

## Original Research Article

# High prevalence and associated risk factors of dehydration among college students: implications for health and academic performance

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## ABSTRACT

**Background:** Existing data indicate that poor hydration status adversely affects academic performance and health status of college students, but hydration studies among students have not received sufficient research and educational attention. The aim of this study was to determine the prevalence and associated risk factors of dehydration among college students in Southern Nigeria.

**Methods:** A total of 500 students (190 males and 310 females), ages between 18 and 35 years filled out a supervised questionnaire which included questions pertaining to socio-demographics, lifestyle habits, perceived symptoms, academic performance, urinary characteristics and water/fluid intake. Hydration status was determined using urinary specific gravity during the month of October 2016. Mean values were calculated and used to determine the hydration status of participants. Multivariable regression analysis was used to determine odds ratios (ORs) and 95% confidence interval for factors associated with poor hydration status of participants.

**Results:** About 46.4% of participants were dehydrated. Insufficient water intake (OR=6.41, 95% CI:2.121-19.385, P=0.001), alcohol drinking habits (OR=4.17, 95% CI: 1.313-13.258, P=0.015), night clubbing habits (OR=2.51, 95% CI:1.261-3.822, P=0.034) and being exposed to hot environment (OR=2.16, 95% CI:1.998-4.656, P=0.041) were factors associated with increased odds of dehydration among participants. Other factors associated with higher odds of dehydration include regular coffee intake (OR=2.93, 95% CI:1.788-5.622, P=0.017), experiencing academic stress (OR=1.53, 95% CI:1.041-2.251, P=0.031) and having parents or guardians of middle or low SES (OR=2.21, 95% CI:1.70-4.267, P=0.42) and (OR=3.42, 95% CI:1.655-7.82, P=0.015) respectively.

**Conclusions:** Indeed, there is a high prevalence of dehydration and associated risk factors among college students. Intervention programs to reduce dehydration among students should include these factors among others for improved quality of life and academic performance.

**Keywords:** Dehydration, Students, Risk factors, Cognitive function, Health effect

## INTRODUCTION

The prevalence of inadequate water intake has increased substantially among college students globally and is a major public health concern because of its association with dehydration which has been associated with several adverse health outcomes including poor academic performance.<sup>1-4</sup> However, inadequate hydration is an understudied health problem among college students in some geographic regions.<sup>5</sup>

Water constitutes a greater proportion (about 60%) of the human body and plays a significant role in virtually all aspects of human life including disease prevention and health promotion.<sup>6</sup>

Living cells need water for nourishment, metabolic activities, elimination of metabolic waste, electrolyte homeostasis, acid-base balance, temperature regulation and functioning of various systems (respiratory,

digestive, renal, cardiovascular, neural, sensory endocrine and haematopoietic systems).

When water intake is less than water loss, a state of fluid deficit (dehydration) ensues. The extent of dehydration and associated adverse health effects may vary and is a function of the extent of fluid homeostasis, which is highly regulated and maintained by the body.<sup>7</sup>

A deficit of 1-2% of the body fluid leads to mild dehydration, while losses of more than 5% of the total body fluid leads to severe dehydration.<sup>8</sup> Interestingly, even mild dehydration is reportedly detrimental to human health, including alterations in several aspects of cognitive function such as concentration, alertness and short-term memory.<sup>5,9</sup> Symptoms of dehydration are varied and may depend on the degree of fluid deficit. However, the symptoms range from mild to moderate headache, tiredness, dizziness, confusion, reduced motor activities, reduced cognitive functioning and difficulty in concentrating.<sup>6</sup>

Common causes of dehydration include exposure to extreme environmental conditions (heat and humidity), physical exertion, inadequate fluid intake as well as lifestyle related factors.<sup>6,10</sup> Regardless of the aetiology, dehydration is detrimental to health, and in particular, among students, dehydration may be associated with a number of short-term and long-term systemic complications including mental deterioration, and poor academic performance (learning and memory).<sup>5,9,11-13</sup> Also, decrease cognitive, visual, psychomotor and physical performance has been reported following dehydration, and are attributable to the associated impaired, hemodynamic and neurotransmitter processing leading to changes in blood-brain barrier permeability and decrease blood flow in some brain areas.<sup>14-16</sup> There is also, associated dysfunctioning of the dopaminergic and noradrenergic systems, impaired cholinergic activities leading to defective neurotransmission.

Poor control of attention, motivation, fatigue and poor performance in psychomotor tasks.<sup>12</sup> Activation of the hypothalamic-pituitary-adrenocortical axis and increased cortisol and other stress hormone release have been reported and is causally related to the impaired cognitive function such as perception, spatial ability and impaired memory observed in dehydrated individuals.<sup>17</sup> As a guide for preventing dehydration and the afore-mentioned associated health problems, the Institute of Medicine (IOM) and European Food Safety Authority (EFSA) have established age and sex specific adequate intake (AI) levels of total water for humans. According to IOM, intake of 1.7 litres (about 7 cups) per 24 hrs is adequate for boys and girls between the ages of 4-8yrs. Intake of at least 2.1 L (roughly 9 cups) and 2.4 L (roughly 10 cups) are adequate for boys and girls between the ages of 9-13yrs respectively. For adult men and women, 3.7 L (roughly 16 cups) and 2.7 L (roughly 12 cups) respectively are regarded as adequate.

