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Dietary intake according to hydration status in 9-10 year-old soccer players

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Abstract

Introduction: Children have an increased risk of voluntary dehydration especially during physical activity which may increase the risk of non-compensating water losses.

Objectives: The aim of this study was to assess the hydration status and its relation to food intake in a children group of soccer players.

Method: A sample of 36 boys aged 9-10 years was included in this study; 30 completed a 24 h urine collection. Participants completed a 24 h urine collection; a 24 hours food recall corresponding to the day of urine collection was applied, weight and height were measured and parents/caregivers filled a lifestyle and socio-demographic questionnaire. The free water reserve (FWR [ml/24 h] = urine volume [ml/24 h] - obligatory urine volume [ml/24 h]) was used to assess the hydration status. Food and beverage groups were created and models of unconditional logistic regression were fitted in order to estimate the magnitude of the association between the hydration status and diet.

Results: Forty three per cent of participants were classified as at risk of hypohydration. Children who reported a high fruit and vegetables intake (above the median) were at decreased risk of hypohydration (OR = 0.19, 95% CI 0.04-0.94, p = 0.041), compared to children who reported a low fruit and vegetables intake.

Conclusions: Almost half of the children were at risk of hypohydration. Our results suggested that water food sources such as fruit and vegetables may contribute to euhydration.

Key words: Free water reserve. Children. Dietary intake. Hydration status. Sport.

ological disturbances as headaches, obstipation, urolithiasis and renal malfunction (5). However, water consumption habits are complex and receive under-attention when evaluating eating habits (6).

Soccer is characterized as a high intensity exercise with a general intensity of 70-80% VO_2 max (7). The elevation of body temperature and the sweating response results from the high intensity of this sport and normally generate a loss of body water that needs to be replaced to avoid dehydration (8).

The amount of water in children is approximately 75% of their body weight (9), and in the case of young athletes, adequate fluid intake is important to maintain a satisfactory body hydration status and avoid the risk of low performance and heat injury (10).

As far as we are aware, very few studies addressed the hydration status in children using FWR as hydration marker and dietary intake, particularly fruit and vegetable intake (11) which favors hydration. New studies are needed focusing on dietary intake and hydration status (5,6) and the present study aims to contribute to fill this research gap in children soccer players.

INTRODUCTION

Water is essential to a wide variety of physiological functions in cell structure, metabolic transportation and temperature regulation, as well as in residual elimination (1). The human organism regulates body water content in order to maintain the equilibrium of fluid ingestion and excretion through the hypothalamic mechanism of thirst control, antidiuretic hormone regulation, renal function, breathing and perspiration (2,3).

The demand of water intake varies between subjects and depends on environmental factors such as climate conditions, lifestyle, physical activity and eating habits. The water intake should be sufficient to compensate daily losses (4). An appropriate hydration can reduce the risk of several diseases and physi-

OBJECTIVES

The aim of this research was the evaluation of the hydration status and its relation to food intake in a children group of soccer players.

METHODS

This study was performed in a convenience sample of 30 male 9-10 years soccer players from a club of the north of Portugal, which completed a 24 h urine collection. Additionally, a food record corresponding to the day of urine collection combined with a lifestyle and socio-demographic questionnaire was filled with their parents help.

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URINE SAMPLING AND ANALYSIS

To estimate hydration status, urine samples were collected during 24 hours, on Sunday 23rd of November 2013. The mean temperature was 9 °C, with 59% humidity. All subjects and their parents received written instructions on the urine collection procedure. Only the first morning urine was discarded, while the first urine of the following day was considered. The urine collection was stored in individual containers that were maintained at low temperatures until analyzed. A certified laboratory analyzed the urine samples to determine urine volume (ml), creatinine (mg/d) and sodium content (mg/d) [12]. Every child had a weight-related 24 h creatinine excretion rate equal or higher than 0.1 moll kg^{-1} d^{-1} [13,14], so the total sample was considered.

DATA COLLECTION

Trained interviewers from the Faculty of Nutrition and Food Science of the University of Porto performed data collection. A Tanita segmental BC-418 was used to evaluate the subject's weight (kg). Height (m) was obtained using a portable stadiometer and waist perimeter (cm) [29] was analyzed through a SECA® tape measure.

