


# Hydration Deficit in 9- to 11-Year-Old Egyptian Children

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## Abstract

**Background.** Children who drink too little to meet their daily water requirements are likely to become dehydrated, and even mild dehydration can negatively affect health. This is even more important in Middle-Eastern countries where high temperatures increase the risk of dehydration. We assessed morning hydration status in a sample of 519 Egyptian schoolchildren (9-11 years old). **Methods.** Children completed a questionnaire on breakfast intakes and collected a urine sample after breakfast. Breakfast food and fluid nutritional composition was analyzed and urine osmolality was measured using osmometry. **Results.** The mean urine osmolality of children was 814 mOsmol/kg; >800 mOsmol/kg (57%) and >1000 mOsmol/kg (24.7%). Furthermore, the results showed that a total water intake of less than 400 mL was associated with a significant higher risk of dehydration. Surprisingly, 63% of the children skipped breakfast. **Conclusions.** The results showed that a majority of Egyptian schoolchildren arrive at school with a hydration deficit. These results highlight the fact that there is a need to educate schoolchildren about the importance of having a breakfast and adequate hydration.

## Keywords

hydration, children, urine osmolality, Egypt

## Introduction

Current dietary behaviors and practices observed in children may have detrimental consequences on their health. The adverse health consequences that may result from excessive intake of soda and sweetened beverages; fast-food consumption; inadequate intakes of fresh fruits, vegetables, fiber-rich foods, and dairy and other calcium-rich foods; reduced levels of physical activity; and increasing obesity rates indicate a need to revisit the diet and lifestyle characteristics of this age group.<sup>1,2</sup> Among others, the maintenance of an adequate hydration status in children is critical, especially in countries or regions with hot and arid climate. The total volume of body water ranges around 20 to 23 liters in 9- to 11-year-old children.<sup>3</sup> Healthy children should drink enough liquid to maintain their water-electrolyte balance and to compensate their daily loss of water through the lungs, skin, urine, and stools, and those who drink too little to meet their water requirements are likely to become dehydrated.

Dehydration has been shown to be potentially associated with suboptimal cognitive and physical performance in both adults and children.<sup>4-8</sup>

Children's fluid requirements vary as a function of gender and age. Gender, age clusters, and definitions of recommended daily water intakes vary widely between countries. The US Institute of Medicine recommends 2400 mL/day and 2100 mL/day of total water, respectively, for American boys and girls aged 9 to 13 years.<sup>9</sup> For children aged 9 to 13 years, the European Food Safety Authority recommends 2100 mL/day for boys and 1900 mL/day for girls.<sup>10</sup>

The children hydration status in the MENA regions and Egypt in particular remains unknown. Only few articles described the breakfast intake in Egyptian school children without mentioning either their fluid intake or their hydration status.<sup>11,12</sup> Results obtained with large samples of healthy children in the United States, France, Italy, and the United Kingdom have

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shown that a large majority of children (60% to 67.2%) arrived at school with an elevated urine osmolality (over 800 mOsmol/kg) after breakfast intake.<sup>13-17</sup> The results of these studies reveal high prevalence of mild hydration deficit, reflected by a urinary osmolality over 800 mOsmol/kg.<sup>18,19</sup> Furthermore, in MENA countries, the high ambient temperature and low water content in the atmosphere may increase the prevalence of dehydration among these children. As a consequence, some cognitive functions could be affected. Indeed, a study performed on 10- to 12-year-old school children living in Israel showed that dehydrated students (urine osmolality >800 mOsmol/kg H<sub>2</sub>O) performed inferiorly to their well-hydrated peers (urine osmolality <800 mOsmol/kg H<sub>2</sub>O) on several cognitive tests.<sup>6</sup> It appears therefore important to determine the hydration status of children from these countries.

We conducted a study to determine the prevalence of morning mild hydration deficit (defined as a urinary osmolality >800 mOsmol/kg of water) in a sample of healthy 9- to 11-year-old children living the Damanhour District of the Beheira governorate in Lower Egypt. The secondary objectives included a description of the distribution of morning urinary osmolality after breakfast and of food and drink consumed at breakfast in broad food groups. The intake from breakfast foods and drinks (water, energy, macronutrient content, osmotic load, energy density) were also estimated, and the relationship between food, water, and nutrient intake and urinary osmolality was examined.