Physically active individuals or those living in hot climates may require more water intake than the estimates mentioned above.<sup>18</sup>

However, because regulation of water balance is complex and dynamic and disparities in the prevalence of dehydration exist across population groups and is influenced by environmental and non-environmental factors and can be modified by cultural dietary customs, and given the effect of dehydration on academic performance and health-related quality of life, a population-specific evaluation of hydration status and associated risk factors, and in particular among college students would be necessary to identify groups at risk.<sup>19</sup> Therefore, we sought to accurately assess the prevalence and associated risk factors of dehydration among college students in Uyo, Southern Nigeria, which hitherto has not been documented.

The results of the present study may enhance better understanding of the causes of dehydration and preventive measures for improving academic performance and quality of life among students globally.

## METHODS

Invitation to participate in this survey was distributed to students through flyers posted at strategic positions within the college campus. An announcement for participation was also made during lectures and practical classes.

Seven hundred and twenty undergraduates aged 18-35 years were randomly recruited from different faculties (Basic Medical Sciences, Arts, Sciences, Law, etc.) in a Nigerian University. Of this number, 500 students (190 males and 310 females) met the inclusion criteria and were assessed between February 2016 and October 2016, to determine the prevalence and associated risk factors of dehydration among participants.

The exclusion criteria included, inappropriate age (<18 and >35 years) pregnancy, metabolic disorders (diabetes, hypertension etc.) inadequate response to questionnaire, use of medication known to affect fluid homeostasis and decline participation. The Institutional Research Ethics Committee approved the research protocol and written informed consent was obtained from all participants, prior to data collection. Before commencement of the study, a pre-survey lecture was delivered by the research co-ordinator to inform participants of the aims and importance of the study. The participants were also informed that participation was voluntary and withdrawal from participation was allowed at any stage of the study.

### Assessment measures

A three-section, semi-structured, self-administered questionnaire was the instrument used to survey

participants who were classified into two groups; (dehydrated and euhydrated). The questionnaire was adapted from previous studies on hydration status assessment.<sup>20,21</sup> However, few modifications were made to suit the hypothesis of the present study.

For the purpose of this study, dehydration was defined as urinary specific gravity (USG) >1.020, while euhydration was defined as USG of  $\leq 1.020$ . Dehydration was further sub-classified into hypo-hydration (USG=1.021-1.025) severe hypo-hydration (USG=1.026-1.030) and clinical dehydration (>1.030) based on the criteria used by the Australian Pathology Association. Body weight measurement was determined in kg using a portable weighing scale. Height measurement was performed using a stadiometer. Participants were instructed to wear lightweight clothing and no shoes. Body mass index (BMI) was calculated as weight (kg)/height (m<sup>2</sup>). BMI was interpreted as underweight (BMI <18 kg/m<sup>2</sup>), normal weight (BMI 18-24.9 kg/m<sup>2</sup>), overweight (BMI 25-29.9 kg/m<sup>2</sup>) and obese (BMI  $\geq 30$  kg/m<sup>2</sup>).

The first part of the questionnaire asked questions about participants' socio-demographic profile such as age, sex, year of study, residence (off or on campus), lifestyle habits (dietary habits, smoking habits, alcoholic intake, drug history, fluid intake, intake of coffee, energy drinks and physical activity status), perceived stress and sleeping habits. They were also instructed to state their involvement in other extra curriculum activities such as night clubbing.

Questions were asked on parents/guardians socioeconomic status. The age of the respondents was stratified into 18-24, 25-30 and 31-35. Sex was stratified into male and female. Marital status was sub-divided into single and married. Dietary habit was assessed by a 24-h dietary recall, and classified into good and poor dietary habits. Poor dietary habit was defined as high frequency of macronutrients consumption, fast food, low fruits and vegetable intake, restaurant patronage, and full portion size intake, while a balance diet consumed 2-3 times/day, including large intake of fruits and vegetables was regarded as good dietary habit. Cigarette smoking habit was stratified into current, ex- and non-smoking. Current smokers were those who smoked up to the day of the survey, ex-smokers were defined as those who had stopped up to six months prior to the study period, while non-smokers were those who never smoked. Alcohol users were grouped into current drinkers defined as (those who drank) alcoholic up to 24 hours prior to the study period. Ex-drinkers were those who had stopped drinking up to six months prior to the study period, non-drinkers were those who never drank, current drinkers were further sub-grouped into high or low consumption based on percentage composition of alcohol and frequency of consumption. Respondents who usually consume drinks with > 2% alcohol and up to 3 to 4 times a week were classified as high consumption, others were low. Physical

activity was assessed based on the U.S healthy people 2010 physical activity standards which recommended 150 minutes of moderate to high-intensity aerobic activity per week in bouts of 10 minutes or more for adults aged 18 to 64 years. Using this scale, respondents were classified into physically active and physically inactive.

