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THE INFLUENCE OF CAFFEINE AND GUARANA ON DEHYDRATION OF YOUNG SOCCER PLAYERS AND PHYSIOLOGICAL ASPECTS OF DEHYDRATION OF THE ATHLETE'S BODY

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Abstract

Introduction. The aim of the study was to assess the effect of caffeine and caffeine with guarana on the dehydration of young soccer players and the effect of dehydration on their reaction time. **Material and Methods.** The study involved 57 players aged 16.8 ± 0.5 years, with an average body weight of 66.5 ± 9.3 kg, and height 178 ± 6.7 cm. An analysis of the body composition was performed. Thus, the results regarding body weight, adipose tissue, muscle tissue, BMI and body hydration were obtained. Next, the competitors performed successively a test for reaction time and speed over a distance of 5 and 15 meters with the use of photocells. After the tests, the players were randomized into 3 groups, where they received 200 mg caffeine, caffeine + guarana (200 mg + 40 mg), and placebo. Then, the players participated in a soccer training of medium intensity on the pitch, which lasted about 60 minutes. Immediately after completing the training, the procedure for testing reaction time and speed as well as body composition analysis were repeated. **Results.** Water loss occurred in each of the study groups and was the highest in players consuming caffeine with guarana and caffeine, but these were not statistically significant differences compared to placebo. Lower BMI correlated with water loss; however, statistically significant differences were noticed only in the placebo group ($p < 0.001$). Water loss also correlated with a smaller decrease in speed over a distance of the 5-meter sprint ($p < 0.039$) and the 15-meter sprint ($p < 0.035$), but only in the caffeine-guarana group. **Conclusions.** Caffeine consumption in the amount of about 3 mg/kg of body weight and also caffeine with guarana did not result in significantly greater loss of water in young soccer players. The loss of water during training in players was almost 0.7 l and did not affect the reaction time. The obtained results are important in the context of consuming supplements based on caffeine and guarana for young footballers in order to improve parameters such as speed or reaction time. However, it is also worth conducting research on a group of adult players.

Key words: caffeine in sports, supplementation, dehydration in sport, athlete's diet, nutrition in sport, football, soccer

Introduction

Soccer matches are becoming more and more spectacular almost every year. This is largely due not only to more technically trained and more versatile players, but also to higher intensity of the game, especially in the best leagues in the world. During matches, players cover 11-13 km [1] although they move with varying intensity. Research has shown that soccer players move around the field by jogging at an average speed of 7-9 km/h, running at a low speed in the range of 9-13 km/h, running at a moderate speed of 13-16 km/h, running at a high speed of 16-22 km/h and sprint above 22 km/h [2]. It is estimated that soccer players cover about 1.2-1.3 km of the entire match with the highest intensity [3]. Such efforts are accompanied by an increase in the stroke capacity of the heart and a decrease in the peripheral resistance of blood vessels, which results in a much faster blood flow in the vessels of skeletal muscles [4]. Moreover, matches are often held in not always favorable climatic conditions, when the competition takes place at an ambient temperature exceeding 25 degrees Celsius. Such an effort often results in considerable dehydration of the body, which affects not only the deterioration of the quality of the game or motor parameters, but also the player's health [5, 6].

Water can be considered the most valuable and the largest component of the body. It constitutes as much as 70% of the human body composition. In well-trained athletes, its content is 65-70%, while in an untrained person it is 50-60%. Therefore, adequate hydration is one of the key elements of nutrition for athletes. The rate of fluid loss during and after exercise is very individual and depends, among other things, on body weight, age, intensity and duration of exercise, as well as ambient temperature and humidity. Obviously, the higher the ambient temperature, the greater the loss of water from sweat. It is estimated that the average rate of sweating is within a wide range, i.e. from 0.5 l to 2 l of sweat per hour of exercise, and in conditions of high ambient temperature and with very intense exercise, one may even lose 4 l of sweat per hour [7]. During a soccer match, the amount of sweat produced will vary from player to player depending on their position and style of play, as well as the total time spent on the pitch [8]. It is also worth adding that each liter of excreted sweat contains 2.3-3.4 g of NaCl. Therefore, after the effort, one should strive not only to replenish the water deficit, but also the missing electrolytes such as sodium, chlorine, potassium and magnesium, and in smaller amounts: calcium, iron, copper, bicarbonates, phosphates, sulfates, amino acids and some vitamins. That is why hydration is

