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# Effects of Carbohydrate and Caffeine Mouth Rinsing Methods on Repetitive Kick Force and Duration, and Hand Reaction Time in Karate Athletes[*]

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## Abstract

The effect of carbohydrate (CHO) and caffeine (CAF) solutions rinsing in the mouth in combat sports where high-intensity movements are performed intermittently despite fatigue is unknown. This research was carried out to investigate the effects of rinsing CHO and CAF solutions in the mouth on kick force, duration, and hand reaction time in karate athletes. 16 male trained karate players (average age 21.6 years, weekly training time 8.4 hours, training experience 7.8 years) voluntarily participated in the study. In a replicated, double-blind, placebo-controlled, and crossover design study, after the 10 seconds mouth rinsing of CHO (6.4% maltodextrin), CAF (1.2%), and placebo (water) solutions in sessions, repeated sprint test (6sec sprint ×10 repetitions, with 30sec rest) on a bicycle ergometer, after light stimuli kick test (consecutive 5 times), hand reaction time test (consecutive 5 times), kick test (consecutive 5 times), hand reaction time test (consecutive 5 times) were performed respectively. The results obtained from the tests in the constructed protocol by causing fatigue (peak power, average power, minimum power, power drop; kicking reaction time, strength, power, and time; hand reaction time) were compared between sessions. The highest peak power and average power outputs (W/kg) obtained from the repeated sprint test were obtained in the CAF session, and the best kick and hand reaction times (ms) were obtained in the CAF session in the 2nd set of tests. The results obtained from this study suggest that the CAF mouth rinsing method can improve kick and hand reaction time despite fatigue in karate competitions.
**Keywords:** Kick power, Mouth wash, Power output, Reaction time

[*] This article is based on the doctoral thesis of the first author.
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## INTRODUCTION

The oral cavity is sensitive to many tastes. Taste receptors in the mouth activate the nervous system at the peripheral level, which transmits signals to relevant areas of the cerebral cortex to produce an appropriate response. The mouth rinsing method is an ergogenic aid in sports, and it is defined as a method of circulating a liquid in the buccal cavity for a short time without swallowing and expelling it through spitting (Carter et al., 2004). The caffeine (CAF) or carbohydrate (CHO) rinsing method in the mouth has become increasingly popular in sports, as it is a method that avoids the side effects that may occur with the consumption of the supplements, as well as the positive effects observed on sports performance by rinsing the nutritional supplement in the mouth (Ehlert et al., 2020; Mark et al., 2019).

It has been reported that rinsing a liquid containing 6% CHO in the mouth can increase especially for about one-hour endurance performance by 2-3% (Carter et al., 2004; Chambers et al., 2009; Fares & Kayser, 2011; Lane et al., 2012; Pottier et al., 2010; Rollo et al., 2008). It has been observed that high-intensity interval exercises also have a significant effect, especially in the late stages of an exercise. Moreover, in addition to having some cognitive benefits, it also provides improvements in the rate of perceived exertion level (RPE) and motor skills during exercise (Anantaraman et al., 1995; Ball et al., 1995; Pomportes & Brisswalter, 2020). A 5-second CHO mouth rinse in cyclists was found to be more effective than a placebo on peak power and mean power output of the first sprint (+22.1 W and +39.1 W, respectively) in 5 x 6-second sprint performance (with 24 seconds of active recovery) (Beaven et al., 2013). Additionally, rinsing 25 ml of a solution containing 6% maltodextrin has significantly increased 5-second peak power output (+2.3%) during 30-second repetitive sprinting against resistance on a bicycle ergometer (Gant et al., 2010). Another study reported that 10 seconds of CHO mouth rinsing showed a smaller decrease in peak and mean torque of isometric maximal voluntary contraction during knee extension performed immediately after fatigue (Jensen et al., 2015). These findings have been explained by a mechanism by which oral CHO receptors activate the insular and motor cortices, stimulating neuromuscular pathways and improving performance (Chambers et al., 2009).

CAF is another substance believed to increase performance by rinsing the mixed solution in the mouth, activating taste receptors, and stimulating the central nervous system (Guest et al., 2021). Studies about CAF mouth rinsing to improve physical performance have been observed to show a mixed effect, and these results have been interpreted as being attributable to the studies' different methodological approaches (e.g., different CAF concentrations, exercise types, and nutritional status). Compared to the placebo solution, CAF mouth rinse failed the Wingate anaerobic sprint test (Karayiğit et al., 2017; Marinho et al., 2020) and on the Bench press movement at one repetition maximum (1RM) test or 60% of 1RM test until exhaustion (Clarke & Duncan, 2016). The Taekwondo Anaerobic Intermittent Kicking Test was applied to 27 Taekwondo athletes, and the percentage of successful kicks was found to be significantly higher with the CAF mouth rinse method compared to glucose and placebo conditions in the first three weeks of Ramadan (Pak et al., 2020). The effect of CAF mouth rinsing on cognitive performance appears to be particularly positive compared to placebo, it leads to a reduction in mental fatigue (Van Cutsem et al., 2018) and reaction time (De Pauw et al., 2015) and an increase in cognitive control (Pomportes et al., 2017). CAF is believed to provide a performance-enhancing effect on the central nervous system by blocking adenosine receptors and increasing neural excitability (Walton et al., 2003). RPE and pain may be reduced in this way (Pataky et al., 2016). The second mechanism of action is the activation of bitter taste receptors in the mouth, which are directly connected to the brain regions involved in information processing and reward, by CAF (Gam et al., 2014).