Consumption of energy drinks and coffee were stratified into users, ex-users or non-users. Nightclubbing habits were classified into clubbing and non-clubbing.

Students' academic stress scale (SASS) was used to assess the level of stress among participants. Items for the scale were obtained from previous studies on academic stress among students.<sup>22</sup> This scale measures students' stress responses. It rates how much the student experienced symptoms on a 5-points Likert Scale with the scoring as follows: none of the time = 1, a little of the time = 2, some of the time = 3, most of the time = 4, and all of the time = 5. Higher scores indicate greater stress responses.

Parents' or guardians' socio-economic status was assessed using the modified Kuppuswamy's socio-economic status (SES) assessment scale, as described elsewhere.<sup>23,24</sup> Sleeping habit was determined based on duration and frequency as adequate or inadequate.

A 24h recall questionnaire on water intake was used to obtain participants water intake status. They were asked to state their daily water and other fluid intake in terms of quantity and frequency of consumption. They were also asked to state the number of cups of water they drink each day. Those who drink bottled water were asked to specify the size of the bottle by selecting from the following option; 50 CL, 75 CL and 1 L. Participants with <3.7 L/24 h for men <2.7 L/24 h for women (according to IOM) were considered as inadequate intake while  $\geq 3.7$  L/h for men  $\geq 2.7$  L/24h for women were considered adequate intake. Based on the number of cups and frequency of consumption, low water intake was defined as the consumption of less than 16 cups of water for adult men and < 12 cups for adult women. Likewise, the consumption of water for < 3 times/24 h was defined as low intake while  $\geq 4$  times was defined as adequate water intake.

Based on U.S institute of medicine recommendation standard, adequate water intake was defined as intake of 1.7 liters (roughly 7 cups) of total water each day for boys and girls between the ages of 4-8 years.<sup>18</sup> For girls and boys between the ages of 9-13 years, adequate intake of water was defined as at least 2.1L (roughly 9cups) and 2.4 L (roughly 10 cups) respectively for water within 24 hours. For adult men and women, adequate intake of water was defined as 3.7 L (roughly 16 cups) and 2.7 L (roughly 12 cups) of water each day, that includes plain drinking water and water content of all foods and beverages consumed.<sup>18</sup>

The third section of the questionnaire contained 12 open-ended questions adapted from previous studies on assessment of knowledge and perception of hydration status, and included questions such as:<sup>25,26</sup>

- Does hydration mean having sufficient amount of fluid in the body?
- How many glasses of water/fluid should one drink in 24hrs to stay hydrated?
- Does the daily adequate fluid intake depend on age, sex and activity status?
- Does hydration in adult the same thing with drinking water?
- Questions were also asked to assess participants' knowledge on risk factors of dehydration and included such question as;
- Does temperature variation cause dehydration?
- Is dehydration associated with caffeinated drink, strong alcohol consumption, and poor dietary habit?
- To assess knowledge of adverse health effects of dehydration, questions such as;
- Can dehydration be associated with several health problems such as poor health status, poor academic performance and associated symptoms such as headache, confusion, dizziness and fatigue?

Participants were assessed on a 4-point Likert scale: strongly agree 4, agree 3, equivocal 2, not agree 1. The total sum up to 100. A score of  $\geq 80$  very good knowledge, 60-79 good knowledge, 50-60 poor knowledge, 10-49 very poor knowledge,  $<10$  point doubtful knowledge and  $<5$  no knowledge.

Questions were also asked on respondents' urinary characteristics including quantity, color and frequency. Common symptoms perceived by respondents such as headache, dizziness, dryness of tongue or mouth, tiredness, blurring of vision, perceived stress were also enquired about.

This part of the questionnaire also enquired about respondents academic records, particularly in the last semester's examination. Academic performance was graded as excellent for grade A parallel, very good for grade A mixed with B, good for grade B and C, and poor for grade D-F.

#### **Assessment of hydration status**

First-morning urine sample was collected from each participant for measurement of urine specific gravity (USG) using a clinical digital refractometer (Atago). Clinical refractometer has been identified as a valid and reliable device for measurement of hydration level.<sup>27</sup> Likewise, USG is a valid, reliable, convenience widely accepted indicator of hydration status in most cases and strongly correlates with changes in other physiochemical properties of the urine.<sup>28,29</sup> Cross-contamination of samples was prevented by regularly cleaning and calibrating the refractometer after each use. Euhydration

was defined as USG  $<1.02$ , while USG  $>1.02$  was defined as dehydration. The color of the urine samples collected was also assessed via urine color chart developed by Armstrong et al and reported as either clear, amber, deep yellow and light yellow.<sup>29</sup>

#### **RESULTS**

This survey conducted in a Nigerian university included 500 undergraduates (190 males and 310 females) selected from 720 students initially invited to participate. These represent a response rate of 71.4%. Among the participants, 46.4% were dehydrated (USG  $>1.020$ ), while 53.6% were euhydrated (USG  $<1.020$ ).

The socio-demographic variables of the participants showed that most of them were between the ages of 18 and 25 years (88.4%), females (62%), single (94.4%), alcohol drinkers (69%), non-smokers (94.6%) physically inactive (86.2%), had adequate sleep (75.2%), good dietary habits (55.6%), exposed to hot environment (70%) and had hostel residence (97.6%).