important not only after exercise, but also before and during it, because the loss of body fluids in the amount of 2% of the body weight may disturb many physiological functions of the body [9], which in turn significantly reduce its exercise capacity by approx. 10%, as well as the ability to make decisions [10]. Progressive fluid loss acts as a physiological stimulus that increases the feeling of fatigue and thirst in soccer players [11]. Further water loss, corresponding to 5% of body weight, reduces physical performance by 30%, and fluid loss in the amount of 15% may be fatal [4]. Although, of course, this is an extreme situation, such cases do happen. Nevertheless, it is also worth knowing that as a result of intense sweating and water loss, fluid shifts in the external and intracellular space may occur. The characteristic symptoms of dehydration then appear, such as feeling thirsty, dry mouth, impaired salivation, reddening of the skin, irritability, impaired coordination of movements and general weakness. The circulatory system is heavily loaded. The body tries to retain the necessary amount of water by reducing the amount of urine excreted. As a result, the kidneys produce small amounts of concentrated urine, which can promote the development of kidney stones. In addition, insufficient production of urine causes the body to retain toxic substances, which may also lead to the disturbance of various physiological functions of the athlete. From a physiological perspective, these responses include reductions in muscle and cerebral [12] blood flow, increased body temperature, increased heart rate/cardiovascular strain and increased muscle glycogenolysis [13], possibly limiting peak oxygen uptake. From a perceptual standpoint, hypo-hydration stimulates thirst [14,15] and lowers mood [16], producing a level of discomfort that may distract from the task at hand [17]. Ultimately, these physiological and perceptual responses likely act in combination to increase perception of effort at a given intensity, thereby compromising performance [18]. Hypohydration induced by exercise is presented in figure 1 [19].

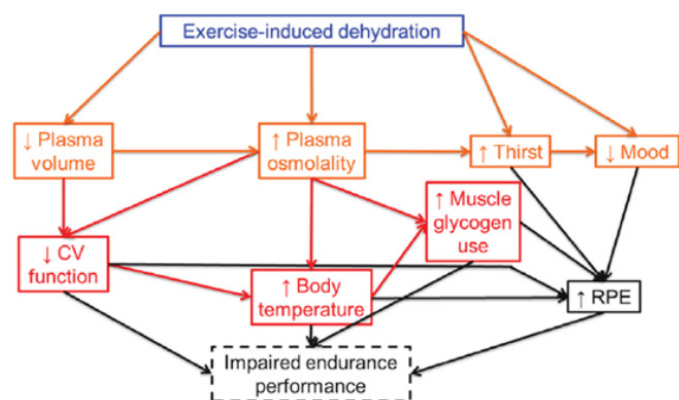


Figure 1. Basic flow diagram representing how exercise-induced dehydration might impair endurance exercise performance. CV cardiovascular, RPE rating of perceived exertion, ↑ increased, ↓ decreased.

Material and Methods

Participants and measurements

The study involved 57 soccer players aged 16.8 ± 0.5 years, with an average body weight of 66.5 ± 9.3 kg, and height of 178 ± 6.3 cm. Minimum training period was 4 years. A week before the start of the study, each participant was informed about the purpose and course of the study and about the possibility of withdrawing from the study at any time without giving a reason.

Each of them also provided the supervisor's written consent to participate in the study. The subjects were advised not to consume caffeine or other stimulant supplements 7 days before the tests. Before the tests, each participant presented current medical examinations; each was asked about their well-being and a possible use of medications. Nobody was taking any medications. Then, each of the contestants replenished their fluids to quench their thirst, and from then, until the end of training and taking the next measurement, did not replenish fluids. An analysis of the body composition was performed using BIA method in the tetrapolar version on the Tanita BC 780 device. Thus, the results regarding body weight [kg], adipose tissue [%], muscle tissue [kg], BMI and body hydration [kg] were obtained. Body height was measured for each competitor before the test, using a stadiometer.

