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The Immediate Effects of High Carbohydrate and Caffeinated Drinks on Speed, Coordination, and Cognitive Function in Professional Futsal Players

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Abstract

Background: Researchers believe the beneficiary role of some supplements in improving futsal player's performance, since their performance is disturbed by lactate accumulation.

Objectives: In the present study, we aimed to investigate the acute effects of high-carbohydrate and high-caffeine drinks on the motor performance (speed and coordination) and cognitive function of futsal players.

Methods: The study utilized a quasi-experimental design with a pretest-posttest control group. The study involved 40 participants who were randomly assigned to one of four groups: (1) carbohydrate supplementation (N = 10), (2) caffeine supplementation (N = 10), (3) carbohydrate and caffeine supplementation (N = 10), and (4) control group (placebo). The subjects were given two different sports drinks, one containing carbohydrates and caffeine, each at a dose of 6 mL per kilogram of body weight, while the control group received a placebo. To measure speed, a 36-m sprint test was used, while coordination was assessed using a dribble and shoot test. Cognitive performance was measured using a modified version of the continuous performance test (CPT) developed specifically for use with futsal players.

Results: The study found that carbohydrate intake had a significant positive effect on reaction time and coordination ($P < 0.05$). Caffeine intake was also associated with a significant improvement in cognitive performance ($P < 0.05$), but no significant effect was observed on speed and coordination ($P > 0.05$). Furthermore, the group that received both carbohydrate and caffeine supplements showed improvements in speed, coordination, and cognitive performance ($P < 0.05$).

Conclusions: It is suggested that taking a supplement containing a combination of carbohydrates and caffeine for 5 days prior to performance may lead to improved results in speed and coordination tests.

Keywords: Cognitive Performance, Futsal Players, Caffeine, High Carbohydrate Drinks

1. Background

Futsal is one of the most exciting and popular sports that, like any other sport, requires certain physical and mental characteristics to succeed. The optimal performance of futsal skills results from the interaction of motor and cognitive factors (1). In order to achieve the peak athletic performance, futsal players have to increase the level of coordination, endurance, strength, power, agility and speed, improve aerobic and anaerobic capacity, and acquire and maintain physical fitness (2). There are limited studies in futsal (while this sport has gained a lot of fans and popularity among the people in recent years). Futsal is one of the sports that needs anaerobic energy system due to the nature of the game and the high pressure during the match. During a match, players make frequent substitutions after a few minutes for getting energy, and in a short period of time they have to recuperate and return to the game. Therefore, it is believed that the use of almost harmless supplements that can modify the fatigue caused by the accumulation of lactate and increase the speed of the athlete's return to the initial state, can be helpful in this field. Since, this kind of sport needs high speed, it is very important to make correct and quick decisions in futsal. Therefore, athletes in this field are looking for ways to improve their cognitive performance (2). Researchers have always been looking for solutions that can improve the enhance athletic performance during training or competition through variable sports