In karate, kumite is a controlled encounter in which two opponents compete within certain rules, including punching, kicking, and dropping techniques. It has been reported that a karate competition lasts 2-4 minutes, where high-intensity movements are performed intermittently, anaerobic energy sources (ATP-PCr and anaerobic glycolysis) are mostly used in the movements and explosive force affects the techniques that determine the score (Glaister, 2005). Considering karate's characteristic features and competition environment, sudden attacks, techniques, and tactics are applied with endurance (Güzel et al., 2010). The reaction time must be short despite the fatigue caused by fast arm and leg technical combinations in dynamic combat.

Neuromuscular fatigue is defined as a decrease in strength or power resulting from any exercise or activity, regardless of the inability to sustain the assigned task (Boyas & Guevel, 2011). The most common type of sprint exercise used to examine neuromuscular fatigue is movements involving the legs (Gist et al., 2014), and repetitive sprints performed with leg movements in many studies are an adequate type of exercise to examine neuromuscular fatigue in the lower extremities (Duffield et al., 2009; Monks et al., 2017). Reaction time is the speed between giving a signal and initiating the movement consciously and depends on neurophysiological characteristics (Jain et al., 2015; Sperdin et al., 2009).

The number of studies showing the effects of CAF and CHO mouth rinsing methods on exercise performances is limited, and no study has been found showing the ergogenic impact of these methods on the force and duration of repetitive kicks in combat sports. The aim of this study, which was designed with the hypothesis that the CAF mouth rinsing method will be more effective on hand and kick reaction time than the CHO rinsing and placebo, is to investigate the effects of rinsing a solution containing CHO and CAF on the repetitive kick force, duration, and hand reaction time in karate athletes.

## METHOD

### Research Model

A repeated, double-blind, placebo-controlled, and crossover-designed laboratory study

### Sampling

16 male karate athletes were trained in the Kumite (between the ages of 18-30, participating in training for at least 45 minutes at least four days a week, and at least five years of training experience). They participated in national and international competitions and did not have any injuries.

Exclusion criteria from the study were determined as follows:

1. Not being able to participate in all the tests to be carried out within the scope of the research.
2. Failure to comply with the necessary protocols for tests and measurements.
3. Getting ill or injured during research.

### Data Collection Tools

In the familiarization session, the study design (Table 1) was introduced, and test trials were attempted for the participants to get used to the test equipment, environment, and researchers. The athletes' training levels and competition levels were obtained using the athlete information form, and information about their general health and injury status was obtained using the athlete health examination form.

The participants' height was measured with a height meter (Seca 769, Germany) with a sensitivity of 0.1 cm, with the head in the frontal axis and the overhead table touching the vertex point, feet bare, back, and attached to the height measurement rod. During the measurement, participants were asked to take a deep breath and hold it. Body mass was measured with a portable scale (Seca, Germany) with an accuracy of 0.1 kg, without shoes and wearing shorts and a T-shirt. Athletes were asked to stand in an upright position with their arms at their sides (anatomical stance), with both soles touching the ground.

In the test sessions, after the mouth rinsing application, the repetitive sprint test, repetitive kick force, duration test, kick reaction time test, and hand reaction time test were performed, respectively.

Participants were asked to come to the laboratory at least 48 hours apart for each session on the measurement day, to be rested, to have eaten at least 3 hours before, to have drunk an average of 500 ml of water, and to avoid alcohol, cigarettes, and caffeine consumption.

**Table 1.** Flow chart of the study design

| Familiarization Session | Test Sessions |
|---|---|
| Familiarization with the tests | 1. Resting heart rate (HR) and RPE |
| Height, body mass, body fat ratio measurement | Application of mouth rinse method |
| Athlete information form | 2. HR and RPE |
| Athlete health examination form | Repetitive sprint test |
| Mouth rinsing practice | 3. HR and RPE |
| | Repetitive kick force, duration, & kick reaction time tests |
| | Hand reaction time test |
| | 4. HR and RPE |
| | Repetitive kick force, duration, & kick reaction time tests |
| | Hand reaction time test |
| | 5. HR and RPE |

## Mouth Rinse application

Participants were asked to rinse 25 ml of various solutions in the mouth for 10 seconds in different sessions: CHO (6.4% maltodextrin solution), CAF (1.2% caffeine solution), and placebo (water). Non-caloric sweetener was added to all solutions administered to the participants to make them taste similar.