Next, the subjects performed a reaction time test one by one using 4 BlazePods, which they hit when the light came on. The test lasted 15 seconds and was performed twice, after which the better results were taken into account. Afterwards, a speed test was performed over a distance of 5 and 15 meters with the use of photocells – both tests were performed in a gym. After the tests, the players were randomly divided into 3 groups (20, 20 and 17 individuals), where the first group (20) received caffeine (C) at a dose of 200 mg, the second group (20) got caffeine + guarana (CG) at a dose of 200 mg + 40 mg, and the third group (17) received placebo (P). Then, the players participated in a soccer training of medium intensity on the pitch, which lasted about 60 minutes and took place in the conditions of 16°C and air humidity of 70%. Immediately after completing the training, the procedure for testing reaction time and speed as well as body composition analysis were repeated. Repeated body composition analysis showed a difference indicative of water loss and weight loss during training. After completing the procedure, the players replenished their fluids in the form of mineral water and isotonic drinks.

Statistical analysis

Descriptive statistics are presented as mean (standard deviation), median (interquartile range). The Shapiro-Wilk test was utilised to verify the normality of the distribution of continuous variables. Variables were compared using the Pearson correlation or Spearman's rank correlation (an explanation of the correlation index can be found in table 1). Two independent groups were compared using Mann-Whitney's test or Student's t-test. The analysis of three and more independent groups was performed with a Kruskal-Wallis test or ANOVA test. Two dependent groups were compared with the Wilcoxon test or Student's t-test (dependent). All data were analysed using R software, version 3.6.3 (The R Foundation for Statistical Computing).

Results

During an hour-long, medium-intensity training, the players lost an average of 0.67 l. The most, i.e. 0.74 l, was lost by the players taking CG, while group C lost an average of 0.65 l, and group P at least 0.58 l; however, these differences were not statistically significant (Tab. 1).

It was observed that the BMI index correlated with the loss of water by young players during exercise. However, statistically significant differences were noted only in group P ($p < 0.001$). It turned out that players with a lower BMI, and therefore lighter than the rest, lost more water than competitors with a higher BMI (Tab. 2.)

Table 1. Statistical analysis of the body weight before training and after training, water loss after training in the studied groups

Research point	N	x	SD	Min	Q ₁	Me	Q ₃	Max	test result	p value
The amount of water before training (kg)										
Caffeine	20	43.42	4.22	35.1	41.1	42.95	46.45	51.8	0.049	0.953 ^A
Caffeine + Guarana	20	43.53	3.92	35	41.05	42.95	45.65	52.1		
Placebo	17	44.08	7.78	30.2	40.1	44.7	52.8	56.6		
The amount of water after training (kg)										
Caffeine	20	42.73	4.16	34.3	40.55	42.35	45.6	51	0.069	0.933 ^A
Caffeine + Guarana	20	42.79	3.92	34.5	40.35	42.45	44.7	51.6		
Placebo	17	43.48	7.57	29.9	39.7	43.8	52	55		
Water loss										
Caffeine	20	0.70	0.20	0.3	0.55	0.7	0.8	1	2.677	0.078 ^A
Caffeine + Guarana	20	0.74	0.24	0.4	0.5	0.7	0.9	1.2		
Placebo	17	0.57	0.23	0.3	0.4	0.5	0.7	1.1		

^A – test ANOVA.**Table 2.** Correlation of BMI with water loss – all respondents and subgroups

Groups	Number of people N	Correlation coefficient R	p value
Correlation of BMI with water loss			
All respondents	57	0.469	< 0.001
Caffeine	20	0.243	0.303
Caffeine + Guarana	20	0.456	0.043
Placebo	17	0.787	< 0.001

R – Spearman's test, p – Pearson correlation coefficient.