The General Organization of Teaching Hospitals and Institutes ethics committee, Egyptian Ministry of Health, approved the study in April 2013 (ethics approval number: HD000087; issued on April 8, 2013). Authorization was granted to the Damanhur Nephrology Department to conduct this research program.

## Methods

Recruitment was conducted from May to June 2013. The children included had to meet the following criteria: aged from 9 to 11 years, in good health (absence of concomitant disease), and written consent obtained from parents and children. The exclusion criteria included severe or acute disease likely to interfere with the results of the study or to be life-threatening; history of renal, metabolic, or digestive disease, with the exception of possible appendectomy; and local or general treatment (prescribed drugs, food supplements, etc) likely to interfere with evaluation of the study parameters, including hydration state in particular (diuretic treatment or treatment interfering with metabolism and eating behavior).

## Participants

Children were mainly recruited through primary schools from the city of Damanhur and surrounding areas. These schools received a recruitment envelope describing the study and outlining the school's potential involvement in addition to a copy of the ethics approval and agreement from the Ministry of Education to access these schools. All children were given a study pack to take home, containing a study information document, a parent and child consent form, a questionnaire covering demographic information, contact details, use of medications, exercise, personal medical history for chronic diseases (diabetes mellitus, chronic kidney disease, and gastrointestinal disease), and a urine sample container with specific instructions regarding sampling collection time. Parents and children who agreed to take part in the study were required to return the study materials (the answered questionnaire and a signed copy of the consent) to the study team in the school. The participation day was usually 3 to 4 days immediately following the return of parents' consent forms. The parents were asked to bring back the urine sample with the child during participation.

## Dietary Intake Measurement

Dietary intake was determined using a diary, where children recorded all foods and drinks consumed at breakfast, or the last meal of the previous day for children who did not take breakfast. Children were asked to describe what they had to eat or drink, including brand name, cooking method, and portion size (household measures or packet weight). Dietary information was obtained by an experienced nutritionist, who recorded qualitative and quantitative data related to meals. All dietary information was entered into a dietary software (Nutro-Plus [N+]; adapted for children by the Department of Nutrition, Mansura Medical Directorate, Egypt) using recommendations and guidelines of the Egyptian Institute of Nutrition for the calculation of food and nutrient intake for Egyptian food items, which allows finding the nutrition deficiencies and bad dietary habits. The software outputs the dietary food and statistical analyses output in an Excel file.

## Definitions

Total water was defined as the amount of water coming from fluid *and* food intake. Total energy and potential renal solute load ( $\text{mmol} = 5.7 * [\text{g of protein}] + [\text{mg of sodium}/23] + [\text{mg of potassium}/39] + 0.55 * [\text{mg of phosphorus}/31]$ ) were used as proxies for total solute intake. For some analyses, the total water intake was categorized as above or below 400 mL. The adequate

water intake recommended by European Food Safety Authority was used, since no national guidelines for children's water intake were available in Egypt. Osmolality was broken down into 4 different clusters: (a)  $\leq 300$  mOsmol/kg, (b) 301 to 800 mOsmol/kg, (c) 801 to 1000 mOsmol/kg, and (d)  $>1000$  mOsmol/kg.

### Urine Samples

Children were asked to collect morning urine sample at home under parents' supervision, for the analysis of urinary osmolality, minimum 30 minutes after breakfast. Those who did not eat breakfast were instructed to collect urine samples immediately after getting up. Children had to bring back the study pack including the urine sample to the research team in the clinical center or to the school administrative staff on arrival at school. Study packs were collected on a daily basis by research staff. Urine samples were sent daily in a temperature-adjusted box for measurement of urinary osmolality.

### Measurement of Urinary Osmolality

Urinary osmolality measurement were performed in the Elborg Clinical Chemistry Laboratory, Damanhur branch, under the supervision of Dr Lamiaa El-Messairy using osmometry, FDA approved with a reference range 300 to 900 mOsmol/kg.

