EXERCISE AND SPORTS MEDICINE CLINIC

ORIGINAL ARTICLE

Effects of a Carbohydrate-Electrolytic Drink on the Hydration of Young Soccer Players

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ABSTRACT

The hydration status of nine male under 18 soccer players was evaluated after ingestion of the most accepted carbohydrate-electrolytic drink between three tests. The study was conducted during 80 minutes of training. The soccer players ingested 900 mL of a commercial carbohydrate-electrolytic drink (control) plus 300 mL of water or 900 mL of the most accepted drink (test) plus 300 mL of water. The time of training, exercise intensity, urinary status, weight, weight loss, the weight loss rate, the dehydration degree and the sweat rate were determined to verify the hydration status. The drink with 8% carbohydrate was the best accepted. The exercise intensity of the players was higher on the days that they ingested the tested drink. The time of training in relation to the tested drink was significantly lower than the control beverage (p = 0.008). The weight loss, the dehydration degree and sweat rate of the athletes with fluid intake test was higher when compared to control fluid intake. The athletes completed the game more dehydrated with the drinking fluid test; however, the limit of 2% weight loss was not exceeded. The exercise intensity (mild to moderate) and climatic conditions (lower temperature and higher relative humidity) on the day of the fluid control intake control may have helped the best results from the hydration capacity of the fluid control.

Keywords: sport, athletes, sports drink, dehydration.

INTRODUCTION

Soccer presents very peculiar characteristics concerning hydration, especially for not having regular pauses so that the players can ingest fluids during the matches. Before the beginning of the match and in the half-time break are situations in which the players have guarantee of ingesting fluids[1,2].

Soccer players can lose up to three liters or more of sweat during a match. Chronic dehydration status and thermal stress during a match may limit performance and be harmful to the player, being common to observe body temperatures above 39ºC after soccer matches[3].

Ingestion of fluids containing electrolylites and carbohydrates during exercise is extremely benefic for the player, since it minimizes the dehydration effects. Liquid replacement should be proportional to some factors, such as: exercise intensity, climatic conditions, athlete's acclimatization, physical conditioning and individual physiological and biomechanic characteristics[1].

The presence of electrolytes, especially sodium, may aid in the hydration process, increasing palatability and glucose and water absorption[4]. Performance is optimized when there is concomitant ingestion of water, electrolytes and carbohydrate. Glucose, besides increasing water absorption, provides energetic substrate for the physical activity and gives more taste to the solution, stimulating ingestion of higher quantities of liquid. The ideal solution should contain about 5% to 10% of carbohydrates and 20-30meq/L sodium[4,5]. Moreover, the liquids should be in temperature lower than the environment's (between 15°C and 22°C) and with attractive taste to consumption[6].

The present work was proposed with the intention to test a hydrating drink of easy elaboration and low cost, considering the importance of hydration for good performance in soccer. Thus, this research had the aim to assess hydration in under-18 players from the Vila Nova Futebol Clube team after ingestion of the mostly accepted hydroelectrolytic supplement in an affective test.

METHODOLOGY

In order to assess hydration three electrolytic supplements were elaborated. The basic formula of the drinks was prepared with a single salt concentration (1.48g/L) and varied amounts of carbohydrate, fruit juice (orange), sugar (sucrose) and maltodextrin, according to recommendations by the *American College of Sports Medicine*[5]. The drinks were prepared with two carbohydrate concentrations: 6% and 8%, and a commercial supplement was used as control, with 6% of carbohydrate (Table 1).

Acceptance of the hydroelectrolytic supplements was evaluated through an affective test in laboratory with 40 untrained potential consumers of sport drinks. The volunteers participated in the sensory analysis after having signed the Free and Clarified Consent Form (protocol # 046/09).

Global acceptance (taste, odor and texture) and appearance were evaluated in a monadic way in a laboratory. The structured hedonic scale of nine points was used for analysis of the global acceptability and appearance [7]. The mostly accepted formula (cohort point 6: lightly liked it) was selected for the hydration evaluation.

Osmolality analyses of the commercial supplement (control), and of the designed supplement of highest acceptability were performed with the aid of a vapor pressure osmometer (VAPRO Model 5520, Wescor, 370 West 1700 South Logan, Utah,USA).

The sample was composed of nine male soccer players from the under-18 category of a soccer team which regularly participated in competitions of the Soccer Federation of Goiás (Brazil).