and nutritional interventions. Among the reasons for this increasing effect, we can mention ergogenic compounds such as taurine, caffeine, sugars, sodium, bicarbonate and glucuronolactone that are present in sports drinks (3, 4). Energy drinks can reduce the effect of alcohol on the central nervous system (5). Various mechanisms have been proposed regarding the effectiveness of the compounds of these drinks in improving enhance athletic performance. For example, a group of researchers believe that sports drinks for adjusting the storage capacity of calcium ions in the sarcoplasmic reticulum, increase the speed of ATPase pumps due to the stimulation of calcium ions, and by affecting ion channels and stimulating adenylate cyclase and inhibiting phosphodiesterase that increases the regeneration of cyclic adenosine monophosphate in the heart (6). However, other researchers believe that the mechanism mentioned above is specific to skeletal muscle and has no effect on heart muscle (7). Based on previous research findings, the caffeine in these drinks increases the amount of catecholamine's in the plasma, by increasing the consumption of fats and preserves muscle glycogen reserves (8). Caffeine is an antagonist of adenosine receptors and is a stimulant that can affect the central and peripheral nervous system. Caffeine is one of the drugs used worldwide and is mostly found in food sources such as tea, coffee, cola drinks and chocolate (9). Systemic effects of caffeine include increasing blood pressure and stimulating the release of catecholamine's, especially epinephrine (10). It has been reported that athletes use caffeine to increase performance and endurance in long-term sports (11). In elite athletes, caffeine is commonly used to enhance athletic performance, that it is common in some sports such as cycling and triathlon. The effect of this supplement on muscle glycogen synthesis was previously studied by Battram et al. in 2004 (12). Caffeine consumption increases dependence on non-muscular free fatty acids. According to the nature of short-term intense sports activities, there are three main areas of caffeine effect in the human body. There are three main places where caffeine affects the human body: Central nervous system, neuromuscular transmission and muscle contractility process. The results of research on the effect of caffeine consumption on anaerobic activities are contradictory. Some studies have reported significant effects of caffeine, while the results of other studies show insignificant differences between the control and experimental groups (13). Other studies have shown a positive effect of 5 mg/kg of caffeine on anaerobic power. On the other hand, carbohydrates are a source of muscle contraction, nerve conduction and brain activity. Studies have shown that consuming carbohydrates with caffeine improved performance by 4 - 6% compared to carbohydrates alone (14). The simultaneous consumption of carbohydrates and caffeine increased the volume of glycogen compared to carbohydrates alone (15). It also improves endurance performance and increased muscle glucose oxidation compared to carbohydrates alone (16, 17). It is obvious that the amount of muscle glycogen decreases after training and its increase is possible by providing external carbohydrates. In this regard, the dose, timing and frequency of carbohydrate intake play an important role in determining the amount of glycogen obtained during the recovery period (18). Carbohydrate consumption has benefits such as maintaining plasma glucose, delaying the onset of fatigue, increasing performance, and concentration, the glycogen process usually occurs in two phases: The fast phase, which is called insulin-independent, and the slower phase, which is called insulin-dependent (5). Ivy et al. reported that not only the amount, but also the time and frequency of carbohydrate intake can play a decisive role in the amount of glycogen that can be useful during recovery (18). Lopez-Samanes et al. (19) came to the conclusion that excessive and regular consumption of carbohydrate-containing energy drinks without any nutritional value increases the daily caloric intake in people. Also, due to the fact that a certain amount of carbohydrates, fat and protein is required for the optimal growth and development of the body, therefore, frequent consumption of such drinks causes disturbances in receiving the optimal amount of carbohydrates, fat and protein and threatens the health of the body. Reis et al. (1) also showed that excessive consumption of caffeine through energy drinks, in addition to causing dehydration and addiction-like dependence, causes a decrease in sensitivity to insulin, kidney and digestive disorders. Even in the available scientific literature, contradictory results have been reported about the benefits of sports drinks and supplements on improving endurance performance. It has been stated in various researches that there is no definite opinion regarding the support of the consumption of sports drinks before or during physical activity and more research is needed. Although energy drinks have been sold for more than a decade, few studies have been conducted on the effects of these drinks on the physical and mental performance of athletes. Glycogen synthesis after exercise occurs in two phases; the first phase is one hour after activity that glycogen synthesis is at its peak and independent of insulin; the second phase is insulin-dependent, which the rate of glycogen synthesis is slow and lasts for several hours. When carbohydrates are consumed, glycogen recycling rate is directly related to insulin response to glucose; glycogen recycling rate is directly related to insulin response to glucose; therefore, insulin increases muscle glucose transport and muscle glycogen synthesis (20-24).

2. Objectives

In the course of time, the use of various supplements by athletes has been tremendously increasing of which caffeine and carbohydrates are among those that are present in sports drinks. Considering the lack of studies on the effect of carbohydrate and caffeine supplements on physical and cognitive performance of futsal players, we intended to address this issue in this study.