### Statistical Methods

Statistical analyses were performed using SPSS software (version 19; IBM, New York, NY). Quantitative data were expressed as means  $\pm$  standard deviation (SD), and qualitative data were expressed as percentages. The prevalence of mild dehydration (as defined by a urinary osmolality  $>800$  mOsmol/L) was assessed in the entire population and by gender. Stratification according to age and nature of beverages consumed was also performed.

The relation between urinary osmolality and the nature and amount of beverages taken at breakfast was studied using Pearson correlation, linear regression, and independent *t* tests. The influence of the following nutrient parameters was explored: total energy intake at breakfast (kcal), macronutrient intake at breakfast (protein, fat, and carbohydrate), osmotic load from foods and fluids taken at breakfast, and total amount of water coming from foods and beverages.

A multivariate logistic regression model with adjustment for age, gender, body weight, height, energy intake, and place of recruitment was used to test whether the type of beverage, foods consumed, and nutrient characteristics at breakfast were associated with increased

urinary osmolality or not. This logistic regression analysis was used to determine the risk factors for mild dehydration after breakfast.

As adapted from Rampersaud et al,<sup>20</sup> for some analyses, we grouped the population into 8 different clusters according to their diet characteristics (called "diet clusters"): (a) No fluid—No food; (b) Only food—No fluid; (c) Only fluid—Only water; (d) Only fluid—Only drinks other than water; (e) Only fluid—Water and other drinks; (f) Food and fluid—Only water; (g) Food and fluid—Only drinks other than water; and (h) Food and fluid—Water and other drinks.

## Results

### Population Characteristics and Sample Size

Overall 705 children participated in the study, and 32 participants were excluded due to missing dietary food information (15 participants), diabetes mellitus (2 participants), gastrointestinal disease (7 participants), and missing birth date (8 participants). Thus, there were 673 eligible participants included in the database at the start of the analysis. Of these, 154 participants were excluded from the final analysis due to noncompliance with urine sample collection (30 participants), below 9 years old (78 participants), and above 11 years old (46 participants). We accepted the high rate of participation out of the 9- to 11-year-old range to motivate the eligible group for participation (brothers, friends, etc). The final analysis included 519 participants: 194 children who collected their urine after breakfast and 325 children who did not have breakfast and thus collected their fasting urine (Table 1).

### Demographic Characteristics and Medical History

The mean  $\pm$  SD age of the cohort was  $10.03 \pm 0.79$  years and included 260 boys (50.1%) and 259 girls (49.9%). Cohort characteristics are presented Table 1. The mean body weight was significantly higher ( $P = .002$ ) in girls ( $32.9 \pm 9.6$  kg) than in boys ( $30.6 \pm 7.1$  kg). The mean body mass index (BMI) was calculated for 511 participants (256 boys and 255 girls). Using the International Obesity Task Force cutoffs, we observed that 35.8% of the children enrolled were overweight, with 97/256 boys (37.9%) and 86/255 girls (33.7%); and 19.2% were obese, with 35/256 boys (13.7%) and 63/255 girls (24.7%).

### Environmental Determinants

On the days of urine sample collection and on the previous days, the average temperatures were  $25.97 \pm 3.0^\circ\text{C}$