25ml water × 6.4% CHO = 1.6gr powdered maltodextrin and 25ml water × 1.2% CAF = 0.3gr (300 mg) powdered CAF (equivalent to 1.5 capsule powder content) for each participant in each application. It was prepared in graduated tubes (Falkon Izolap Sterile Tube). The solution rinsed in the mouth was spit back into the graduated tube to check whether the solution was swallowed.

Maltodextrin (TITO) is a food supplement product in powder form, it is a tasteless and easily digestible CHO, usually obtained from corn starch. It is used in many fast foods and in sports drinks, which are considered functional food products. Maltodextrin can also be obtained from potatoes, wheat, barley, rye, and oats.

CAF (Nature's Supreme) is a food supplement in capsule powder form. It has effects that stimulate the central nervous system and ensure alertness. It is considered normal for daily CAF intake to be 250-400 mg.

Sucralose-based table sweetener (Splenda Sweetener), one tablet is equivalent to 2 kcal of sugar (sucrose). It is widely used as a sugar substitute and does not contain aspartame and saccharin. It can be used in hot and cold drinks.

## Repetitive sprint test

It was carried out by participants pedaling (sprinting) at the fastest speed of 10 × 6 seconds on a bicycle ergometer (Monark Ergomedic 894E, Monark, Sweden) at a load corresponding to 0.05 kg per body mass (kg). There was a 30-second interval between all out sprints, and these resting breaks were spent cycling at low speed. The average rpm reached in the repeated sprints performed in the sessions were for CAF: 149.5, CHO: 144.2, and PLA: 147.2. Verbal motivation was provided during sprints. With this test, peak power (PP: W and W/kg), average power (AP: W and W/kg), minimum power (MP: W and W/kg), and power drop (PD: %) were determined. The arithmetic means of the data obtained through sprints repeated ten times was taken. Before the test, a standard warm-up protocol was applied, including pedaling on an ergometer for ~5 minutes at low tempo, ~1 minute at increasing speeds, and ~4 minutes of dynamic stretching for the lower extremities.

**Kick force and duration test & Kick reaction time test**

A free-standing kick-boxing stand (safeguard) was used as a target to obtain repetitive kick force and duration data, directly opposite the athlete, at a height of 170 cm from the ground and 200 cm away from the athlete. The camera was positioned in such a way that the full impact of the kick was visible on the boxing stand. Footage of the movement was recorded with a GoPro Hero 4+ Black camera (GoPro, Inc., San Mateo, CA, USA) 720p 240 fps full frame. The recorded kick images were analyzed with motion analysis (Kinovea 0.9.3) software (Picture 1).

For the kick reaction test, an electronic reaction measurement device was designed that gives an audible and light warning, consisting of a red LED light placed on the head of the kick-boxing stand, at the eye level of the participants, and two separate green and red buttons connected to the pressure sensor placed under the right feet of the participants. Participants positioned themselves so that their kicking feet were on the pressure sensor connected to the reaction device on the floor. After the system was started, they were asked to respond by kicking the red LED light that turned on at the end of a random period of 1-5 seconds after the audio stimulus was heard. The other foot of the participants was positioned in the suplex position in karate. The time between the red LED light turning on and the lifting of the right foot from the pressure sensor on the ground was considered as the kick reaction time. The time was recorded on the screen by the device. The practitioner manually pressed the start button from a place out of sight of the receiver athlete on the sensor, and an audible warning was given to them to wait in the ready position. The reaction device gives values of 1/1000 second (ms).

**Picture 1.** Repetitive kick force and duration test (Source: Captured by authors.)

To determine the validity and reliability of the kick reaction time test device, the suitability of the data for normal distribution was evaluated with the Kolmogorov-Smirnov test. The level of correlation between the reaction times obtained from the created device and the camera was determined by Spearman's rank correlation coefficient test ($r=0.912$ and $p<0.000$). The coefficient of variation of the results obtained from the device was calculated with the formula CV = Standard deviation / mean × 100 using Microsoft Excel software. Cronbach's alpha coefficient (0.927) was calculated for internal consistency. The validity (ICC: 0.912, CV: 7.4%) and reliability ($R^2$ = 0.750) of the device were found to be within accepted limits.

