 min rest was allowed. When the participant failed to perform the 1RM attempt, the weight was reduced by 2.5-5% and the participant was asked to perform 1RM attempt again. This process continued until 1RM value of the participant was determined. After detecting 1RM, 3 min passive recovery was given and then muscular endurance was tested by continuing to lift the weight at 40% of 1RM until exhaustion. In the muscular endurance test consisting of 3 sets, 3 min passive rest was allowed between the sets. The repetition velocity of the contractions was determined as 2 seconds eccentric and 2 seconds concentric with a metronome, and on the familiarization test day the participants were given instant feedback during the repetitions to accord with this velocity. The participants rinsed the solutions in the mouth for 10 seconds immediately before 1RM attempt and with 1-minute intervals during the passive rest before the muscular endurance test. The variables of heart rate (Hr) (Polar Team 2, Finland), capillary lactate (La), glucose (Glu) (Accutrend Plus Roche, Germany), ratings of perceived exertion (Rpe) (6-20 Borg scale) and arousal (Ar) (Svebak 1-6) were measured at different time points in the test protocol.

Statistical Analysis

IBM SPSS version 22.0 software was used for data analysis. After applying descriptive statistics, strength differences between the trials were tested by the Paired Samples T-test, while muscular endurance and the values of Hr, La, Glu, Ar and Rpe were tested by two-way analysis of variance in repeated measures. The sphericity assumption was tested by the Mauchly test. In the case of violation of the sphericity assumption, the Greenhouse-Geisser correction was applied for epsilon less than 0.75, while the Huynh-Feldt correction was applied for epsilon greater than 0.75. Partial eta square (η_p^2) was used to calculate the effect size. Alpha value was accepted as 0.05 for all analyzes.

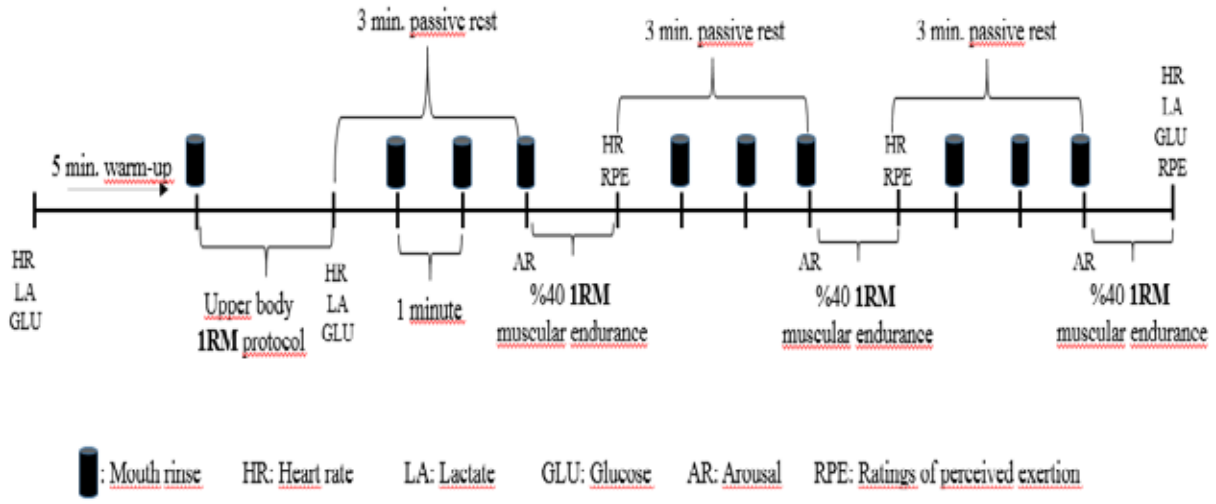

Figure 1. Upper body strength and muscular endurance test protocol

Results

Cho mouth rinse did not have a significant effect on the values of bench press strength (p=0.435). The strength value was found as 98.21 kg in the Cho trial and 97.50 kg in the PLA trial. The variable of strength did not show a significant difference between the trials (p> 0.05) and were shown in Figure 2.