3. Methods

A quasi-experiment method with pretest-posttest with control group was used. The study subjects were all professional futsal players (18 - 30 years). The protocol of study was described for subjects, 40 futsal players completed a Physical Readiness Qestionnaire (PAR-Q) and gave written informed consent to the study. 40 participants were randomly divided into 4 groups: (1) carbohydrate supplementation (N = 10); (2) caffeine supplementation (N = 10); (3) carbohydrate and caffeine supplementation (N = 10); (4) control group (placebo). The study was approved by the research ethics committee of Qazvin University of Medical Sciences (code: IR.QUMS.REC.1400.399). The subjects read and signed the consent form to participate in the test. The inclusive criteria included having competitive training in the last three months, and at least four days a week for 30 minutes per session; moderate daily coffee consumption (less than 4 cups); not being treated with drugs or supplements; lack of regular consumption of sports or energy drinks; no history of cardiovascular and neurological diseases. The exclusive criteria were as follows: Any sensitivity to the substances and compounds in the supplements; absence of three sessions in each test; failure to pay attention to nutritional guidelines and taking supplements in research. Information about subjects' physical activity history was obtained through the health and physical activity questionnaire. Subjects were got familiar to training protocol in first session and then speed, coordination and cognitive function were performed in the upcoming next sessions. One dose of supplementation in the present study contains 6 mL per kg body weight of carbohydrate drink, caffeine drink or placebo. Vitamin C supplementation (2.5 g/L) is also used as a placebo. (Pre-test): In the first session, the height and weight and heart rate of the subjects were measured. After that subjects had a standard meal for breakfast (containing 378 kcal, 48% carbohydrates, 17% protein and 30% fat) at 8 o'clock in the morning, motor and cognitive function tests were performed two hours after breakfast. The second session (immediate effect of supplements): The conditions of this session were the same as the first session, with the difference that a dose of a drink (carbohydrate or caffeine or placebo) was given to the subjects 40 minutes before the test (in order to absorb the ingredients of the drinks), then motor and cognitive function tests were performed. A bottle containing a drink was also given to each subject containing half dose of supplementation. The time of the test, the temperature and relative humidity of the laboratory environment were controlled during the tests. The maximum heart rate and pressure perception were measured respectively by polar heart rate monitor (Kempele, Finland) and the Borg index with a class scale (6-20). All participants had enough time for recovery. Height was measured with a standard tape measure; weight was measured with a scale made in Germany (Seca brand).

Speed was measured using a 36-meter (40 yards) running test. This test has a 95% reliability. A record of 4 to 4.5 seconds is considered an ideal result and shows a standard record for most championship level athletes. It is natural that the closer the record gets to 4 seconds, it indicates a better physical fitness in the speed item and indicates that the player is faster. The speed test process is shown in Figure 1.

Dribble and shoot tests were used to check coordination. First 5 m was allocated for fast dribble, second 5 m was allocated for zigzag dribble and third 5 m was allocated for fast dribble and finally players would shoot the ball to the sign in futsal gate. The coordination test process is shown in Figure 2.

To measure cognitive performance, a modified version of continuous performance test (CPT) was used. this test was performed for measuring sustained attention and motor control. Various forms of the "continuous performance" test have been prepared for therapeutic and research purposes, and in all forms, the subject must pay attention to a set of relatively simple visual or auditory stimuli for a while, and when the target stimulus appears, press a key to respond. In most studies, visual stimuli are presented for a short time on the computer screen and the subject has to respond to the target stimulus by pressing one of the keyboard keys. There are 150 stimulus images, 30 images (20%) are stimulus and 80% are non-stimulus which each image were shown after 1 second for 0.002 second. The test duration was 200 second. To prevent the effect of fatigue, all images were divided into 5 groups of 30. The final scores were calculated based on the average of 5 tests. The reliability of the instrument and correlation were calculated by holding a traditional continuous performance test and continuous performance test in futsal players after 4 hours. The continuous performance test process is shown in Figure 3.

Paired *t*-test was used to examine intra-group changes from pre-test to post-test. Independent *t*-test was used

Figure 1. Speed test process

to evaluate the differences between experimental and control group. Intergroup comparison was performed by analysis of covariance. A significance level of $P \geq 0.005$ was set.

4. Results

The mean of age, height, weight and BMI were 23.65 ± 1.6 years, 173 ± 2.1 cm, 66.84 ± 1.6 kg, 22.16 ± 1.1 kg/m^2 respectively. Table 1 shows the mean and SD scores of groups in the 36-meter sprint (speed), dribbling and shooting (coordination) tests and cognitive performance factors in the pre-test stage.

According to the findings of Table 2, there is a significant difference between the groups in the motor preparation ($P \leq 0.05$).

According to the results of covariance analysis, there was a significant difference between the post-test average of speed, coordination and cognitive performance among the four supplementation methods (carbohydrate, caffeine, combined and placebo), so Tukey's post hoc test was used to determine the difference between the four groups. The results are shown in Figure 4.