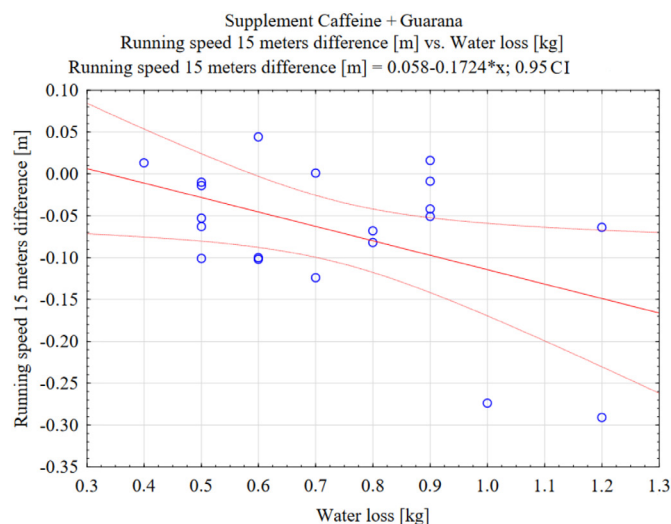
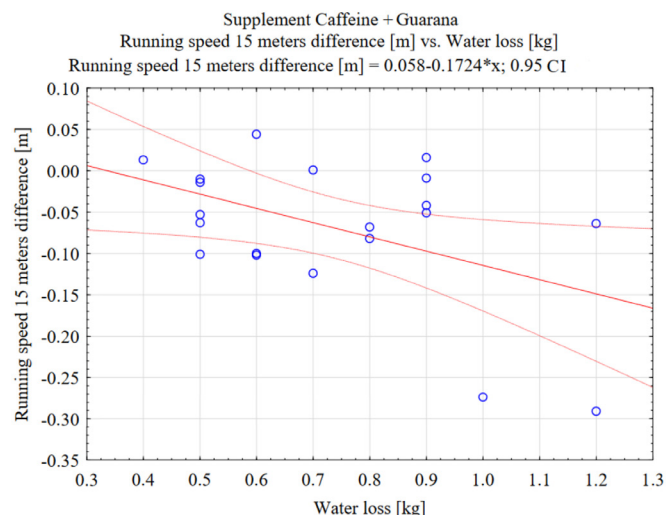
Table 3. Correlation of water loss with reaction time difference after training – all respondents and subgroups

Groups	Number of people N	Correlation coefficient R	p value
Correlation of water loss with reaction time difference after training			
All respondents	57	-0.212	0.113
Caffeine	20	-0.341	0.141
Caffeine + Guarana	20	-0.078	0.743
Placebo	17	-0.154	0.556

R – Spearman's test, p – Pearson correlation coefficient.

The dehydration of the organism did not significantly worsen the reaction time in the studied groups. However, in the context of the 5 meter speed test, such an effect was noted. Group CG had significantly lower speed loss than the other groups compared to the pre-training test. (Tab. 3, Fig. 2).

The effect of dehydration on the results of the speed test at a distance of 15 meters was also noted only in the group taking CG ($p < 0.005$), where the decrease in running speed was statistically significant and was lower than in the group taking C and P. (Fig. 3).

**Figure 2.** Relationship between dehydration and running speed 5 meters difference after training – group Caffeine + Guarana**Figure 3.** Relationship between dehydration and running speed 15 meters difference after training – group Caffeine + Guarana

Discussion

According to Maughan and Burke, the loss of fluids in soccer is significant and depends directly on the climatic conditions. For example, at a temperature of 13 degrees, players lose an average of 1 liter of sweat per hour of exercise [20]. In the authors' own research, players lost an average of 0.67 l at a slightly higher temperature, with the most, i.e. 0.74 l, being lost by players taking CG. However, these differences were not statistically significant. Dehydration is a frequent element of football effort and it translates directly into the form of a player during a match. It happens that although soccer players are generally aware of the importance of hydration, they do not use this knowledge in practice and do not care about proper body hydration both during training and matches [21]. Research has shown that training effort differs from the match effort. During training, competitors usually cover less than 7 km, and the distance of fast running during training does not exceed 300 m, while in a match situation it is more than 900 m [22]. The same is true for sprinting distances. For training it is less than 150 m, while during a match it is more than 200 m [23]. On the other hand, does caffeine help the body lose water more quickly? The study conducted on 50 physically active men consuming 4 mg/kg of caffeine showed that there was no significant difference in water loss from the body [24]. The study confirmed that the intake of caffeine in the amount of 3.06 mg/kg and caffeine with guarana in the dose of 3.03 mg/kg by young players did not significantly affect dehydration of the body compared to the placebo group.