**Table 1.** Demographic and Physical Characteristics of the Sample (N = 519)<sup>a</sup>.

	Boys (n = 260)	Girls (n = 259)	All (N = 519)
9 years old, n (%)	76 (29.3%)	79 (30.5%)	155 (29.9%)
10 years old, n (%)	107 (41.1%)	87 (33.6%)	194 (37.4%)
11 years old, n (%)	77 (29.6%)	93 (35.9%)	170 (32.7%)
Body weight (kg), mean [95% CI] (SD)	30.6 [17.3-76.3] (7.1)	32.9 [19.1-75] (9.6)	31.8 [17.3-76.3] (8.5)
≤30 kg, n (%)	125 (48.6%)	107 (41.8%)	232 (45.2%)
>30 kg, n (%)	132 (51.4%)	149 (58.2%)	281 (54.8%)
Body height (cm) <sup>b</sup> , mean [95% CI] (SD)	131.6 [113-153] (7.6)	132.6 [107-156] (9.7)	132.1 [107-156] (8.7)
BMI (kg/m <sup>2</sup> ) <sup>b</sup> , mean [95% CI] (SD)	17.6 [11.1-35.7] (3.1)	18.5 [12.8-38.3] (3.8)	18.0 [11.1-38.3] (3.5)
BMI ≤ 13.5 kg/m <sup>2</sup> , n (%)	11 (4.3%)	5 (2.0%)	16 (3.1%)
13.5 < BMI < 17 kg/m <sup>2</sup> , n (%)	113 (44.1%)	101 (39.6%)	214 (41.9%)
17 < BMI ≤ 20 kg/m <sup>2</sup> (overweight), n (%)	97 (37.9%)	86 (33.7%)	183 (35.8%)
20 < BMI kg/m <sup>2</sup> (obese), n (%)	35 (13.7%)	63 (24.7%)	98 (19.2%)

Abbreviations: CI, confidence interval; SD, standard deviation; BMI, body mass index.

<sup>a</sup>Data are presented as number (percentages) or mean values [95% CI] (SD).

<sup>b</sup>Body weight values were documented for 257 boys and 256 girls, body height values for 256 boys and 256 girls, and BMI values for 256 boys and 255 girls.

**Table 2.** Number of Children by Diet Cluster.

	No Food				Food			
	No Fluid	Beverages Other Than Water	Water	Water and Other Beverages	No Fluid	Beverages Other Than Water	Water	Water and Other Beverages
Boys	154	2	5	5	9	16	34	35
Girls	171	1	1	4	11	6	43	22
All	325	3	6	9	20	22	77	57
All (%)	62.6	0.6	1.2	1.7	3.9	4.2	14.8	10.9

and  $24.13 \pm 1.0^{\circ}\text{C}$ , respectively, and the average percentages of humidity were  $60.70 \pm 6.6\%$  and  $68.85 \pm 4.6\%$ , respectively. There was no significant difference between temperature and humidity between the day of urine collection and the previous day.

Urinary osmolality was positively correlated to the average atmospheric temperature on the day of participation ( $P = 0.002$ ) and to the average humidity percentage on the day before participation ( $P = .011$ ).

### Breakfast and Water Intake

Unexpectedly, a majority of children enrolled (62.6%) did not consume breakfast (neither food nor drink) in the morning; only 37.4% ate any food or drank any fluid or both (Table 2). The majority of children having breakfast consumed both food and water (39.7%), or food, water, and beverages other than water (29.4%). Only a few children had only fluids at breakfast (9.3%), and 12.8% drank only beverages (other than water) with or without food. In addition, 10.3% of breakfast consumers left home without drinking anything at breakfast.

The average volume of total water intake by breakfast consumers was 399.6 mL (Tables 3 and 4), mostly provided by fluids (275.8 mL). Children who consumed only drinking water without food at breakfast had an average volume of 216.7 mL of total water intake, which increased to 421.2 mL in children who consumed drinking water and other beverages without food. The highest amount of total water intake (579.3 mL) was reported by children who consumed food, drinking water, and other beverages ( $n = 57$ ). The main source of water intake by breakfast consumers was drinking water (170.1 mL) followed by water from food (123.8 mL). The main source of drinking water came from tap water. On average, the breakfast consumed by Egyptian children enrolled in the study provided 381.9 kcal, 13.6 g of proteins, 11.6 g of lipids, 53.1 g of carbohydrate, 603.3 mg of sodium, 509.4 mg of potassium, and 236 mg of phosphorus (Table 3).