5. Discussion

This study investigated the effect of acute consumption of high carbohydrate and caffeinated drinks on speed, coordination and cognitive function in 40 professional futsal players. As indicated, carbohydrate supplement had a significant effect in cognitive performance (reaction time) and also coordination. On the other hand, caffeine supplement was associated with a significant improvement in cognitive performance, but no significant effect was found on speed and coordination; however, it was shown that carbohydrate supplement with caffeine improved speed and coordination. Therefore, only the combination of carbohydrate supplement with caffeine could have a more immediate effect on motor and cognitive performance. The results suggested that those who used carbohydrates and caffeine was better than others in speed and coordination. In general, the combination of carbohydrates and caffeine had a greater immediate effect on motor readiness and cognitive performance compared to their separate consumption or the placebo group. In this study, there was no significant the acute effect of carbohydrate and caffeine consumption

Figure 2. Coordination test process

Figure 3. CPT test process

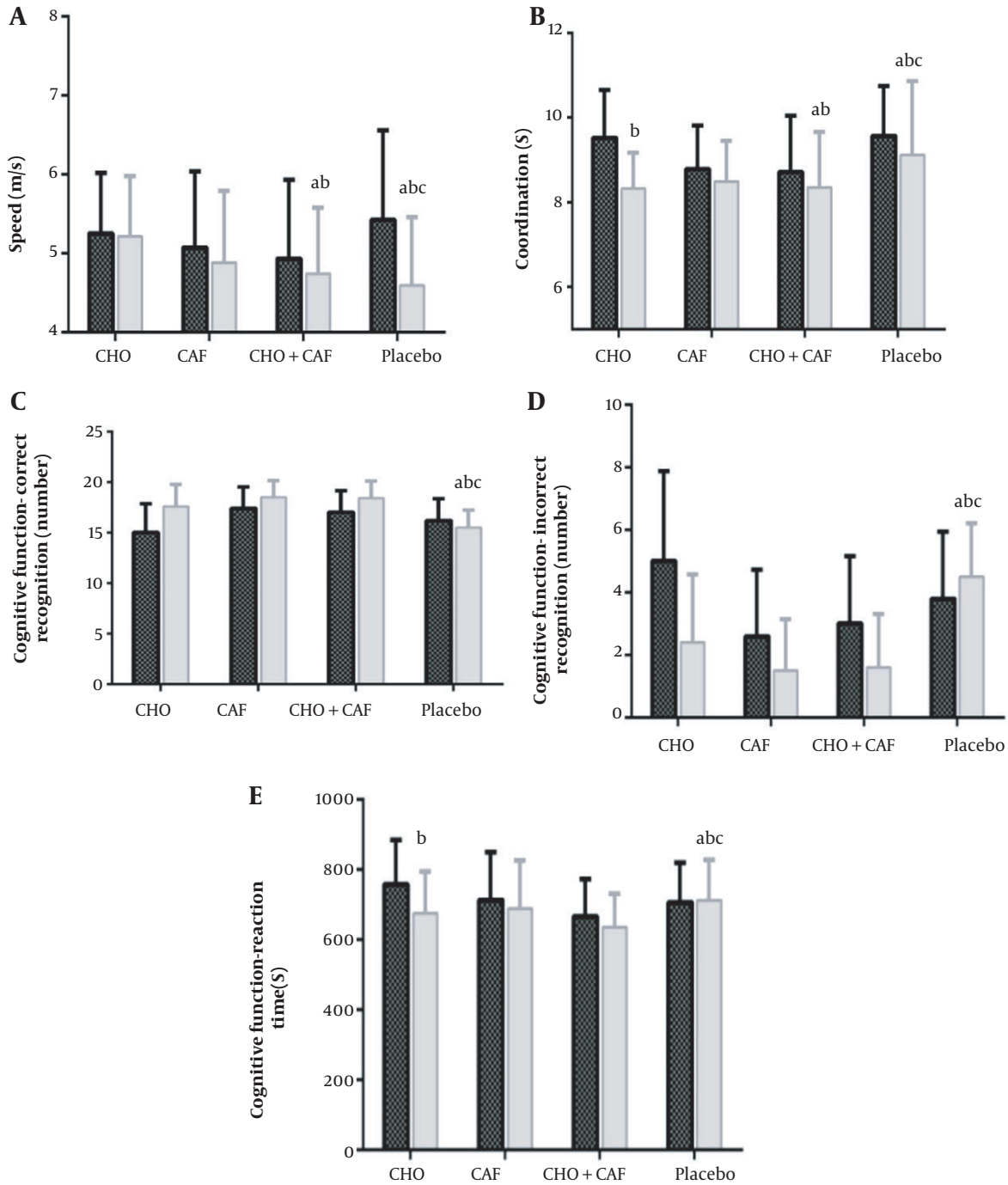

Figure 4. Results of Tukey's test to compare means at post-test. A, significant difference with carbohydrate group ($P \leq 0.05$); B, significant difference with caffeine group ($P \leq 0.05$); C, significant difference with carbohydrate and caffeine group ($P \leq 0.05$); D, significant difference with the placebo group ($P \leq 0.05$).