Body mass index (BMI) was calculated according to the following formula: BMI = (weight [kg])/(height^2 [m^2])

BMI percentiles were classified using the OMS growth curves (5-18 year-olds): low BMI (< percentile 3), normal BMI (≥ percentile 3 and < percentile 85), overweight (≥ percentile 85 and < percentile 97) and obesity (≥ percentile 97) [15,16].

HYDRATION STATUS AND FWR

The free water reserve, calculated as FWR (ml/24 h) = (measured urine volume [ml/24 h] - obligatory urine volume [ml/24 h]) was used to assess hydration status. The obligatory urine volume (ml/24 h) was derived from the excreted 24 h urine solutes (mOsm/24 h; mainly determined by urinary concentrations of nitrogen, sodium, potassium, and phosphorus) divided by the mean value (2 standard deviation) of maximum urine osmolality of the renal concentrating test for healthy subjects in the respective age group. In children and young adults having a typical affluent Western diet, this value is 830 mOsm/l. Positive and negative FWR values correspond to "euhydrated state" and "risk of hypohydration", respectively [17].

DIETARY ASSESSMENT

To estimate individual food and nutrient intake one-day dietary record was used. Images of the Manual of Quantification of Foods [18] were also used to obtain a more accurate portion intake. To convert food into nutrients (including water composition of food), the Food Processor Plus® software was used (ESHA Research, USA). This software follows food composition guidelines of the United States Department of Agriculture, however, typically Portuguese food were added to this database of nutritional content of foods, according to the Portuguese Food Composition Table (PFCT) [19,20].

Foods and beverages were grouped in four categories (Table I): "milk and dairy products", "fruit and vegetables", "coffee, barley, soft drinks, juices and water" and "others"; and then, each category was divided in two groups according the median of the ingested amount: "low consumption" (≤ 50th percentile) and "high consumption" (> 50th percentile). Models of unconditional logistic regression were fitted in order to estimate the magnitude of the association between the contribution of different food groups and the hydration status.

The total energy intake was used to reject potentially implausible records by relating it to the basal metabolic rate [21] considering age- and sex-specific cut-offs [22]. Eight children presented implausible eating records, however, the data was analyzed considering the overall sample since non-significant differences in the hydration variables were detected between children with plausible and implausible eating records.

STATISTICAL ASSESSMENT

Data was analyzed with the statistical software IBM SPSS Inc. (Version 21.0). Kolmogorov-Smirnov test was used to test variables normality. Categorical variables were expressed in absolute value and percentage, and the continuous variables in mean ± standard deviation, median (P50) and percentiles (P25, P75). T-student's test was used for independent samples, and the Mann-Whitney U test was utilized to compare cardinal variables. Chi-squared test was used for categorical variables. Statistical significance was considered for a p < 0.05.

Table I. Categorization of dietary intake in food groups

	Foods included
Milk and dairy products	Natural milk, aromatized milk, yogurt, yogurt shake, buttermilk, cream, condensed milk and *cottage cheese*
Fruit and vegetables	Fresh, dried, canned (without syrup) and frozen fruit
	Soup and all of the vegetables: raw, cooked, canned and frozen
Coffee, barley, sodas, juices and water	Infusions, tea, coffee, barley, soft drinks including light/diet/zero versions (carbonated and non-carbonated), sugar drinks (lemonades and iced tea) aromatized drinks, sport drinks and 100% natural juices. Water (bottled or not)
Others	Meat, fish, eggs, cereals, cheeses non considered on the milk and dairy group, pastry, potato, legume, sweets, spices and foods containing fat

Fruit and vegetables groups were considered in an unconditional logistic regression model, in order to estimate the degree of association between food groups intake and hydration status of children.

RESULTS

The characteristics of children and their parents/legal guardians, according to hydration status, are presented in tables II and III; there are no significant differences between any of these descriptive variables with regard to hydration status. The majority of the children (16, 53.3%) had a normal weight. FWR was positive in 17 children (56.8%), presenting euhydrated status; however, negative FWR values with risk of hypohydration were observed in 13 children (43.3%). Energy intake was 1,683 ± 566 kcal, and it was not significantly different according to the hydration status.