### Osmolality and Its Determinants

The mean urinary osmolality of the whole study sample was  $813.79 \pm 249.80$  mOsmol/kg. This value is above

**Table 3.** Breakfast Composition.

	No Food				Food				Mean for Breakfast Consumers (n = 194)
	Only Beverages Other Than				Only Beverages Other Than				
	No fluid	Water	Only Water	All Fluid	No Fluid	Water	Only Water	All Fluid	
Water (mL)	0.0	0.0	216.7 ± 10.5	259.7 ± 36.1	0.0	0.0	220.9 ± 10.2	216.7 ± 6.0	170.1 ± 8.2
Water in other beverages (mL)	0.0	244.8 ± 35.8	0.0	161.5 ± 18.0	0.0	236.0 ± 29.8	0.0	230.2 ± 11.1	105.7 ± 9.4
Water in all fluids (mL)	0.0	244.8 ± 35.8	216.7 ± 10.5	421.2 ± 47.6	0.0	236.0 ± 29.8	220.9 ± 10.2	446.8 ± 13.5	275.8 ± 12.0
Water from food (mL)	0.0	0.0	0.0	0.0	116.1 ± 24.3	88.8 ± 16.8	158.2 ± 16.0	107.1 ± 14.2	123.8 ± 8.8
Total water intake (mL)	0.0	244.8 ± 35.8	216.7 ± 10.5	421.2 ± 47.6	116.1 ± 24.3	324.8 ± 30.8	379.2 ± 18.1	579.3 ± 18.9	399.6 ± 14.3
Protein (g)	0.0	5.4 ± 2.5	0.0	5.2 ± 0.9	15.4 ± 2.9	12.5 ± 1.3	14.1 ± 1.4	15.9 ± 1.3	13.6 ± 0.8
Fat (g)	0.0	5.7 ± 2.7	0.0	5.5 ± 1.0	14.0 ± 2.6	9.9 ± 1.4	11.2 ± 1.1	14.4 ± 1.4	11.6 ± 0.7
Carbohydrate (g)	0.0	26.2 ± 15.0	0.0	7.5 ± 1.3	48.1 ± 7.5	52.7 ± 4.5	55.5 ± 3.9	66.2 ± 5.4	53.1 ± 2.7
Energy (kcal)	0.0	177.8 ± 25.5	0.0	101.8 ± 17.8	386.7 ± 41.6	359.1 ± 59.4	391.8 ± 25.7	471.6 ± 32.2	381.9 ± 16.6
Sodium (mg)	0.0	86.2 ± 28.1	2.7 ± 1.7	78.6 ± 12.3	464.0 ± 76.1	359.1 ± 58.6	781.7 ± 89.4	678.6 ± 82.6	603.3 ± 46.9
Potassium (mg)	0.0	450.4 ± 112.3	0.0	233.6 ± 34.5	419.8 ± 69.62	499.8 ± 63.4	468.7 ± 42.4	699.8 ± 52.5	509.4 ± 27.3
Phosphorous (mg)	0.0	164.8 ± 54.3	0.0	146.3 ± 25.7	191.8 ± 27.6	271.1 ± 26.3	198.6 ± 19.8	331.2 ± 24.4	236.0 ± 12.6
PRSL <sup>a</sup> (mmol)	0.0	48.8 ± 13.5	0.1 ± 0.1	41.9 ± 7.1	122.3 ± 19.0	104.6 ± 10.5	150.9 ± 9.4	144.2 ± 11.1	121.0 ± 6.5

<sup>a</sup>Potential renal solute load (PRSL) = 5.7 \* (g of protein) + (mg of sodium/23) + (mg of potassium/39) + 0.55 \* (mg of phosphorus/31). Values are mean ± SEM.