The muscular endurance values (number of repetitions) were detected 25.21 in 1.set, 18.57 in 2.set, 15.35 in 3.set for the Cho trial. As for the PLA trial, they were found as 25.14 in 1.set, 18.14 in 2. Set, 15.85 in 3.set. As expected, repetition numbers for the Cho and Pla trials significantly decreased with time through the end of test protocol (p<0.05) respectively. However, the number of repetitions did not differ significantly between the trials (p=0.571, η_p^2=0.034) as seen in Figure 3.Muscular endurance (kg) for the Cho and Pla trials significantly decreased with time through the end of test protocol (p>0.05) respectively. The Cho trial had no significant effect on muscular endurance (kg) values (total kg, p=0.430, η_p^2=0.057). Similarly, Rpe for the Cho and Pla trials significantly increased with time through the end of test protocol (p<0.05) and was not significantly different between the trials (p=0.517 η_p^2=0.040). Muscular endurance (kg) and Rpe variables were shown in Figures 4 and 5, respectively. As it is seen in table 1, La and Hr values were significantly increased at the end of test protocol compared to rest (p>0.05), however, no significant difference were detected between trials as for La (p=0.425 η_p^2=0.064) and Hr (p=0.715 η_p^2=0.039). Glu (p=0.366 η_p^2=0.074) and Ar (p=0.195 η_p^2=0.118) levels didn't differ between trials and with time (p>0.05).

Discussion

The purpose of this study was to investigate the effect of rinsing of carbohydrate in the mouth on bench press strength and endurance performance. Contrary to our hypothesis, Cho mouth rinsing did not improve bench press strength and endurance performance. Also, it did not show a significant effect on the variables of rpe, heart rate, capillary glucose and lactate, and arousal measured at different time points in the test protocol.

The ergogenic mechanism of Cho mouth rinsing is the stimulation of the cerebral cortex through Cho-sensitive receptors in the oral cavity, resulting in an increase in sensorimotor cortex activation and an increase in motor output and performance (21). Results confirming this mechanism are available in the literature (5). Sinclair et al. (22) examined the effects