Also, a greater number of the dehydrated participants had normal BMI (81%), were in the first year of study (54.7%) experienced academic stress (55.2%), active night clubbers (56.5%), do not take enough fluid (59.1%), users of energy drink (41.8%), users of coffee (51.7%) and with parents/guardians from middle SES (44.4%) (Tables 1a and 1b).

Perceived symptoms with significantly higher prevalence among dehydrated participants were headache (0.029), tiredness (0.0001), poor concentration (0.000), increased thirst (0.000), and excessive fatigue (0.004) (Table 2). Others include poor academic performance, and altered menstrual characteristics and symptoms (premenstrual syndrome, dysmenorrhea) and pre-menstrual dysphoric disorders (Table 3).

Results of multiple logistic regression analysis showed factors significantly associated with higher risk of dehydration to include exposure to hot environment (OR=2.16, CI=1.998-4.656, P=0.041), inadequate water intake (OR=6.41, CI=2.121-19.385, P=0.001), alcohol drinking (OR=4.7, CI=1.313-13.258, P=0.015), academic stress (OR=1.53, CI=1.041-2.251, P=0.031), and BMI (OR=3.75, CI=1.200-11.630, P=0.023).

Others include nightclubbing (OR=2.51, CI=1.261-3.822, P=0.034), Coffee intake (OR=2.93, CI=1.788-5.622, P=0.017) and middle and low SES (OR=2.21, CI=1.701-4.267, P=0.0042) and (OR= 3.42, CI=1.655-7.82, P=0.015) respectively (Table 4).

Table 5 shows the urinary characteristics of dehydrated and non-dehydrated participants. Majority of the dehydrated participants passed less than normal urine quantity (57.3%) which was deep yellow in colour (38.6%) and amber in colour (36.6%).

**Table 1a and 1b: Distribution of hydrated and dehydrated participants according to socio-demographic characteristics.**

Demographic characteristics	Hydrated (n = 268) <1.020 (53.6%)	Dehydrated (n = 232) >1.021 – 1.030 (46.4%)	$\chi^2$ value	p-value
<b>Age</b>				
18 – 25	237(88.4)	205(88.4)	2.73	0.436
26 - 31	27(10.1)	23(9.9)		
32 – 35	4(1.4)	4(1.7)		
<b>Sex</b>				
Male	85(31.7)	105(45.3)	9.11	0.002**
Female	183(68.3)	127(54.7)		
<b>Marital status</b>				
Single	259(96.6)	213(91.8)	4.62	0.032*
Married	9(1.8)	9(8.2)		
<b>Residence</b>				
Hostel	260(97.0)	228(98.3)	0.392	0.531
Off campus	8(3.0)	4(1.7)		
<b>Alcohol intake</b>				
Drinkers	174(64.9)	171(73.7)	4.08	0.043*
Non drinkers	94(35.1)	61(26.3)		
<b>Smoking habit</b>				
Smokers	4(1.5)	23(9.9)	15.65	0.000**
Non-smokers	264(98.5)	209(90.1)		
<b>Daily Physical activity status</b>				
Active	27(10.0)	42(18.1)	6.08	0.014*
Inactive	241(89.9)	190(81.9)		
<b>Sleeping habit</b>				
Adequate	206(76.9)	170(73.3)	0.678	0.410
Inadequate	62(23.1)	62(26.7)		
<b>Dietary habit</b>				
Good	161(60.1)	117(49.6)	4.30	0.038*
Poor	107(39.9)	115(50.4)		
<b>Exposure to hot environment</b>				
Yes	206 (79.9)	148(63.8)	9.66	0.002**
No	62(23.1)	84(36.2)		
Dehydration characteristics	Hydrated (n = 268) <1.020	Dehydrated (n = 232) 1.021 – 1.030	$\chi^2$ value	p-value
<b>BMI</b>				
>18	20(7.5)	3(1.3)	11.96	0.008**
18 – 24	202(75.4)	188(81.0)		
25 – 29	46(17.2)	40(17.2)		
≥30	0(0.0)	1(0.4)		
<b>Year of study</b>				
1	74(27.6)	127(54.7)	41.14	0.000**
2	35(13.1)	17(7.3)		
3	61(22.8)	39(16.8)		
4	93(34.7)	43(18.5)		
5	5(1.9)	6(2.6)		
<b>Academic stress</b>				
Stressed	164 (38.8)	128 (55.5)	12.74	0.000**
Not stressed	164 (61.2)	104 (44.8)		
<b>Night clubbing habit</b>				