The repetitive kicking test was repeated after the hand reaction test. The arithmetic means of all data obtained from the measurements and calculations made for five kicks in each set was taken. For video recording of kicking movements, a camera recording at 240 frames/sec was selected, and the location and height of the camera were fixed. Lighting equipment was placed behind the video camera to illuminate the area where the movement took place. The sharpness adjustment and calibration of the video camera were made before the shooting. The calibration rod was positioned at a 90º angle to the area where the movement would be performed, and calibration images were recorded as 33 cm on the Kinovea program. The kicks (Mawashi back) that the participants applied to the marked kick point on the kick-boxing stand during the test were obtained in two-dimensional (2D) using this program, the spatial position data in cm of the points determined on each square image. The data obtained from the marked point in the study was filtered using the MATLAB (MathWorks, USA) program using a 3rd order low pass digital filter (Butterworth) with a cutoff frequency of 12 Hz. The average speed (m/s) and average acceleration ($m/s^2$) were obtained by taking the arithmetic means of the velocity (x, y) and acceleration (x, y) data in the 5-frame image backward from the impact point determined on Excel (Gordon et al., 2014). Calculation of participants' foot mass was obtained by multiplying body mass (kg) by the segmental (foot) mass ratio (0.0145) in the Dempster table (Dempster, 1955). The segmental foot mass and average velocity resultant were multiplied by the segmental foot mass and average acceleration resultant, and the resulting linear momentum and impact force were obtained. When calculating the kicking power, the average linear momentum was multiplied by the average speed (Gordon et al., 2014).

**Hand reaction time test**

Reaction Meter (Newtest 1000, Finland) was used to measure visual hand reaction time. The first part of the device is the device that gives the selected time and stimulus, and the second part is the warning sign that is placed on the table and helps the participant receive the stimulus. The device gives values of 1/1000 seconds. To determine the reaction time, participants sat on a chair with their hands on the table, palms facing the table, and were asked to respond to light stimuli given at unequal intervals by touching the button on the side of the device where the light was on. Light stimuli were given five times at different time intervals determined by the device, and the participants' response times to these stimuli were recorded in milliseconds. The hand reaction test was applied in two sets, immediately after the repeated kicking test. The arithmetic means of the five measurements in each set was taken.

### Heart rate measurement

HR measurement was performed using the telemetric method (Polar RS 400, Polar Electro Oy, Kempele, Finland) after the participants rested in a sitting position for at least 10 minutes in the laboratory: rest (HR1), before (HR2) and immediately after the repetitive sprint test (HR3), immediately after the hand reaction test (HR4) and, immediately after the second set of the hand reaction test (HR5).

### Determination of the rate of perceived exertion level

RPE was determined by the Borg scale (6-20) (Borg et al., 1987). Measurements were performed four times: before (RPE2) and immediately after the repetitive sprint test (RPE3), immediately after the hand reaction test (RPE4), and immediately after the second set of the hand reaction test (RPE5).

### Ethical Approval

It was approved by the Ege University, Faculty of Medicine Clinical Research Ethics Committee (number: 19-9.1/47) that the research structure complied with the Declaration of Helsinki on Ethical Principles in Medical Research on Humans.

### Analysis of Data

They were performed with the SPSS (version 25.0, SPSS Inc, Chicago, IL, USA) statistical package program. The suitability of the data for normal distribution was evaluated with the Shapiro-Wilk (W) test. Repeated Measures Analysis of Variance (ANOVA) was used to compare dependent variables, and the Bonferroni post hoc procedure was applied to analyze which group caused the difference. Data are expressed as means and standard deviations, with significance based on $p \leq 0.05$.

The sample size was calculated with G-power (version 3.1.9.2, Franz Faul, Universitat Kiel, Dusseldorf, Germany). In the power analysis, the sample size was calculated to be at least 15 to determine a small effect size ($f = 0.3$) for repeated measures ANOVA with $\alpha = 0.05$ and 1-β margin of error of 0.75.

## FINDINGS

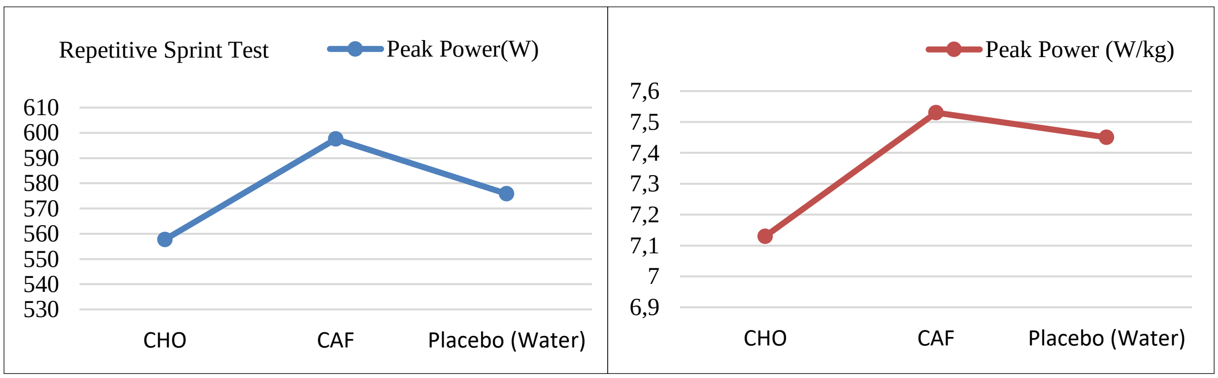
The mean age of the participants was $M$ = 21.6, $SD$ = 3.39 years (range: 19-30 years), the mean height was $M$ =179.1, $SD$ = 8.14 cm (range: 168-196 cm), and the body mass was $M$ =77.9, $SD$ = 16.4 kg (range: 57-112 kg) and their weekly training duration was $M$ =8.4, $SD$ = 1.12 hours (range: 6-12 hours) and their sports experience was $M$ =7.8, $SD$ = 4 years (range: 5-20 years).