Table 1. Formulation of hydroelectrolytic supplements with different flavors and concentrations of fruit juice.

	Types of formulations		
Ingredients (g)	**1**	**2**	**3**
Water	892.5	846.5	778.5
Salt (NaCl)	1.48	1.48	1.48
Flavorless maltodextrin	20	20	40
Granulated sugar	36	32	30
Orange juice	50	100	150

The study was approved by the Ethics Committee in research of the Federal University of Goiás (protocol # 046/09). The research was performed after signature of the Free and Clarified Consent Form by the athletes aged 18 years or by the parents or legal tutors.

Initially, a food anamnesis was performed with the athletes, using a standardized form for data collection on personal and cultural characteristics, health status besides eating and hydration habits.

The mostly accepted hydroelectrolytic supplement in the sensory analysis and the commercial supplement (control) were submitted to the hydration tests performed in the Training Center of the Club, with one-week interval between the drinks. In order to guarantee the athletes' suitable hydration, they were told to frequently drink water one day before the study and ingested 500mL of water one hour before the training.

All athletes were submitted to the same training, which consisted in 30 minutes of physical training with intensity equal or higher than in the match, followed by 10 minutes of interval and 50 minutes of collective training (simulation of a match with subdivision in two teams), resulting in 80 minutes of training.

During the tests 200mL of control supplement or test in individual plastic bottles identified by the researcher in an interval every 15 minutes until completion of an hour and 30 minutes of training (80 minutes of training and 10 minutes of interval) was offered to the players and water ingestion was standardized at 300mL for all players, totalizing 1,200mL of fluids.

Hydration was assessed according to the variables: exercise intensity, time of movement, urine density, difference of body mass, level of dehydration and sweat rate. Each player was individually followed by an observer previously instructed on the study. Room temperature and relative humidity at the day of the tests performance were obtained at the 10th Meteorology District of Goiânia of the National Meteorology Institute.

In order to assess the training intensity, each player had his heart rate monitored with the aid of a frequency meter (Polar Electro, Professorintie 5, Oulu, Finland) in a five-minute interval for each measurement.

Intensity was determined with the use of the maximal heart rate percentage (HR_{max}), expected from the equation presented as follows. Exercise intensity classification was determined according to the classification by Denadai and Greco[8]: very light < 35 %, light 35-54, moderate 55-69 and heavy 70-89 HR_{max}.

$$HR_{max} = 220 - \text{age (years)}$$

During 80 minutes of training, the time of movement was measured with the aid of a digital stopwatch when the movement time of the player was recorded, disconsidering the direction and the ball possession. When the player performed a pause, the stopwatch was stopped and restarted when the body dislocation returned.

Urine density was performed through a sample provided by the players in individual containers of 80mL, before and after each match (about 15 minutes). Density was determined three times with the aid of a refractometer (Passed), tow hours after collection the most, in the Rômulo Rocha Laboratory of the Pharmacy College of the federal University of Goiás. The containers with the samples were carried in a styrofoam box and stored in refrigeration (about 4ºC) until the moment of the analysis.

Body mass was checked before the urine collection on a digital platform portable scale of 150kg of capacity and sensitivity of 0.1kg (Plenna, Rua Javaés, 640, Bom Retiro – São Paulo, SP, Brazil), with the individuals wearing shorts, barefoot and not wearing any accessories. The procedure occurred before and after training, disconsidering corrections for fluids ingestion. Alteration in body mass was obtained by the difference between the pre and post-training values.

The dehydration value was calculated from the measurement of the body mass, according to the equation described as follows:

$$\text{\% dehydration (DH)} = \text{(alteration in body mass} - \text{urinary volume during training) / initial body mass} \times 100$$

Urinary volume was determined during training with the players being instructed to urinate in individual containers graded in mL, found in the lockers room of the club.

Sweat rate in L/h was measured through the body mass and water intake, according to the equation proposed by Horswill[9]:

$$\text{Sweat rate} = [\text{initial body mass (kg)} + \text{water intake (L)}] - [\text{final body mass (kg)} + \text{urinary volume}] / \text{time (min)} \times 60$$

The results of the sensory analysis were assessed through analysis of variance (ANOVA) and Tukey mean test with 5% of probability, besides the analysis of the frequency histogram (acceptance scores versus triers' percentage). Personal, anthropometric and hydration status data were analyzed by median estimation and percentiles obtained with the aid of the Epi Info program (version 6.04). Hydration analysis data of the control and test drinks were compared with the Wilcoxon non-parametric test and the *Statistical Package for the Social Sciences* test (SPSS) 10.0 for *Windows*, ($\alpha = 0.05$).