Clubbing	86 (32.1)	137 (56.5)	29.10	0.000**
Not clubbing	182 (67.9)	101 (43.5)		
<b>Fluid intake (water )</b>				
Adequate	198 (73.9)	95 (40.7)	54.24	0.000**
Inadequate	70 (26.1)	137 (59.1)		
<b>Energy drink consumption</b>				
Users	65 (24.3)	97 (41.8)	45.97	0.000**
Ex-users	27 (10.1)	52 (22.4)		
Non-users	176 (65.7)	83 (35.8)		
<b>Coffee intake</b>				
Users	42 (15.7)	120 (51.7)	72.16	0.000**
Non-users	226 (84.3)	112 (48.3)		
<b>SES of parents/ Guardian</b>				
Upper	105 (39.2)	58 (25.0)	17.83	0.000**
Middle	74 (29.6)	103 (44.4)		
Lower	89 (33.2)	71 (30.6)		
<b>Knowledge of dehydration and complications</b>				
Good	120 (44.8)	67 (28.9)	12.75	0.000**
Poor	148 (55.2)	165 (71.1)		

\*=significant at 5% (p<0.05); \*\*=significant at 1% (p<0.01)

**Table 2: Distribution of hydrated and dehydrated participants according to perceived symptoms.**

Perceived Symptoms	Euhydrated <1.020	Dehydrated >1.021 – 1.030	$\chi^2$ value	P-value
<b>Dizziness</b>				
Yes	8(3.0)	4(1.7)	0.392	0.531
No	260(97.0)	228(98.3)		
<b>Headache</b>				
Yes	31(11.6)	44(19.0)	4.77	0.029*
No	237(88.4)	188 (81)		
<b>Tiredness</b>				
Yes	170(63.4)	160(69.0)	1.46	0.000**
No	98(36.6)	72(31.0)		
<b>Poor concentration</b>				
Yes	22(8.2)	52(22.4)	1879	0.000**
No	246(91.8)	180(74.6)		
<b>Thirsty</b>				
Yes	99(36.9)	128(55.2)	15.95	0.000**
No	169(63.1)	104(44.8)		
<b>Confusion</b>				
Yes	82(30.6)	69(29.7)	0.012	0.912
No	186(69.4)	163(70.3)		
<b>Recurrent fatigue</b>				
Yes	150(56.0)	160(69.0)	8.37	0.004**
No	118(44.0)	72(31.0)		

\*=significant at 5% (p<0.05); \*\*=significant at 1% (p<0.01).

## DISCUSSION

In agreement with the findings of previous studies, our results indicate high prevalence (46.4%) of dehydration among participants.<sup>19,29</sup> It provides additional support to studies by other investigators that showed that poor hydration status is common among college students.<sup>19,30,31</sup>

Inadequate water intake was significantly associated with the highest Odds (OR=6.4, CI 2.121-19.385) for dehydration among participants. This was found in more than half (59.1%) of all dehydrated participants, further confirming the assertion that most children and adults, and in particular school aged children, adolescences and adults do not consume enough water for their age groups as defined by IOM and EFSA.<sup>9</sup>

In 2012, Stookey et al reported inadequate hydration in 63% and 66% in school-aged children in Los Angeles and New York City respectively.<sup>30</sup> In that study, low water intake was the factor most strongly associated with poor hydration status and was present in 75% of the

participants. A recent study by Kenney et al reported 54% prevalence of dehydration in a study of 4134 US children and adolescents, and only higher water intake significantly improved the hydration indices of the participants.<sup>5</sup>

**Table 3: Distribution of hydrated and dehydrated participants according to academic performance and menstrual characteristics.**

Variables	Hydrated (n = 268) <1.020 (53.6%)	Dehydrated (n = 232) >1.021 – 1.030 (46.4%)	$\chi^2$ value	p-value
<b>Academic performance</b>				
Excellent	15 (5.6)	12 (5.2)	21.96	0.000**
Very good	63 (23.5)	54 (23.3)		
Good	155 (57.8)	98 (42.2)		
Poor	35 (13.1)	68 (29.3)		
<b>Menstrual characteristics</b>				
Premenstrual syndrome	141 (77.0)	102 (80.3)	6.26	0.012
Premenstrual dysphoric disorders	109 (59.6)	71 (55.9)	8.02	0.005
Dysmenorrhoea	85 (46.4)	75 (59.1)	4.28	0.039
Oligomenorrhoea	47 (25.7)	48 (37.80)	0.011	0.918

\*=significant at 5% (p<0.05); \*\*=significant at 1% (p<0.01)

**Table 4: Results of Multiple Logistic regression study showing associations between dehydration and associated risk factors (Odd ratios and 95% confidence interval).**

Risk factors	OR	95% C.I	p-value
Dietary habit (Good/Poor)	1.62	0.287 – 16.604	0.109
Exposure to hot Environment (Yes/No)	2.16	1.998 – 4.656	0.041*
Water Consumption (Adequate/Inadequate)	6.41	2.121 – 19.385	0.001**
Smoking habit(Nonsmokers/Smokers)	0.92	0.621 – 1.370	0.687
Alcohol drinking habit(Drinkers/Non-drinkers)	4.17	1.313 – 13.258	0.015*
Academic stress (Yes/No)	1.53	1.041 – 2.251	0.031*
Physical activity status (Active/Inactive)	1.03	0.650 – 1.642	0.890
Gender (Male/Female)	1.32	0.873 – 1.992	0.188
Residence (off campus/Hostel)	0.54	0.361 – 1.806	0.623
Night clubbing habits (clubbing/not clubbing)	2.51	1.261-3.822	0.034*
Energy drink consumption(Yes/No)	1.37	0.829-2.966	0.085
Coffee intake (Yes/No)	2.93	1.788-5.622	0.017*
<b>SES of Parents/Guidance</b>			
Upper	100	(reference)	
Middle	2.21	1.70-4.267	0.042*
Low	3.42	1.655-7.82	0.015*
Knowledge of adequate water intake and dehydration and complications (Good/Poor)	1.52	1.02-3.047	0.048*

\*=significant at 5% (p<0.05), \*\*=significant at 1% (p<0.01).