In table IV, urine biomarkers of hydration are presented for each of the hydration status categories. Table V shows the intake of the different food groups (low and high intake) according to hydration status, and a significant higher prevalence of euhydrated children is found in the group with a higher intake of fruit and vegetables. This association was confirmed after logistic regression analysis, and children with higher intake of fruit and vegetables were at a lower risk of hypohydration (OR = 0.19, CI 95% 0.04-0.94).

DISCUSSION

This study provides evidence for higher intake of fruit and vegetables and lower risk of hypohydration, defined according to FWR values, in children athletes aged 9-10. Although there is no fully accepted method to characterize hydration status, FWR may be recommended to define 24-h hydration status (23), and previous studies also revealed that FWR values may be affected by the quality of the diet (24,25). Montenegro-Bethancourt (2013) provided, for the first time, evidence for an association between fruit and vegetables intake and children hydration status. Although other authors (26,27) speculated that fruit and vegetables were an essential predictor of hydration status, we also assessed the association with other food groups such as "milk and dairy products", and "coffee, barley, sodas, juices and water". Nonetheless, our findings revealed that only high "fruit and vegetables" intake was significantly associated with a better hydration status. Therefore, a better hydration status could be achieved not only with water and other fluids but also with the ingestion of fruit and vegetables.

In the present study, urine collection was made on Sunday to facilitate the collection on a 24 h period with the help of the children's parents/legal guardians. Although this day may not represent a typical weekday, Sunday may offer the best logistic conditions to characterize familiar food and beverages intake pattern and avoid the influence of professionals at school, which we considered to be a strength of our study. On the other hand, the small size of the sample and the difficulty in obtaining precise data of the dietary intake were the bigger limitations in our study. Moreover, only one-day urine collection and one 24 h diet record made our results harder to generalize to normal daily behavior.

The results obtained in this research showed that the mean total intake of water was 1.5 l and when compared to the 2.1 l recommended by European Food Safety Authority (EFSA), only 71% of the children met EFSA recommendations. A large pro-

Table II. Age, life style characteristics and nutritional intake according to hydration status

		Percentile			Risk of hypohydration	Euhydration	
	$\bar{x} \pm SD^a$	P25	P50	P75	$\bar{x} \pm SD^a$	$\bar{x} \pm SD^a$	p
Age (years)	9.5 ± 0.5	9.5	9.5	10	9.6 ± 0.5	9.4 ± 0.5	0.285
Sleep (h/day)	9.3 ± 0.6	9.0	9.5	9.6	9.2 ± 0.8	9.3 ± 0.5	0.580
Physical Education classes (min/week)	114.0 ± 34.2	90	135	135	116.5 ± 45.1	112.1 ± 24.4	0.729
Sport activity (min/week)	30.1 ± 47.8	0	0	49	17.3 ± 34.6	39.88 ± 54.9	0.206
Energy (kcal)	1,683 ± 566	1,357	1,552	1,887	1,699 ± 688	1,670 ± 474	0.889
Protein (g)	74.76 ± 20.0	62.5	73.9	85.9	77.8 ± 21.2	72.4 ± 19.5	0.487
Total CH (g)	215.7 ± 102.0	161.0	184.7	269.5	217.5 ± 120.6	214.4 ± 89.2	0.798
Total lipids (g)	54.9 ± 24.0	43.3	52.4	63.2	57.1 ± 21.8	53.2 ± 26.1	0.385
Protein (% TEV)	18.9 ± 6.8	14.9	17.0	21.1	19.8 ± 6.1	18.3 ± 7.3	0.325
Total CH (% TEV)	49.7 ± 11.0	44.5	49.8	55.5	48.9 ± 9.1	50.3 ± 12.5	0.735
Total lipids (% TEV)	29.1 ± 7.9	26.3	29.9	33.2	30.9 ± 4.7	27.9 ± 9.6	0.317
Fiber (g)	19.3 ± 26.1	11.2	14.3	20.5	12.6 ± 6.9	24.4 ± 33.7	0.053
Cholesterol (mg)	219.1 ± 127.5	117.9	188.9	296.9	246.5 ± 127.2	198.1 ± 127.4	0.312
Total water (g)	1,473.0 ± 526.2	1,182.8	1,468.5	1,873.8	1,444.2 ± 548.9	1,495.1 ± 524.1	0.798

TEV: Total energy value; CH: Carbohydrate.