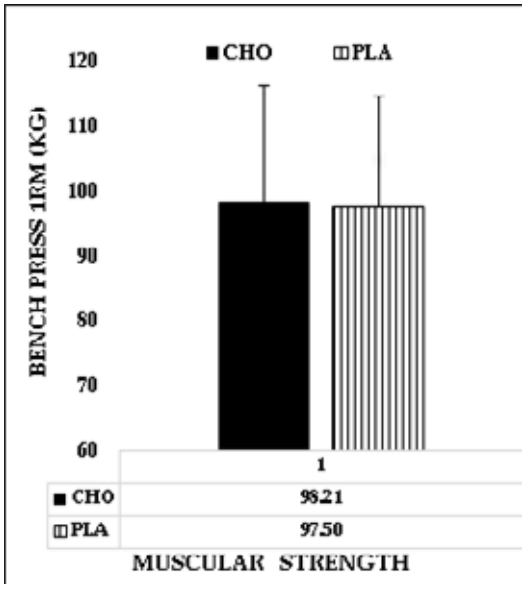

Figure 2. Strength

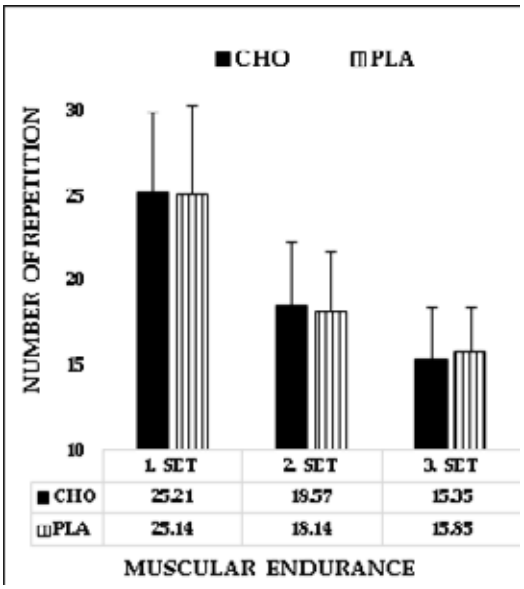

Figure 3. Muscular endurance

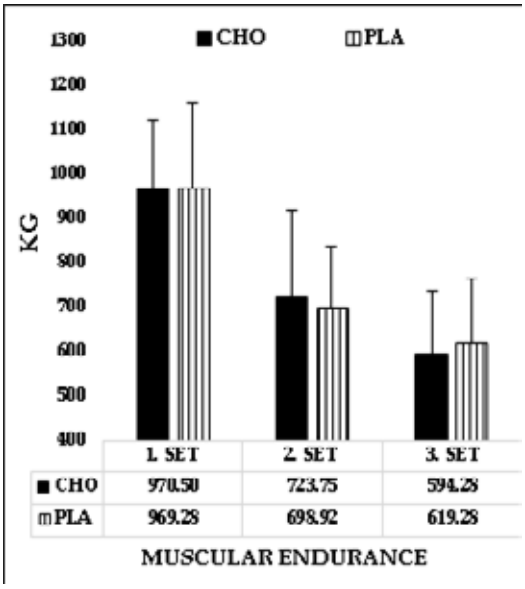

Figure 4. Muscular endurance (kg)

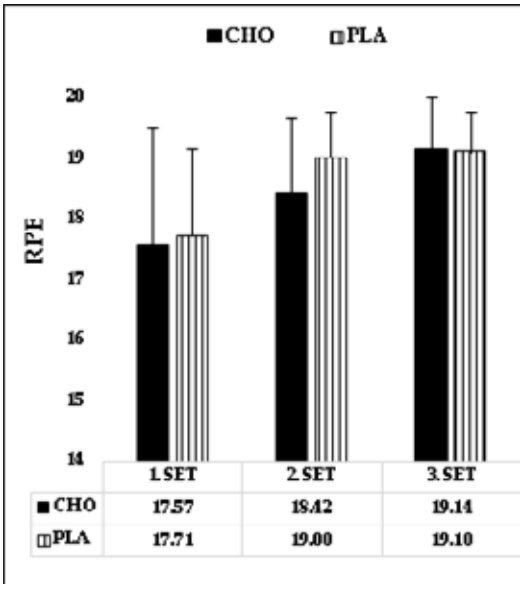

Figure 5. Rpe

of mouth rinsing a 6.4% Cho solution on the upper-body muscular endurance performance in their study and reported that Cho trial showed significant difference (a 17% improvement) in the 30-minute time trial performance on an arm ergometer compared to the placebo trial. The ergogenic effect of Cho mouth rinsing is commonly shown for lower body muscular endurance performance and this improvement is reported as averagely 2-3% (23). The factors such as higher percentage of type-2 muscle fiber distribution of the upper body when compared with lower body and relatively high carbohydrate usage are regarded as the reasons for the differences between the percentage increase of upper and lower body muscular endurance

Table 1 Mean and Standart Deviations of La, Glu, Ar and Hr

	CHO	PLA
Lactate (mmol/L)		
Rest	1.50 ± 0.62	1.30 ± 0.50
After 1RM	2.38 ± 0.95	2.50 ± 0.91
Post-test	8.02 ± 1.48	8.45 ± 1.43
Glucose (mg/dL)		
Rest	86.14 ± 10.53	85.50 ± 10.88
After 1RM	86.64 ± 14.84	89.78 ± 9.76
Post-test	89.78 ± 10.54	85.71 ± 8.25
Arousal (1-6)		
Before 1. set	4.28 ± 1.06	4.28 ± 0.91
Before 2. set	4.00 ± 1.30	4.50 ± 1.09
Before 3. set	4.07 ± 1.20	4.50 ± 0.94
Heart Rate		
Rest	63.21 ± 8,71	66.14 ± 10.09
After 1RM	115.28 ± 14,60	118.71 ± 13.80
After 1. set	128.28 ± 16,40	130.85 ± 12.47
After 2. set	131.35 ± 17,09	133.57 ± 17.87
After 3. set	135.78 ± 18,08	134.00 ± 16.01