RESULTS

The measurements of the global acceptance and appearance of drinks 2 and 3 were not significantly different from each other (Table 2). However, drink 3 was chosen for the hydration tests, since it reached the cohort point (6: slightly liked it).

The hedonic results corroborate that the drink with 8% of carbohydrate (drink 3) obtained scores equal to or higher than 6 (slightly liked it) of 70% of the triers.

Osmolality of the commercial supplement, composed of 6% of carbohydrate, was of 300mOsmol/kg and of the test supplement, formulated with 8% of carbohydrate, was of 232mOsmol/kg.

The studied athletes presented age range of 17 to 18 years, with stature median of 1.74m, body mass of 65kg and of maximal heart rate of (MHR) of 203 beats per minute (bpm).

Table 2. Mean of the acceptance scores for drinking and appearance of the formulated hydroelectrolytic replacement drinks.

Type of drink	Global acceptance	Appearance (scores) [1]
Drink 1	4.55[b]	4.90[b]
Drink 2	5.77[a]	6.15[a]
Drink 3	6.12[a]	6.90[a]

[1] Scores 1: strongly disliked it, 5: indifferent, 9: extremely liked it.
In the same column, means with common letters do not significantly differ from each other ($\alpha < 0.05$).

All athletes have declared not to use alcohol or tobacco and concerning gastrointestinal problems, two individuals presented gastritis. They performed from two to five daily meals and habitual water intake was of over two liters of water a day. Only on days with matches they made use of commercial hydroelectrolytic supplement *ad libitum* with no determined time interval besides water, as hydration strategy.

Temperature and humidity variation by the hour according to the time spent in the field activity and for the data collection is shown in table 3. There was a slight temperature difference in the three research days and the day destined to the control drink administration was the one which presented the lowest temperature and the highest relative humidity.

The results of the variables used to evaluate the hydration effect of the control and test drinks are shown in table 4. In the present study, higher exercise intensity was verified, which was assessed according to the heart rate for the test drink when compared to the control drink. The movement time concerning the test drink was significantly lower than the control drink ($p = 0.008$).

No significant differences have been found between the two treatments performed concerning urinary density before and after the 80 minutes of training ($p = 0.20$).

The median of the body mass loss of the athletes with ingestion of the test drink (0.9kg) was higher ($p = 0.012$) when compared to the ingestion of the control drink (0.10kg). Body mass loss was verified in all athletes immediately after training with ingestion of the two drinks (control and test), except for one athlete who gained 200g of body mass in the two situations.

Table 3. Variation per humidity and room temperature hour, according to the date and time of the analyses performed on the field of the Vila Nova Futebol Clube, Goiânia, GO.

	14/08 (test drink)		15/08 (test drink)		21/08/09 (control drink) controle)	
Time	Humidity (%)	Temperature (ºC)	Humidity (%)	Temperature (ºC)	Humidity (%)	Temperature (ºC)
9:00	53	21.4	50	22.3	78	20.9
10:00	45	23.6	44	24.1	73	21.8
11:00	38	24.8	37	25.6	71	22.1
Mean ± SD[b]	45.3 ± 7.5	23.3 ± 1.7	43.7 ± 6.5	24.0 ± 1.6	74 ± 3.6	21.6 ± 0.62

[a] Data provided by the Meteorology and Hydrology System of the Goiás State – SIMEHGO, according to analysis of the automatic and telemetric station, situated about 4km from the research site.
[b] Mean ± standard deviation.

Table 4. Distribution in percentile of the results of the evaluation of the hydration effect of the control and test drinks of the soccer players of the amateur under-18 category of the Vila Nova Futebol Clube.

Characteristic	Control			Test			
	25	50	75	25	50	75	p*
Time of movimentation	65	72	75	48	55	56	0.01
UD before	1.012	1.021	1.022	1.008	1.015	1.020	0.19
UD after	1.015	1.023	1.025	1.012	1.020	1.025	0.39
Body mass before	61.40	64.40	68.80	61.00	65.20	68.00	
Body mass after	61.10	63.90	68.80	60.10	64.10	67.10	
Body mass loss	0.10	0.10	0.30	0.90	0.90	1.10	0.01
Dehydration level	0.15	0.18	0.49	1.04	1.64	1.81	0.01
Sweat rate	0.87	0.87	1.00	1.40	1.53	1.53	0.01

*Significant statistical difference between the different drinks, $\alpha = 0.05$, by the Wilcoxon test.
UD before a: urinary density before training.
UD after b: urinary density after training.