**Table 5: Distribution of hydrated and dehydrated participants according urine characteristics.**

Urine characteristics	Hydrated (n = 268) <1.020	Dehydrated (n = 232) >1.021 – 1.030	$\chi^2$ value	P-value
<b>Quantity</b>				
Adequate	142 (52.0)	99 (42.7)	0.780	0.377
Inadequate	126(47.0)	133 (57.3)		
<b>Colour</b>				
Amber	92(34.3)	85(36.6)	8.14	0.017*
Deep yellow	79(29.5)	89(38.6)		
Light yellow	97(36.2)	58(25.0)		

\*=significant at 5% (p<0.05).

In a study by Senterre et al among Belgium school children to assess compliance with EFSA recommendations for total fluid intake, 91.5% of children did not take adequate water for their age and sex.<sup>32</sup> In that study, 41.3% of all fluids consumed to maintain euhydration was contributed by water.

According to Senterre et al, at least 55% total fluid required to achieve a state of euhydration should be contributed by water and should be taken at least 3-4 times/ 24 hrs.<sup>32</sup> Water intake < 3 times/24 hrs is described as low water intake, and is significantly associated with poor hydration status.<sup>4</sup>

Park in a cross-sectional study of US high school students reported 54% prevalence of low intake of water (< 3 times/24hrs) with a significant increase in risk among those aged ≤ 15 years, with poor dietary habits (frequent fast food restaurant use) and physically active.<sup>4</sup>

The discrepant prevalence rates of poor hydration status and low water intake observed across studies in different populations could be due to the confounding effects of several covariates such as differences in socio-demographic characteristics of the studied participants including age, gender, race, ethnicity, dietary habits, physical activity status and BMI.

Others include SES-total household income,<sup>5</sup> disparities in study design, methodological differences, differences in definitions of adequate hydration status, using different recommended standards or cut off points for assessing water intake, differences in assessment measures of hydration status and variations in environmental factors.<sup>19</sup> Above all, variations in cultural practices regarding water intake in healthy subjects is also contributory, making it difficult to compare results.<sup>3</sup>

Although the consumption of beverages and foods contribute to total body fluid balance, water intake is known to contribute a greater proportion of the total body fluid. Therefore, water intake has a significant clinical bearing on the overall hydration status of individuals, due to the physiochemical properties and numerous health benefits of adequate water intake.<sup>5</sup> These include its inverse correlation with intake of total sugars and poor dietary habits (low consumption of milk, low intake of fruit juice, high intake of diet soda, fruit-flavored drinks/sport drinks, fast food consumption and fiber intake).<sup>4,33</sup> Others are sedentary behaviors, obesity, dental caries, type 2 diabetes mellitus, poor mental health, poor academic grades and thirst quenching effect.<sup>18,33-35</sup> Despite the important role of water in maintaining a state of euhydration, inadequate water intake is surprisingly common and global.

It is interesting to note that, although adequate water intake plays a significant role in maintaining normal hydration status, not all participants who took adequate

water achieved adequate hydration status. In the present study, about 40.7% of participants were dehydrated despite having consumed enough water.

This finding suggests that inadequate water intake is not the only risk factor of dehydration. There are several other factors such as gender (female), marital status (single), alcohol intake, physical inactivity, exposure to extremes of environment condition, academic stress, nightclubbing habits, use of energy drink, middle and lower SES of parents or guardians, use of coffee drink, poor knowledge of dehydration and associated complications. In the univariate analysis, these factors were significantly associated with higher prevalence of dehydration among participants. They have been found to directly or indirectly affect the hydration status through the effect on water intake or other lifestyle-related behaviors leading to inadequate hydration.

A recent study by Kavouras et al in Greece among children aged 9 to 13 years reported a mean prevalence of hypo-hydration as 33% (44% of boys and 23% of girls).<sup>31</sup> Interestingly, the authors found that despite the adequate water intake, >27% of participants were still found hypo-hydrated confirming the hypothesis that inadequate water intake is not the only driver of dehydration.

Similarly, Padrão et al reported a high prevalence (almost 60%) of hypo-hydration in a sample of Portuguese children despite mean total water intake of 2, 411 ml and 2, 286 ml in boys and girls respectively, an amount that surpasses the documented normal values in Germany, France and USA, further suggesting a greater influence of other risk factors of dehydration other than inadequate water intake.<sup>19,36-38</sup> The multivariable logistic regression analysis of individual risk factors in the present study confirmed higher odds for dehydration among participants with parents or guardians of middle or low SES. Parents/guardians of low SES had a greater risk than those of middle SES.