However, regardless of this, dehydration during training and matches can be high and one should ensure proper hydration of the body. Water seems to be the most common choice, but the composition of mineral water varies, and it largely depends on how much and how quickly water will be absorbed into the body. Most types of water available in stores contain 200-500 mg of micronutrients per liter. In 2011, the names and composition of mineral water were systematized. Natural mineral water has been divided into 3 categories: low-mineralized – below 500 mg/l (this category also includes spring water), medium-mineralized – 500-1500 mg/l and highly mineralized – containing more than 1500 mg/l of minerals [25]. The effectiveness and efficiency of fluid absorption depends on their osmolality (osmotic pressure). The osmotic pressure of the blood plasma ranges from 275 to 295 mOsm/kg water, and this value represents the number of moles of osmotically active substances dissolved in 1 liter of plasma. Due to the amount of mineral salts contained in drinks in relation to the amount of electrolytes in the blood, the following drinks are distinguished: hypotonic, isotonic and hypertonic. Interestingly, research on the assessment of water and drink consumption by athletes of various sports shows that in team sports, hypotonic drinks are used the most, i.e. by as many as 50% of competitors, hypertonic drinks are consumed by about 28% of players, while isotonic drinks are used only by approx. 15% of athletes [26]. In our own research, it turned out that 65% of competitors used hypotonic drinks (various types of mineral water), and 35% used isotonic drinks. On the other hand, the study conducted on the group of juniors practicing soccer showed that hypotonic drinks were consumed by them every day, hypertonic drinks were used almost every day and isotonic drinks were consumed several times a week [27]. On the other hand, another study showed that up to 100% of footballers consumed isotonic drinks [28]. In the post-exercise period, fluid and electrolyte replacement is particularly important when dehydration exceeds 1-2% of body weight. After exercise that causes significant dehydration, within 4-6 hours

you should drink about 1.5 liters of fluid for each kilogram of body weight lost, regularly taking small portions of water with sodium and electrolytes (or ready-made isotonic drinks), remembering that the amount of fluids you drink should be greater than the amount of water lost. If you weigh 2 kg less after training than before it started, you should drink up to 3 liters of water or a drink with electrolytes. The restoration of water and electrolyte balance occurs within 24 hours at the earliest [25]. It should be remembered that total daily training loads depend on several factors including the phase of the season, the player's position, coaching philosophy, match frequency, athletic status, and the player's training goals, e.g. rehabilitation after injury or manipulation of body composition [29]. In a traditional in-season scenario, where one match per week is scheduled, players may perform four to five on-field training sessions, where the total training load will be distributed periodically throughout the weekly microcycle depending on the proximity and relevance of the match. Players can perform additional off-field training, e.g. weight training [30]. Therefore, there are important differences between individuals in terms of sweating rates, the amount of electrolytes loss and the specific request of the sport practiced and the sporting event to pursue, so the amount and type of fluids after exercise may be different for everyone [31].

Conclusions

During an hour of soccer training, players lost 0.67 liters of fluid on average. The consumption of caffeine in the amount of 3.06 mg/kg of body weight and caffeine with guarana in the amount of 3.03 mg/kg of body weight an hour before training did not significantly affect dehydration in young soccer players, which was comparable to the dehydration of players taking placebo. Greater water loss was noted in athletes with the lowest BMI. The loss of water by the players did not significantly affect their reaction time and the loss of speed. Only at a distance of 5 and 15 meters were better results (lower speed decrease) recorded among the players taking caffeine with guarana.

The stimulants used had no effect on the amount of dehydration in young soccer players caused by training.

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