Table 1. The Mean and Standard Deviation of the Scores of the Groups (Pre-test)

Group	Carbohydrate	Caffeine	Caffeine + Carbohydrate	Placebo
Speed (m/s)	25 ± 0.76	5.07 ± 0.96	4.94 ± 0.99	5.42 ± 1.13
Coordination (m/s)	9.12 ± 1.12	8.88 ± 1.02	8.91± 1.33	19.17 ± 1.17
Cognitive function				
Correct diagnosis (number)	16.30 ± 2.14	17.30 ± 2.11	17.01 ± 2.16	16.01 ± 2.86
Misdiagnosis (number)	3.70 ± 2.14	2.70 ± 2.11	3.01 ± 2.16	5.01 ± 2.77
Reaction time (seconds)	706 ± 113	712 ± 136	765 ± 107	756 ± 126

Table 2. The Effect of the Group on the Results of Motor Preparation (Immediate Effect)

Variables	Sum of Squares	Degrees of Freedom	Mean Square	F	P
Speed (m/s)					
Pre-test	38.77	3	12.92	3.472	0.013
Group	30.95	1	30.95	13.645	0.014
Coordination (m/s)					
Pre-test	7.92	3	2.64	3.198	< 0.001
Group	1.53	1	1.53	2.225	0.001
Cognitive function					
Pre-test	33.96	3	11.32	3.412	0.016
Group	20.50	1	20.50	0.815	0.005
Pre-test	33.36	3	11.12	3.412	< 0.001
Group	20.50	1	20.50	0.815	0.396
Pre-test	43.08	3	14.36	3.472	< 0.0010
Group	29.76	1	29.76	12.975	0.002

on speed. Glycemic effect of carbohydrates ingestion causes release insulin that lead to absorbing large amount of blood glucose by the cells. This process of filling up at the beginning of sports activities leads to a drop in performance (25). Regarding the effect of caffeine, it should be mentioned that the immediate effect of caffeine on the athlete's nervous system is to increase alertness, concentration, freshness and reduce fatigue. In previous studies, positive effect of caffeine has suggested in aerobic training but there are contradictory studies a bout anaerobic training. Our findings show that only carbohydrate with caffeine has significant effect on coordination. Caffeine is a powerful inhibitor of cyclic nucleotide phosphodiesterase enzymes. These enzymes deactivate intracellular secondary messengers such as cAMP. When these cellular enzymes are inhibited, the effect of intracellular messengers such as cyclic AMP increases. On the other hand, carbohydrate consumption can provide the necessary fuel for early activities. These processes are likely to improve neuromuscular coordination in the individual. As a result, the improvement of coordination as a result of the immediate consumption of caffeine with carbohydrates can be justified based on the principles mentioned above. Also, the results of the present research show that if the method of immediate supplementation (40 minutes before implementation) is used, the caffeine supplement and the combination of caffeine with carbohydrates have a greater effect on improving cognitive performance. Caffeine acts as a central nervous system stimulant. Thus caffeine may have an effect on processes that stimulate the nervous system to promote cognitive function (19). In relation to the effect of carbohydrates on cognitive performance, muscle glycogen reserves can be increased, which can help improve cognitive performance in athletes. Finally, athletes who are interested in supplementing immediately and less than half an hour before the performance are suggested to use the combination of carbohydrate supplement with caffeine or caffeine alone. Considering the gap in research

on the effect of caffeine and carbohydrate supplements on anaerobic power, it is necessary to conduct research in this direction. It is also suggested to investigate the effect of caffeine and carbohydrate supplements on cognitive performance by conducting specialized tests for different sports fields. In addition, examining muscle biochemical changes (such as plasma calcium ion concentration) after consuming carbohydrate and caffeine supplements can add to the current knowledge.

Footnotes

Authors' Contribution: Study concept and design: S. A. R. A.; analysis and interpretation of data: S. A. R. A.; drafting of the manuscript: S. A. R. A.; critical revision of the manuscript for important intellectual content: S. A. R. A.; statistical analysis: S. A. R. A.

Conflict of Interests: Research was conducted in the absence of any commercial or financial relationships.

Ethical Approval: The study was approved by the research ethics committee of Qazvin University of Medical Sciences (code IR.QUMS.REC.1400.399).

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Informed Consent: The subjects read and signed the consent form to participate in the test.

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