SES can affect hydration status by directly influencing some physiological processes in the body, and indirectly through health behaviors such as effects on dietary habits and physical activity level. This is consistent with previous studies that showed a strong correlation between SES of parents/guardians and the risk of adverse health endpoints in the offspring.<sup>39</sup>

The direct relationship between SES, dietary habits and health outcomes has been highlighted by some investigators.<sup>40</sup> Accordingly, Groth et al; Drewnowski and Darmon showed that dietary quality relates directly to individuals' SES, and inversely to adverse health outcomes such as dehydration.<sup>40,41</sup> Also, some SES variables such as low educational level may limit access to health information and services.<sup>42</sup>



The income level may predict the availability of heat cooling equipment such as air conditioning equipment at home and their use during extreme heat.<sup>42</sup> In addition, SES may limit access to cooling centers outside home and use of other cooling options such as waterfront location, swimming facility or spray pads.

We also found that poor knowledge about adequate water intake and hydration level of participants was associated with increased risk of dehydration among study subjects. This finding is consistent with several other studies that found a positive correlation between the level of understanding of hydration indicators and fluid replacement among defined groups and hydration status. Using a web-based approach, Tyrwhitt-Drake et al in a study of three Western European Countries (United Kingdom, France and Spain) reported poor knowledge of adequate water intake and hydration indicators among the participants.<sup>26</sup>

Collectively, the results of the present and previous studies are in agreement with several health belief models that suggest that low health risk perception can impede behavioural modification to reduce life-style-related risk and vice versa.<sup>43</sup>

Intriguingly, other investigators evaluating the impact of knowledge and perception on risk behaviours and attitudes leading to adverse health conditions provide results that support the aforesaid hypotheses.

One study reported that smokers are less likely to smoke as their subjective risk of dying from cancer increased.<sup>44</sup> Another report showed that women are less likely to douche as their knowledge of adverse health effect of douching increases.<sup>10</sup> Similarly, having good knowledge about the adverse health effect of obesity reshaped the attitude, perception, behaviour and cultural myths surrounding dietary habits and physical activity patterns as well as perception about body shape and size, and vice versa.<sup>43-46</sup> However, in other studies, discordant results were found showing poor correlation between hydration knowledge and actual hydration status probably due to failure to translate knowledge into good hydration practices. This implies that knowledge alone is not enough. According to Fitzpatrick and Miletti, information or knowledge alone, will not necessary change behaviour unless people understand, believe, personalize and act on the information.<sup>47</sup>

Decher et al found a high incidence of dehydration among studied participants despite good knowledge and awareness of good hydration practices probably because they failed to translate knowledge into good hydration practices.<sup>48</sup>

Consistent with previous studies, the present study indicates a significant correlation between environmental conditions and hydration status of participants.<sup>49,50</sup> Cool and warm climates enhance water losses and can result in

dehydration.<sup>49,50</sup> Those exposed to hot environment had a significantly higher prevalence and odds for dehydration than the unexposed group. This finding suggests a strong correlation between the environmental temperature and the body's thermoregulatory and fluid related variables. Extreme environmental conditions (hot environment) can impair the body's thermoregulatory mechanisms leading to inability to dissipate heat through the normal processes (convection, conduction and radiation) due to temperature gradient between the skin and the ambient air. The resultant effect is a rise in the body's core temperature and sweat rate and leading to dehydration.<sup>51</sup>

Higher prevalence and odds for dehydration were found among participants who consumed alcohol regularly, supporting previous studies with similar observation, and is likely due to the natural diuretic effects of alcohol.<sup>42</sup> When consumed in a significant amount, (>4%), alcohol is reported to increase urine output compared with alcohol-free drinks or drinks with a lower concentration of alcohol (<4%).<sup>52</sup> Alcohol exerts its diuretic effect by inhibiting the release of vasopressin (an antidiuretic hormone (ADH)) from the posterior pituitary gland. Vasopressin when release, inhibits diuresis by increasing the permeability of the distal convoluted tubules and collecting tubules of the renal nephron to water and leading to increased water reabsorption.

Additionally, high prevalence and increased odds for dehydration were found among regular nightclubbers. At these clubs, clubbers engage in several poor lifestyle habits that are associated with increased risk of dehydration such as binge drinking of alcohol beverages, exposure to first hand and second hand tobacco smoking, inadequate water intake, eating junk foods/meats dense with high cholesterol, low in fruit/vegetables and exposure to less sleep. These habits are known to negatively impact hydration status.

Consistent with previous findings, the present study showed a significant inverse relation between physical activity level and hydration status. Physical inactivity was associated with a higher prevalence and a greater risk of dehydration among participants. Accordingly, Mora-Rodriguez et al reported a negative association between physical activity and urinary osmolality ( $r=-0.153$ ) in their study participants.<sup>53</sup> Likewise, a study by Carter and Muller found a significantly lower median USG among physically active participants.<sup>21</sup> High physical activity leads to loss of significant quantity of water through sweating, perspiration and rapid breathing causing an increase in osmotic pressure and ADH release. This causes the stimulation of thirst centers, increase thirst sensation and increase desire to drink water to replace the lost fluid, thereby cancelling the associated dehydration that could have occurred.<sup>42</sup>

Several studies support this hypothesis including a study by Kant and Graubard<sup>33</sup> who found a higher water intake among physically active U.S youths (age 12 to 19 years)

than the physically inactive participants. Conversely, low water intake was more prevalent among Florida adolescents with low physical activity levels Park et al.<sup>34</sup> Indeed, physical activity status directly correlates with water intake, and inversely correlates with risk of dehydration.