performance (22). In the present study, the intensity of the muscular endurance test (40% of 1RM) was reduced and the duration of the test was extended, thus it was hypothesized that the ergogenic effect of Cho mouth rinsing can increase. The average number of repetitions is 20 in 3 sets and the time under tension is 80 seconds in this study. Considering the study by Sinclair et al. (15) the effect of Cho mouth rinsing on muscular endurance can be examined during a training period consisting of 8-10 strength exercises.

In this study, 6% (w/v) Cho was rinsed in the mouth. A dose-response relationship was not found in the studies in the literature (24,16). However, in most of the dose-response studies, time-trial endurance performance was tested. Cho mouth rinsing improves the performance by increasing the activation of the reward-motivation centers in the brain and decreasing the Rpe during long-term endurance exercise. This improvement is not directly proportional to the dose of Cho rinsed in the mouth (16). In another study examining the dose-response relationship, Kulaksız et al. (25) tested the effects of Cho mouth rinsing with different concentrations (3%, 6% and 12%) on time trial performance and reported that Cho mouth rinsing did not improve endurance performance compared to placebo. However, as the performance improvements of endurance and strength occur with different mechanisms, high doses (12%-18% w/v) of Cho mouth rinsing may increase the power output by stimulating the motor cortex more strongly. Therefore, the effect of mouth rinsing with different doses of Cho solutions on 1RM strength and muscular endurance performance can be examined in future studies. Also, in some studies, Cho mouth rinsing increased lower-body muscular activation, even though it did not significantly improve the performance (5). The ergogenic effect of Cho mouth rinsing may be examined by evaluating muscle activation with more sensitive ergometers for strength measurement. One reason for the lack of significant effect of Cho mouth rinse in this study may be the difference in muscle activation level between upper and lower body. It is known that muscle activation level of knee extensors is between 85-95% during maximal voluntary contraction, but that is 90-99% in upper body muscle groups. (26). Considering the ergogenic mechanisms of Cho mouth rinsing, it is less likely to observe a performance increase in upper body muscle groups with a percentage of muscle activation close to 100% compared to lower body muscle groups. This circumstance can be tested by examining the effect of Cho mouth rinsing on the lower and upper body muscular strength and endurance performance.

Although Cho mouth rinsing did not have a significant effect on strength and muscle endurance performance at 40-60% of 1RM, Bastos-Silva et al. (9) reported a significant increase in muscular endurance performance at 80% of 1RM in strength-trained athletes. It is not completely known yet how the intensity of endurance exercise affects the magnitude of the ergogenic effect of Cho mouth rinsing. The magnitude of the daily variation of muscular endurance performance may make the effect of Cho mouth rinsing undetectable which was already small. Bastos- Silva et al. (9) detected the number of repetitions of the bench press as 8.2 in the Cho trial, 7.1 in the placebo trial and 6.8 in the control trial. The difference in the number of repetitions between Cho and Control trials was 1.4 and it was statistically significant. No significant difference was found between the Placebo and Cho trials.

The results of this research should be evaluated more carefully. Similarly, in the previous studies conducted in our laboratory, the Cho trial did not show a significant difference compared to placebo, but it was found significantly different from the Control trial. (27,28). In the studies related to nutritional ergogenic aids, exercise performances of athletes may show differences in the trials without any supplements compared to the trials with any kind of supplements due to the psychological reasons. In future studies, the effect of Cho mouth rinsing in the same research design on muscular endurance performance at 40% and 80% of 1RM can be compared.

Conclusion

This study revealed that 6% (w/v) Cho mouth rinsing did not significantly increase bench press strength and muscular endurance performance and also did not affect blood lactate, glucose, RPE and arousal variables in intermediate level resistance-trained males. Male resistance-trained athletes should consider when using cho rinse strategy in training or competition. Moreover, its effects on female and untrained athletes are not known much. More research is needed on this topic.

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