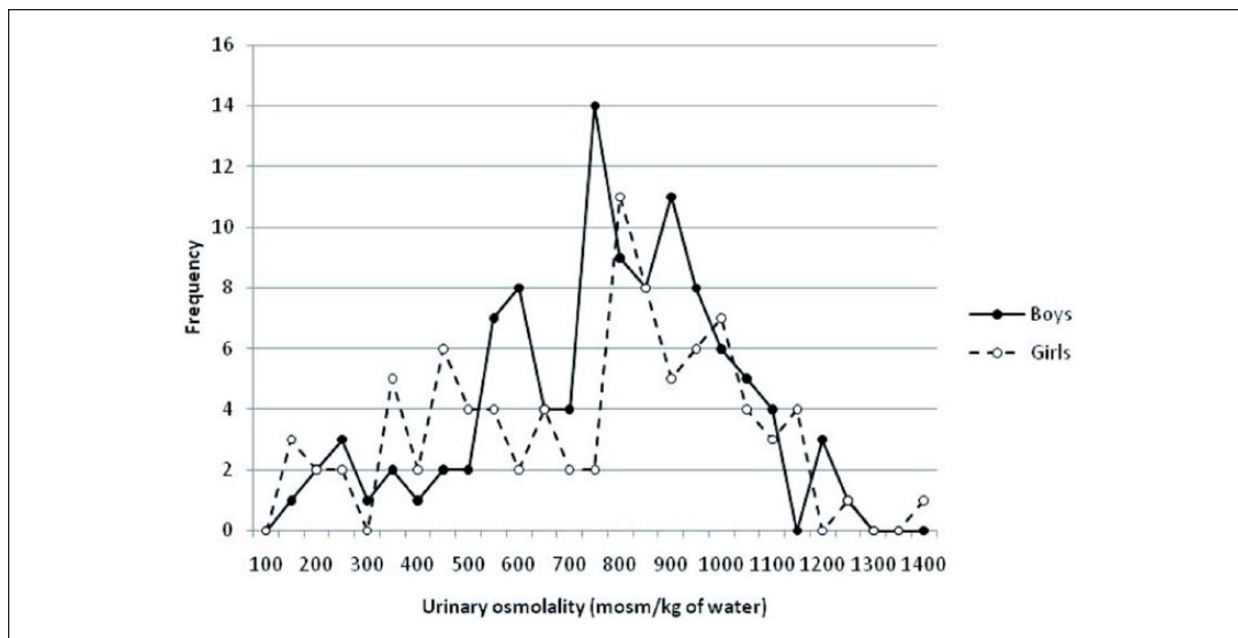
**Table 4.** Mean Breakfast Water Intake Distributed According to Breakfast Diet Cluster and Water Sources (Drinking Water, Water From Beverages Other Than Water, and Water From Food).

Breakfast Cluster		Water (Drinking)	Water (Beverages)	Water (Food)	Water (Total)
Only food/no fluids	N	20	20	20	20
	Mean (SD)	0.0 (0.0)	0.0 (0.0)	116.1 (108.7)	116.1 (108.7)
Only fluid/only drinking water	N	6	6	6	6
	Mean (SD)	216.7 (25.8)	0.0 (0.0)	0.0 (0.0)	216.7 (25.8)
Only fluid/only beverages other than water	N	3	3	3	3
	Mean (SD)	0.0 (0.0)	244.8 (62.0)	0.0 (0.0)	244.8 (62.8)
Only fluid/water and other beverages	N	9	9	9	9
	Mean (SD)	259.7 (108.4)	161.5 (54.1)	0.0 (0.0)	421.2 (142.9)
Food and fluid/only drinking water	N	77	77	77	77
	Mean (SD)	220.9 (89.8)	0.0 (0.0)	158.2 (140.3)	379.2 (158.7)
Food and fluid/only beverages other than water	N	22	22	22	22
	Mean (SD)	0.0 (0.0)	236.0 (145.0)	88.8 (79.2)	324.8 (156.6)
Food and fluid/water and other beverages	N	57	57	57	57
	Mean (SD)	216.7 (45.0)	230.2 (83.7)	132.5 (107.1)	579.3 (142.8)
Total	N	194	194	194	194
	Mean (SD)	170.1 (113.7)	105.7 (131.3)	123.8 (122.3)	399.6 (199.2)

800 mOsmol/kg of water (ie, over the threshold defined for mild hydration deficit). The distribution of osmolality values was very large (range = 122-1525 mOsmol/kg; see Figure 1). Moreover, 296 children (57%) showed urine osmolality >800 mOsmol/kg, with similar proportions in boys and girls (58.8% vs 55.2%, respectively). Among those children, 168 presented a urine osmolality >800 mOsmol/kg (32.3%) and 128 >1000 mOsmol/kg (24.7%). The mean urine osmolality was significantly higher ( $t = 2.050$ ,  $P = .041$ ) in boys ( $n = 260$ , mean =  $836.2 \pm 14.5$  mOsmol/kg) than in girls ( $n = 259$ , mean =  $791.3 \pm 16.4$  mOsmol/kg).