As in previous studies, we found that the risk of dehydration was significantly higher among coffee users than non-users. Intriguingly, some coffee users were dehydrated while others maintained euhydration. Coffee contains caffeine, a methylxanthine with potent diuretic activity. It is posited that caffeine induced its diuretic action by inhibiting phosphodiesterase in the proximal tubule of the kidneys.<sup>54</sup> In other studies, caffeine has also been shown to act as adenosine receptor antagonist.<sup>55</sup> However, in one study, a null association was found between coffee consumption and poor hydration status, probably due to dose-dependent action of caffeine and tolerance among regular caffeine users.<sup>56</sup> Existing research indicates that acute ingestion of caffeine in large doses is associated with a short-term diuresis while low to moderate consumption may not induce any significant diuretic effect.<sup>16,57</sup> Similarly, regular caffeine consumption may lead to the development of tolerance against its diuretic effect. This may provide an explanation to the null dehydration observed among some coffee users (habituated) in the present study.

Use of energy drink also significantly increased the prevalence and risk of dehydration among participants. Studies have shown that it is actually the caffeine constituent in most of these drinks that mediates the diuretic and natriuretic effects and hence dehydration associated with the use of energy drinks.<sup>58</sup>

Poor dietary habits, sex and academic stress conveyed higher risks of dehydration among participants and corroborate studies by other investigations with similar observations. Nevertheless, conflicting reports have been recorded regarding the role of gender in the pathogenesis of poor hydration status. In some studies, the risk of dehydration was higher in men, and in others, women had the greater risk.<sup>59-63</sup>

Higher prevalence of poor academic performance, menstrual disorders (premenstrual syndrome and dysmenorrhoea) and other symptoms suggestive of impaired cognitive function (headache, tiredness, poor concentration and recurrent fatigue) were found among dehydrated than euhydrated participants in the present study. Apparently, this symptom represents some of the systemic manifestations of adverse health effect of dehydration, and depicts the poor related quality of life of the dehydrated participants. These findings are similar to those of Cian et al, Gopinathan et al, who collectively reported a positive correlation between dehydration and a wide spectrum of cognitive function impairments.<sup>14,64</sup>

Some limitations exist in the current study, including those of a cross-sectional study design. For instance, the self-reported socio-demographic characteristics including the daily water consumption are prone to over, or underestimation. Furthermore, the study population of only college students may limit generalization of results. Errors due to assessment measures may also affect results. However, the study was strengthened by a careful selection and characterization of study participants and controlling for confounders. The reliability and validity instruments of measures contribute to the strength of the study.

## CONCLUSION

Taken together, results of the present study indicate a high prevalence of dehydration and associated risk factors among college students. Our findings underscore the need to introduce/or incorporate some school-based intervention programs to improve hydration status and by extension academic performance and health-related quality of life of college students. Such programs should have a multi-dimensional focus on hydration and risk factors of dehydration including programs to improve students' knowledge and awareness about hydration, adequate water intake, risk factors of dehydration and possible adverse health effects. Along with knowledge, good hydration practices among students should be encouraged, because good hydration knowledge not translated into good hydration practices yields no benefits. Introduction and distribution of a single-page nutritional screening and lifestyle chart to all students and regular checks conducted at intervals can help in identifying those at risk of lifestyle and nutrition-related conditions of dehydration.

The creation of a culture of hydration awareness as a preventive measure could be beneficial and therefore strongly recommended. Lectures and seminars on good hydration practices, adequate water intake, features of dehydration and effect on student's health and academic performance should be organized for the fresh men and women. This should be taken as a topic in one of the general courses for all students since the highest incidences of academic stress, poor academic performance, poor quality of life and poor hydration status are common during this period probably due to poor acclimatization.

Strategies for the management of poor hydration status among the high vulnerable group of students, and in particular during certain periods such as examination periods, and periods of extremes of environmental condition as well as high risk individuals (e.g., low SES, night clubbers, alcohol drinkers, physically inactive students, obese and energy drink users) should be introduced. Increase availability and palatability of water at college campuses and student hostels throughout the

school day can enhance water consumption since these characteristics of water are important external barriers for students' optimal hydration at campuses.

Studies have shown that availability of fluid with taste appeal significantly increase intake level, improve hydration status enhance brain function and academic performance.<sup>21,65,66</sup>

The consumption of sugar-sweetened beverages (SSB), physical inactivity, intake of alcohol, nightclubbing habits and poor dietary habits among students should be discouraged because of their significant associations with poor hydration status. Hydration status determination should constitute a component of the preadmission medical examination to identify the high vulnerable groups and those already dehydrated for proper health education and counselling.

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