Table III. BMI, education and physical activity according to the hydration status

	n (%)	Risk of hypohydration	Euhydration	p
BMI for age				
Thinness	0 (0%)	0 (0%)	0 (0%)	0.823
Normal	16 (53.3%)	7 (53.8%)	9 (52.9%)	
Overweight	8 (26.7%)	4 (30.8%)	4 (23.5%)	
Obesity	6 (20.0%)	2 (15.4%)	4 (23.5%)	
Education				
3 and 4 year	13 (43,3%)	3 (10.0%)	10 (33.3%)	0.050
5 year	17 (56,7%)	10 (33.3%)	7 (23.3%)	
Education of the mother (years)				
≤ 12	17 (56.7%)	6 (20.0%)	11 (36,7%)	0.310
> 13	13 (43.3%)	7 (23.3%)	6 (20.03%)	
Education of the father (years)				
≤ 12	23 (76.7%)	10 (33.3%)	13 (43.3%)	1.000
> 13	7 (23.3%)	3 (10.0%)	4 (13.3%)	
Physical activity with shortness of breath (h/week)				
< 6	17 (56.7%)	8 (26.7%)	9 (30.0%)	0.638
≥ 6	13 (43.3%)	5 (16.7%)	8 (26.7%)	

BMI: body mass index.

Table IV. Association between food intake and hydration status

Food intake	Risk of hypohydration	Euhydrated	p
Tea, barley, juices, soft drinks and water			
Low intake	7 (46,7%)	8 (53,3%)	0,713
High intake	6 (40,0%)	9 (60,0%)	
Fruits and vegetables			
Low intake	8 (66,7%)	4 (33,3%)	0,035
High intake	5 (27,8%)	13 (72,2%)	
Milk and dairy products			
Low intake	7 (46,7%)	8 (53,3%)	0,713
High intake	6 (40,0%)	9 (60,0%)	
Other foods			
Low intake	6 (42,9%)	8 (57,1%)	0,961
High intake	7 (43,6%)	9 (56,3%)	

portion of hypohydrated children was also found in the study conducted by Phillips (28). However, according to the calculated minimal fluid intake recommendation (during and following an hour of exercise) of 945 ml (10) plus the daily water needs (2,1 l), children should consume a total of 3,045 ml of water in a single day. Water intake below fluid intake guidelines, particularly considering sport activities, may result in increased risk of heat-related illnesses and increased physiological strain (29,30).

The possibility that inexperienced athletes, attending sports exercise sessions, could fail to drink properly is elevated and it might be explained by anxiety, distraction and diversion (10), typical in this age range. Therefore, coaches and parents should promote the fluid ingestion and educate in the importance of hydration and healthy eating practices in young athletes to improve the overall quality of children's diet and their hydration status (10), and increase sports performance.

CONCLUSIONS

In conclusion, almost half of the children were at risk of hypohydration. Our results suggested that a hydrated state could be better achieved in the group with a higher intake of fruits and vegetables.

DECLARATION OF INTEREST

P.P. was a member of the Scientific Board of the Institute of Hydration and Health between 2008 and 2015.

Table V. Characterization of the urinary variables according to the hydration status

	Mean ± SD	Percentile			Risk of hypohydration	Euhydrated	
	$\overline{x}$ ± SD	P25	P50	P75	$\overline{x}$ ± SD	$\overline{x}$ ± SD	p
Urinary Volume (mL/24 h)	936,0 ± 408,3	700,0	885,0	1092,5	643,8 ± 178,5	1160,0 ± 395,5	≤0,001
Osmolality (mosmol/l)	708,1 ± 175,4	589,5	703,5	851,7	857,3 ± 93,0	593,9 ± 131,8	≤0,001
Urinary Density	1022,3 ± 5,2	1019,0	1022,0	1026,0	1026,8 ± 2,6		≤0,001
Obligatory Volume (mL/24 h)	853,1 ± 211,4	710,0	847,6	1026,2	1033,0 ± 112,0	715,6 ± 158,7	≤0,001
FWR (mL/24 h)	83,2 ± 574,5	-339,6	15,5	321,0	-389,1 ± 198,5	444,9 ± 498,9	≤0,001

FWR: free water reserve.

Table VI. Odds ratio hypohydration status according to fruit and vegetable intake

Intake of fruit and vegetable	OR	IC 95%	p
Low	1		
High	0,19	(0,04;0,94)	0,041

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