The mean urine osmolality in fasting children was  $834.7 \pm 13.6$  mOsmol/kg; it was significantly higher ( $t = 2.43$ ;  $P = .016$ ) compared to children who gave their urine sample after breakfast ( $779.5 \pm 18.8$  mOsmol/kg).

Summary characteristics of urine osmolality and nutritional composition of breakfast for the total population ( $N = 519$ ) indicated an association between protein and phosphorus content and potential renal solute load. This association was likely to reflect high phosphorus excretion in response to breakfasts relatively rich in protein and phosphorus. In addition, we observed an



**Figure 1.** Cumulative distribution of osmolality in a sample of Egyptian children (N = 519).

Measured urine osmolality frequency among sample is represented according to gender and expressed in mOsmol/kg of water.

association between carbohydrates and beverages intake likely to reflect the intake of sweet beverages (Table 3).

Due to the high number of breakfast skippers, we performed a correlation analysis in the population of breakfast consumers only ( $n = 194$ ). There was no statistically significant correlation between urine osmolality and total water intake (Pearson  $r = 0.1221$ ,  $P = .0916$ ) and no significant correlation between urine osmolality and water intake derived from fluid only (Pearson  $r = 0.05910$ ,  $P = .4130$ ). However, a logistic regression analysis with a cutoff for fluid intake at breakfast  $<400$  mL revealed that water intake  $<400$  mL, either coming from fluids (water + beverages) or from food, was associated with a statistically significant increased risk of dehydration ( $P < .0001$ ).

## Discussion

Daily water requirements of children depend on age, gender, and weight among other factors. It is essential to meet the daily water requirements because organs' function (heart, lungs, brain, kidneys, etc) depend on an adequate hydration. Children who drink too little to meet their water requirements are likely to become dehydrated.

To our knowledge, there was no study that investigated the hydration status of Egyptian children. Therefore, we have assessed morning hydration status in a large sample of 519 Egyptian children (9 to 11 years) attending

primary schools in the El-Behira governorate. They completed, under the supervision of a trained nutritionist, a questionnaire describing both their fluids and food intake at breakfast and collected a urine sample after their breakfast for urinary osmolality measurement.

The cohort included an equal number of boys and girls with a mean age of 10 years. The mean BMI was  $18 \text{ kg/m}^2$ , with almost 36% of children overweight and 20% obese. The prevalence of overweight among children is increasing in both developed and developing countries,<sup>21</sup> but varying according to different patterns and pace. A systematic review of nutritional surveys performed in Arab countries between 1990 and 2011 showed that the prevalence of overweight and obesity is increasing in these countries.<sup>21,22</sup>

Surprisingly, 62.6% of children skipped breakfast. Only few articles describe the breakfast intake in Egyptian school children. In 2013, El-Sabely et al described the nutritional status and dietary habits of school children in Zagazig city and reported only 4.7% to 7.1% of breakfast skippers in a population of 288 children (6-12 years).<sup>11</sup> In contrast, Wahba et al reported that in a population of 10- to 11-year-old children from Cairo city ( $n = 2818$ ), 34.9% were skipping breakfast.<sup>12</sup> The 2 main reasons outlined were that children were not accustomed to have a morning meal or that they were afraid to be late for school. Breakfast is considered to be the most important meal of the day, bringing nutrients and fluids to the body after a rather long period of

fasting, but also conditioning appetite and food intake for the remainder of the day. Several studies carried out among children and adolescents have revealed that breakfast skipping was frequently associated with overweight and obesity. In the United States and Australia, studies have shown a significant association between breakfast skipping and overweight/obesity.<sup>23,24</sup> In Europe, several studies have demonstrated a positive association between usual breakfast consumption and healthy BMI.<sup>25,26</sup> In the MENA regions, Musaiger suggested breakfast skipping as a factor associated with obesity, probably because breakfast consumers are more likely to have better overall diet quality.<sup>22</sup>