There was a significant difference between the sessions in the PP output W/kg body weight ($p$ = 0.015) from the repetitive sprint test measured. The differences between CHO and CAF sessions ($p$ = 0.006) and between CHO and placebo sessions ($p$ = 0.030) were significant (Table 2). The change of data according to sessions is given in Graph 1. Accordingly, the best PP was achieved in the CAF mouth rinse session, while the worst result was seen in the CHO mouth rinse session.

**Table 2.** Comparison of peak power (W and W/kg) output obtained in the repeated sprint test between sessions

| | | Peak power (W) | | | Peak power (W/kg) | | |
|---|---|---|---|---|---|---|---|
| | Sessions | X | ± *S* | p = 0.078 | X | ± *S* | **p = 0.015** |
| 1 | CHO | 557.7 | 135.2 | 1<2 (p = 0.046) | 7.13 | 1.01 | **1< 2 (p = 0.006)** |
| 2 | CAF | 597.5 | 120.7 | 1<3 (p = 0.041) | 7.53 | 0.88 | **1< 3 (p = 0.030)** |
| 3 | Placebo (water) | 575.8 | 113.1 | 2>3 (p = 0.253) | 7.45 | 0.84 | 2> 3 (p = 0.611) |

Carbohydrate (CHO), Caffeine (CAF)




**Graph 1.** Change of peak power (W and W/kg) output obtained in the repetitive sprint test according to sessions

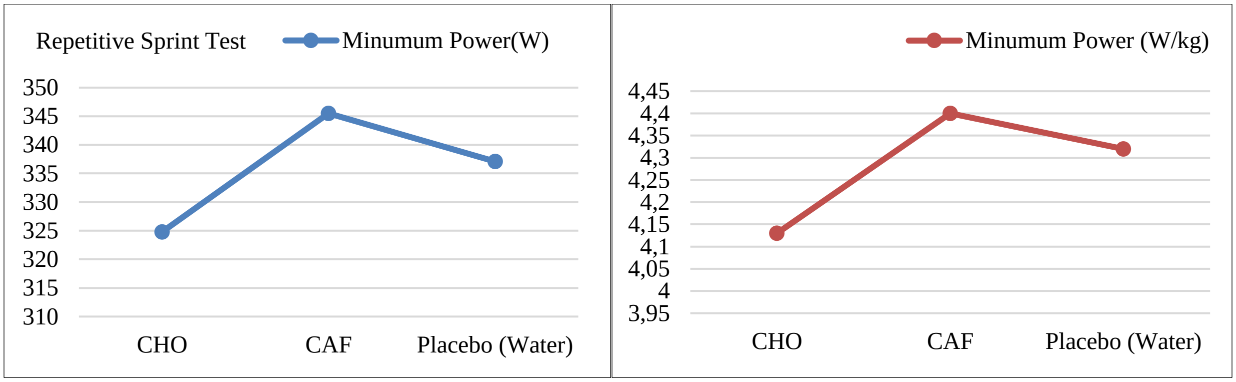
There was a significant difference between the sessions in AP W/kg body weight (p = 0.039). The differences between CHO and CAF sessions (p = 0.017) and between CHO and placebo sessions (p = 0.048) were significant (Table 3). Accordingly, the best AP output was achieved in the CAF mouth rinse session, while the worst result was seen in the CHO session.

**Table 3.** Comparison of average power (W and W/kg) data obtained in the repeated sprint test between sessions

| | | Average power (W) | | | Average power (W/kg) | | |
|---|---|---|---|---|---|---|---|
| | Sessions | X | ± *S* | p = 0.139 | X | ± *S* | **p = 0.039** |
| 1 | CHO | 437.9 | 121.4 | 1>2 (p = 0.073) | 5.60 | 0.81 | **1< 2 (p = 0.017)** |
| 2 | CAF | 467.0 | 103.6 | 1>3 (p = 0.064) | 5.90 | 0.72 | **1< 3 (p = 0.048)** |
| 3 | Placebo (water) | 452.1 | 103.5 | 2>3 (p = 0.378) | 5.81 | 0.70 | 2> 3 (p = 0.637) |