Concerning the dehydration status, there was significant difference between treatments ($p = 0.1$); the median for the control drink was of 0.18%, while for the test drink it was of 1.64%. Significant difference has also been found between treatments for the sweat rate ($p = 0.1$), with the lowest values have been found for the control drink (0.87).

DISCUSSION

According to the acceptance test of the formulated hydroelectrolytic supplements, drink 3 with 8% of carbohydrate reached cohort point 6. Probably, the sweet taste characteristic of the fruit juice has positively interfered in the acceptance, since acceptance decreased with reduction of orange juice percentage.

The test drink presented lower osmolality value than the control drink. Shi and Gisolfi[10], in a meta-analysis study on fluid and carbohydrate replacement during intermittent exercises, reported that solutions osmolality is probably the first determinant for water absorption in the intestine. These authors found that supplements with osmolality ranging between 250 and 370mOsmol/kg have higher hydration capacity.

Although the recommendations by the *American College of Sports Medicine*[5] for carbohydrates and sodium of hydroelectrolytic supplements have been used, the drink's osmolality was slightly below 250mOsmol/kg. It can be classified as hypotonic when compared to the plasma osmolality of euhydrated individuals (286mOsm/kg). Evans *et al.*[11] reported that hypotonic solutions are more effective in rehydration when compared to the hypertonic solutions, which can be unsuitable for causing water movement to the small intestine and reducing the rhythm of gastric emptying and intestinal absorption.

Evans *et al.*[12] also assessed the effect of solutions with glucose concentration and osmolality of 0% and 0mOsm/kg, 2% and 111mOsm/kg, 5% and 266mOsm/kg and 10% and 565mOsm/kg, respectively in 12 male individuals and observed that the ingestion of hypertonic solution (10% of glucose) resulted in decrease of plasmatic volume and led to the onset of water in the small intestine which, probably, was originated from the vascular volume.

Variation in temperature and humidity conditions was verified between the days of ingestion of the control and test drinks, being the difference for relative humidity higher. Lower temperature and higher humidity on the Day of the research performance with the control drink may have favored the hydration results. However, temperature interference was low, as seen in small variation in the three research days. It is possible that the athletes on the Day of the test drink ingestion have had greater sweat evaporation due to the lower room humidity, although on the day of the control drink the high humidity may have favored sweating increase, but made its evaporation difficult. In that case, the higher exercise intensity may have probably been a differential on the days of the test drink.

Training intensity is one of the factors of greatest interference on the body mass loss during exercise. There is a proportional ratio between exercise intensity and physical cost, which, consequently, negatively affects the athlete's body mass and performance[13]. Higher exercise intensity in training with the test drink possibly influenced on the hydration results.

The athlete is well hydrated with urinary density values lower than 1,010, minimally dehydrated with values between 1,010 and 1,020, significantly dehydrated with densities between 1,020 and 1,030 and severely dehydrated with values above 1,030[14]. The median of the urine density before training was 1,021 for the control drink and 1,015 for the test drink. Despite the recommendation of fluid intake on the day previous to the tests and intake of 500mL one hour before training, all athletes have started training dehydrated, except for one player (Table 4).

The players ended training with intake of control and test drinks more dehydrated. The pre-exercise urinary density value of 1,020 to 1,030 is considered common for professional soccer players[15]. In the present research the urinary density of all the players increase at the end of the training. However, three players with intake of the control drink and four with ingestion of the test drink ended the training with urinary density below 1,020.

Finn and Wood[16] evaluated through urinary density the pre-match hydration status of 93 soccer (n = 32), volleyball (n = 43) and basketball athletes (n = 18) in a competition under tropical climate conditions and obtained mean of 1.020 ± 0.008 for these athletes. However, soccer players were considered the most dehydrated since 48% were classified as significantly and extremely dehydrated, which is similar to the present study where 55.5% of the athletes were significantly dehydrated (urinary density higher than 1.021), before the beginning of the training with the control drink and 33% with the test drink.