According to Rampersaud et al, who reviewed the results of 47 studies examining the association of breakfast consumption with nutritional adequacy (9 studies), body weight (16 studies), and academic performance (22 studies) in children and adolescents, breakfast as part of a healthy diet and lifestyle can positively affect children's health and well-being.<sup>20</sup> Parents should be encouraged to provide breakfast for their children or explore the availability of a school breakfast program. We advocate consumption of a healthy breakfast on a daily basis consisting of a variety of foods, especially high-fiber and nutrient-rich whole grains, fruits, and dairy products and beverages. The same authors also argued that breakfast skipping was highly prevalent in the United States and Europe (10% to 30%), depending on age group, population, and definition.<sup>20</sup>

The main result of our study showed that almost two thirds of the 9- to 11-year-old Egyptian children from Damanhur city have a urinary osmolality over 800 mOsmol/kg, reflecting a mild hydration deficit. Mild dehydration affected almost equally boys (58.8%) and girls (55.2%), but the average urine osmolality was significantly higher in boys compared to girls. Furthermore, almost one third of the children had a urine osmolality >1000 mOsmol/kg.

We found a positive correlation between urinary osmolality and the average atmospheric temperature and humidity. These results are in accordance with previous studies showing that urine concentration increased with transepidermal water loss coupled with high atmospheric temperature.<sup>27</sup> Hence, these results strengthen the hypothesis that children living in high ambient temperature and low water content in the atmosphere could be more at risk for mild dehydration.

No significant linear correlation between water intake (either from fluids or from food) and urine osmolality was observed. However, the mean urine osmolality in fasting children (breakfast skippers) was significantly higher ( $834.7 \pm 13.6$  mOsmol/kg) than in children who had breakfast ( $779.5 \pm 18.8$  mOsmol/kg).

In addition, a total fluid intake below 400 mL was clearly associated with a significant higher risk of mild dehydration. These results suggest that a low total water intake (<400 mL) was a contributing factor to the mild hydration deficit observed in this cohort of Egyptian schoolchildren.

Our study showed that most of the Egyptian schoolchildren enrolled in our study presented an elevated urinary osmolality reflecting a mild hydration deficit. This study was in accordance with previous reports. In a large sample of 529 French school children aged 9 to 11 years, more than one third had a urine osmolality between 801 and 1000 mOsmol/kg, and almost two thirds had evidence of a hydration deficit when they went to school in the morning, despite breakfast intake, while 22.7% had a urine osmolality over 1000 mOsmol/kg. This was more frequent in boys than in girls ( $P < .001$ ), and 73.5% drank less than 400 mL at breakfast.<sup>13</sup> Similar results in an Italian population were reported by Assael et al.<sup>17</sup> Another study conducted in 429 elementary school children, aged 8 to 10 years, from 4 subpopulations (Israeli-born Jewish and Bedouin-Arab children, and immigrant children who recently arrived to Israel from Eastern Europe and from Ethiopia) indicated that high proportion of children who reside in a hot and arid environment were found to be in a state of moderate to severe dehydration.<sup>27</sup>

In conclusion, a high number of Egyptian children residing in a hot and arid environment were found to be in a state of hydration deficit, as reflected by their morning urine osmolality.

Because a suboptimal hydration status in children could increase their risk of suffering the adverse effects of dehydration with respect to their physiological functions, it is important to encourage good drinking habits and help them maintain an appropriate fluid intake as an essential part of a healthy lifestyle. Moreover, a large majority of children skipped breakfast (63%) and hence could be even more prone to mild dehydration. Those children who did not take any breakfast and their family should be educated on the importance to take a healthy breakfast, including both fluid and food breakfast, before going to school.

### Author Contributions

ZG: contributed to conception and design; contributed to acquisition and interpretation; drafted manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

MZ: contributed to conception and design; contributed to acquisition and interpretation; drafted manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

UE: contributed to conception and design; contributed to acquisition and interpretation; drafted manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

MV: contributed to analysis and interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

EL: contributed to analysis and interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

NH: contributed to interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

FC: contributed to analysis and interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

### Declaration of Conflicting Interests

The authors declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: F. Constant and N. Hawili are employees of Nestlé Waters. Z. Gouda, M. Zarea, U. El-Hennawy, M. Viltard, and Eve Lopicard declare no conflicts of interest.

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