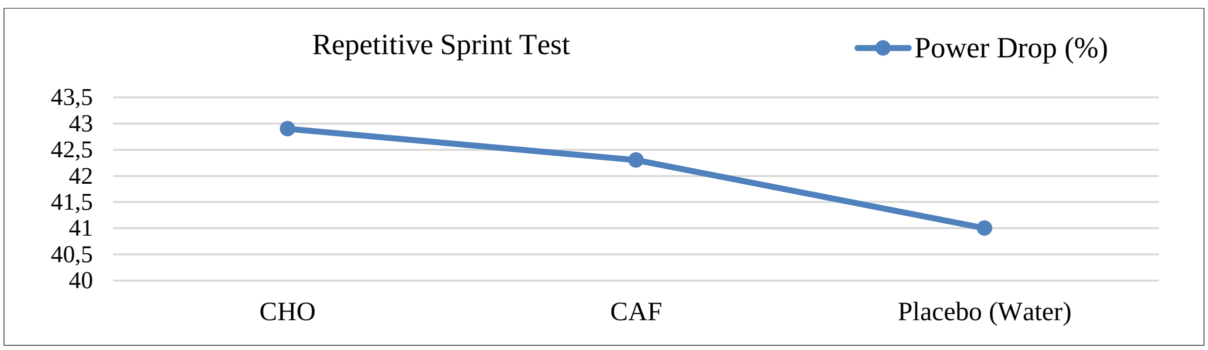
Carbohydrate (CHO), Caffeine (CAF)

There was no significant difference between the sessions for MP (W and W/kg body weight) (p> 0.05) (Graph 2).




**Graph 2.** Change of minimum power (W and W/kg) data obtained in the repetitive sprint test according to sessions

There was no significant difference between the sessions for PD (%) (p> 0.05) (Graph 3).




**Graph 3.** Change of PD (%) data obtained in the repetitive sprint test according to sessions

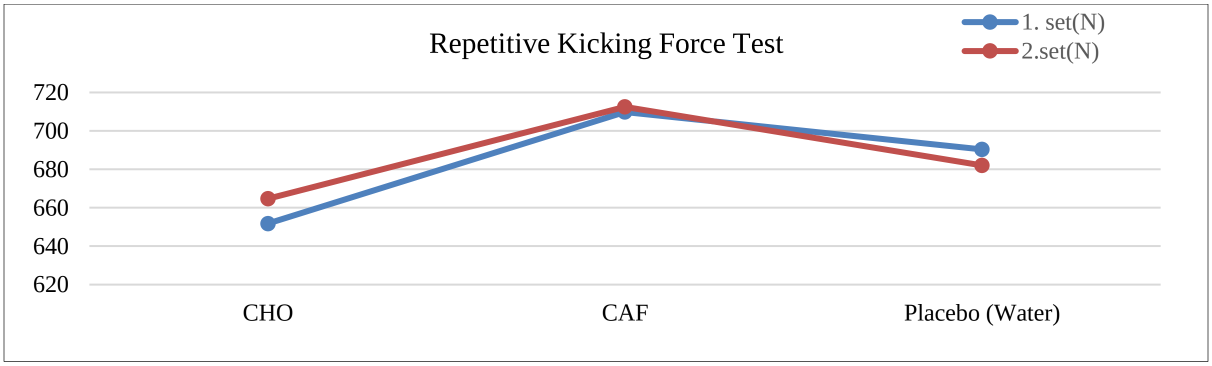
There was a significant difference between the sets of the sessions in the kick reaction time (ms) (p = 0.041). The difference between CHO and CAF sessions was significant (p = 0.041) (Table 4). Accordingly, the best time was achieved in the CAF mouth rinse session, while the worst result was seen in the CHO session.

**Table 4.** Comparison of the mean data (ms) obtained from the kicking reaction time test between sessions

| | **Kicking reaction time test (ms)** | | | | | | |
|---|---|---|---|---|---|---|---|
| | | **1. set** | | | **2. set** | | |
| | Sessions | X | ± *S* | p = 0.102 | X | ± *S* | **p = 0.041** |
| 1 | CHO | 473.2 | 75.8 | 1>2 (p = 0.940) | 458.7 | 49.5 | **1< 2 (p = 0.041)** |
| 2 | CAF | 475.1 | 76.5 | 1< 3 (p = 0.005) | 422.0 | 67.4 | 1> 3 (p = 0.066) |
| 3 | Placebo (water) | 435.4 | 63.4 | 2<3 (p = 0.043) | 429.6 | 55.5 | 2> 3 (p = 0.948) |

Carbohydrate (CHO), Caffeine (CAF)

There was no significant difference in the average force (N) of the repetitive kicking test, which was repeated twice in each session, between sessions (p> 0.05) (Graph 4).