Godek *et al.*[15] analyzed the hydration status of 10 adult American football players with mean age of 21.2 years, during five days of pre-competition training with mean temperature and relative humidity of 28.4ºC and 64.9% in the morning shift and 34.5ºC and 43% in the afternoon, respectively. The athletes received orientation to ingest at least 500mL of water at the nights preceding training. The urine densities before and after training indicated chronic dehydration (values higher than 1.020), although the players had ingested water and supplements in the training intervals.

The results reported by the authors previously described corroborate the idea that athletes generally start the sports practice at dehydration conditions. Athletes who start prolonged exercises dehydrated, especially in tropical climate, are more prone to adverse effects in the cardiovascular function, temperature regulation and exercise performance[16].

Body mass loss during sports practice is a real measurement of hypohydration in athletes, besides urinary density[17]. It is considered dehydration when the body mass percentage was higher than 2% of the initial body mass[14,18].

More remarkable mass loss on the days of ingestion of the test drink was probably caused by high exercise intensity and the low humidity compared to the day of ingestion of the control drink. Ostojic and Mazic[19], in a study with a protocol similar to the performed one, observed mean body mass loss of 0.9kg and 1.4kg for seven soccer athletes who ingested a drink with 7% of carbohydrate and water, respectively, at room temperature of 24.5ºC and 50% of air humidity. These results are close to the ones observed in the present study for the test drink.

The body mass gain in athletes who ingest higher fluid quantities in proportion to the quantity which was lost in sweat is more evident when the individual is hydrated before the exercise practice[18].

In the present study, the athlete who gained weight after training in the two treatments was at least minimally dehydrated, with values of urine density of 1,022 and 1,.015 for the control and test drinks, respectively. The body mass gain of this athlete may be related to his work intensity, which ranged from light to moderate in all test days, differently from the remaining athletes in the research, which possibly allowed lower water loss compared to the remaining athletes in the research. Godek *et al.*[15] also observed mass gain of 3.64kg in an American football player, among 10 individuals, after a training session in the morning.

The level of dehydration may be determined through the alteration in the body mass and reflects in percentage terms the extent to which the athlete dehydrated during the match[14]. The athletes concluded the match more dehydrated with the ingestion of the test drink; however, the threshold of 2% of body mass loss has not been surpassed (table 4).

Guttierres *et al.*[20] compared the effect of the consumption of caffeinated sports drink compared to the commercial carbohydrate drink on the water balance of 20 junior soccer players, at mean temperatures of 32°C and relative air humidity of 47%, and reported mean values of dehydration level of 1.1 ± 0.7% for the caffeinated drink and 0;7 ± 0;6% for the carbohydrate drink. In this case, the commercial carbohydrate drink presented better results than the ones obtained in the present investigation for the test drink, although the dehydration level has been higher than the results of the control drink.

The sweat rate is an indication of fluid loss and expresses how much sweat the individual is able to lose per time unit The mean of the sweat rates for athletes ranges from 0.5L/h to 2.5L/h[14]. Many factors interfere on the sweat production, such as climatic conditions, athlete's acclimatization, physical conditioning, fluid ingestion, clothing, body composition and position on the field[21,22].

Lower training intensity, besides the favorable conditions of the research day with the control drink (lower temperature and higher relative humidity), have probably favored the decrease in the sweat rate.

Reis *et al.*[23], evaluated the anthropometric profile and determined the sweat rate of 16 youth soccer players aged between 14 and 17 years, on a training day of 60 minutes, with mean temperature of 14°C and air humidity of 70%. The mean of the sweat rate values obtained for the athletes was of 8.8 ± 6.6mL/min, which corresponds to 0.53L/h ± 0.4L/h. Thus, the sweat rate values were lower than the ones found in the present study; which can be justified by the low temperature, high air humidity and shorter training time of the athletes researched by these authors.

The best results of hydration capacity of the commercial drink in comparison to the test drink may have been influenced by the exercise intensity (from light to moderate) and the climatic conditions (lower temperature and higher air relative humidity) on the day of the control drink ingestion. However, the test drink was efficient in keeping the body mass loss below 2%, a limit to consider an individual hydrated.

Considering that the evaluated group was composed of adolescents who generally do not receive information on the importance of hydration in physical performance, it is necessary to make the athletes, as well as their parents and coaches aware of the fluids and supplements ingestion before, during and after physical exercises. Moreover, individualized recommendation of fluids ingestion may be more effective in the hydration of these athletes, since each one them may have a different need.

All authors have declared there is not any potential conflict of interests concerning this article.

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