**Graph 4.** Change in the average force (Newton) obtained in the repetitive kicking test between sessions

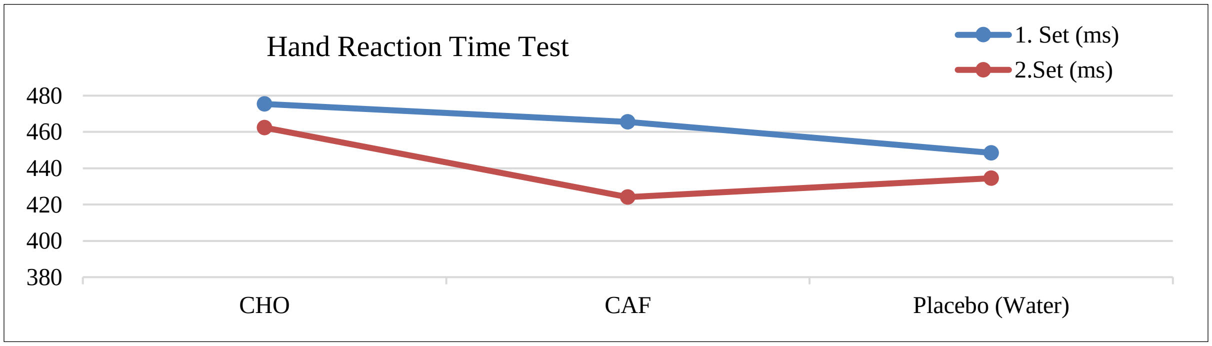
There was no significant difference in the average power (W) calculated from the repetitive kicking test and average kicking times (ms), which was repeated twice in each session, between sessions (p> 0.05).

There was a significant difference between the sets of the sessions in the hand reaction time (ms) in favor of the 2nd set (p = 0.038). The differences between CHO and CAF sessions (p = 0.016) and between CHO and placebo sessions were significant (p = 0.006) (Table 5). Accordingly, the best time was achieved in the CAF mouth rinse session, while the worst result was seen in the CHO session (Graph 5).

**Table 5.** Comparison of average time (ms) obtained in the hand reaction time test between sessions

| | | **Hand reaction time test (ms)** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **1. set** | | | **2. set** | | |
| | Sessions | X | ± *S* | p = 0.379 | X | ± *S* | **p = 0.038** |
| 1 | CHO | 475.4 | 58.8 | 1>2 (p = 0.667) | 462.4 | 42.0 | **1< 2 (p = 0.016)** |
| 2 | CAF | 465.6 | 80.5 | 1>3 (p = 0.088) | 424.1 | 45.3 | **1< 3 (p = 0.006)** |
| 3 | Placebo (water) | 448.5 | 55.0 | 2>3 (p = 0.399) | 434.5 | 43.9 | 2> 3 (p = 0.538) |

Carbohydrate (CHO), Caffeine (CAF)




**Graph 5.** Change in the average data (ms) obtained in the hand reaction time test between sessions

No significant difference was found between sessions in the HR (p=0.607) and RPE (p=0.329) values.

## DISCUSSION AND CONCLUSION

The main finding of the study, in which the effect of mouth rinsing of solutions containing CHO and CAF on the repetitive kick force, duration, and hand reaction time tests after the repetitive sprint protocol in karate athletes was investigated, was that the CHO and CAF mouth rinse applications had no significantly different effect on the repetitive kick force, duration, and hand reaction tests after fatigue than placebo application. However, significant positive effects were detected in the PP and AP obtained from the repeated sprint test and in the second sets of the kick and hand reaction test in the CAF mouth rinse sessions. Additionally, there was no significant difference between sessions in the HR and RPE values measured in each session.

It has been shown that CAF consumption improves performance by increasing attention and alertness in tasks involving psychomotor functions such as reaction time, agility, and decision-making accuracy (Da Silva et al., 2021). Reaction time, which is an important determinant of performance in combat sports, was tested on five consecutive kicks (Bandal Tchagui) in taekwondo athletes after consuming 5 $mg \cdot kg^{-1}$ CAF, just before and after two fights performed 20 minutes apart and compared with placebo application. In conclusion, CAF consumption was found to delay fatigue during consecutive taekwondo fights and improve reaction time only in conditions in which fatigue does not occur (Santos et al., 2014).

In addition to the positive performance effects obtained with CHO and CAF consumption, it has been reported that CHO and CAF mouth rinse methods have the potential to activate the prefrontal cortex (orbitofrontal and dorsolateral) associated with cognition, attention, and reward, which can play a central role in the motor control process and improve exercise performance (Ehlert et al., 2020; Pomportes et al., 2020), reduces mental fatigue (Van Cutsem et al., 2018), improves information processing in terms of both speed and accuracy and increases reaction time (De Pauw et al., 2015; Pomportes & Brisswalter, 2020) and delaying fatigue (Jeffers et al., 2015), formed the basis of the hypothesis of this study. In addition, it has made the effects of this nutrition strategy on karate athletes more curious in combat sports, because this method can offer athletes the opportunity to mouth rinse during combat sets without hindering their performances and losing to an opponent despite cognitive weakening and physical decline during fatigue in such sports (Decimoni et al., 2018; Pomportes et al., 2017).

Five-second mouth CHO rinses improved peak power output (2.3%) during a 30-second sprint (Phillips et al., 2014) and power output and muscle strength (2%) increased significantly immediately after mouth CHO rinse application (Gant et al., 2010), it has been shown that 10 seconds of CHO mouth rinsing reduces the decrease in peak and mean torque of isometric maximal voluntary contraction during knee extension immediately after fatigue (Jensen et al., 2015). However, some studies did not find any evidence of a beneficial effect on 6 × 40-meter running sprint performance with 5 minutes of rest (Bortolotti et al., 2013), maximal sprint, and maximum power performance (Clarke et al., 2015; Chong et al., 2011; Painelli et al., 2011), the repeated bench press test (Green et al., 2022), repeated jump, sprint, and strength performances (Dorling & Earnest, 2013) after CHO mouth rinsing. 10-second CHO mouth rinse solutions (6%, 12%, and 18%) did not affect upper body muscle strength or muscle endurance in female athletes (Karayiğit et al., 2021), and on reaction time and accuracy measures after a single 20-second CHO mouth rinse (De Pauw et al., 2015)

The fact that CAF mouth rinsing is an effective alternative method for improving exercise performance is based on two potential mechanisms. First, CAF binds to adenosine receptors in the mouth and increases the release of neurotransmitters and motor unit firing rates. Secondly, bitter taste receptors in the oral cavity, which are directly connected to the brain regions responsible for information processing and reward, are activated when exposed to CAF and increase mental alertness through dopamine transmission (Gam et al., 2014; Pickering, 2019).

CAF mouth rinse increased brain activity in areas associated with attention control (De Pauw et al., 2015), and mean power in the first and second sprints was compared with placebo in the protocol 5 × 6 s maximum sprints with 24 seconds rest (Beaven et al., 2013), improved sprint cycling performance in low muscle glycogen with 10 seconds of CAF (2%) mouth rinsing (Kizzi et al., 2016), successful kick performance compared to glucose and placebo during a taekwondo test performed in a fasted state (Pak et al., 2020), and 3 km cycling performance in subjects who exercised only in the morning compared to exercise performance in the afternoon (Pataky et al., 2016). On the other hand, it has been reported that CAF mouth rinse has not improved running performance in Yo-Yo Level 1 test (Dolan et al., 2017) and 1RM strength performance (Clarke et al., 2015), Wingate anaerobic power test (Marinho et al., 2020) and repetitive jumping test (Karuk et al., 2022).

One of the most common and consistent cognitive effects of caffeine is shortening reaction time (Deslandes et al., 2004; Lieberman et al., 1987; McLellan et al., 2016; Santos et al., 2014; Saville et al., 2018; Torres & Kim, 2019). CAF mouth rinse method resulted in a reduction in mental fatigue (Van Cutsem et al., 2018), improvement in reaction time (De Pauw et al., 2015), and an increase in cognitive control (Pomportes et al., 2017) compared to placebo.

Fatigue is defined as a decrease in physical performance associated with exercise or strain during an activity (John, 1995). The main cause of fatigue during maximum resistance exercise is related to decreased neural stimulation (Walker et al., 2012). It was shown that CAF mouth rinse delayed the time to fatigue (Kasper et al., 2016), and increased fatigue tolerance with increased RPE and decreased electromyographic activity (Melo et al., 2021).

Although there were no significant differences in HR and RPE between sessions in our study, CHO mouth rinsing in women has been shown to reduce RPE compared to placebo during repetitive resistance exercise (Decimoni et al., 2018), a result interpreted to suggest that CHO mouth rinsing may reduce fatigue-related declines in motor function by activating new signaling pathways (De Pauw et al., 2015; Pomportes & Brisswalter, 2020; Van Cutsem et al., 2018). Studies have also found that CHO mouth rinsing can significantly increase neuromuscular performance during an isokinetic fatiguing task and improve sprint power output with similar or higher HR and RPE values (Bazzucchi et al., 2017; Pataky et al., 2016).

The main limitations of the study are that the participants could not be kept under continuous surveillance during the test period and that the number of participants could not be increased. It was assumed that the participants were not affected by circadian rhythm changes by being tested at the same time of day, that they did not use any ergogenic support that could affect the test results, that they did not change their diet during the test period, that they entered the tests sufficiently rested, that they entered the test sessions 3 hours after their last meal, and that they filled out the forms with real information. The results obtained from this study, CAF mouth rinsing had significant effects on the PP and AP achieved in the repetitive sprint test and the second set of the kick and hand reaction tests, showed that the CAF mouth rinsing method can improve kicking and hand reaction times in karate competitions where high-intensity movements are performed intermittently. In future studies, the effects of single or multiple uses of the caffeine mouth rinsing method can be evaluated during official or friendly competitions.

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**Ethical Approval**
**Ethics Committee:** Ege University, Faculty of Medicine Clinical Research Ethics Committee
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