Hydration and obesity among outpatient-based population: H2Ob study

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Accepted 28 December 2017

To cite: Carretero-Gómez J, Arévalo Lorido JC, Gómez Huelgas R, *et al*. *J Investig Med* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/jim-2017-000641

ABSTRACT

Recent evidence suggests that obese people are hypohydrated and that water consumption may be a useful indicator for the prevention and treatment of obesity. Nevertheless, there is no agreement regarding the best hydration status indicators and there are few data about the relationship between hydration and body weight. In the present study, we aim to analyze the correlation among hydration status with obesity measured by three different methods (plasma osmolarity, urinary specific gravity (USG) and urinary osmolarity) in a hospital-based outpatient population. We have carried out a cross-sectional study to evaluate the association between obesity and hydration status in 260 patients, average 56.5±15.7 years. Hydration status was estimated by means of plasma osmolarity, urine osmolarity and USG. We did show significant trend of higher urine osmolarity (P=0.03), USG (P=0.000) and plasma osmolarity (P=0.000) with an increase of weight status categories, more accurate in the case of plasma osmolarity. In a multivariate analysis, after controlled by confounders, we found that obesity was associated with plasma osmolarity (OR 1.09; 95% CI 1.02 to 1.17, P=0.009), urine osmolarity (OR 1.00; 95% CI 1.00 to 1.01, P=0.05) and USG (OR 1.02; 95% CI 1.00 to 1.04, P=0.05). Our results have shown a more accurate relationship between plasma osmolarity with all body mass index categories. This finding may have clinical implications that must be confirmed in further studies.

INTRODUCTION

Obesity is the most prevalent, costly and debilitating chronic metabolic disease in most developed countries. The overall prevalence is 5.0% and 12% for children and adults, with estimated figures of 2.16 million individuals with overweight and 1.12 million with obesity by the year 2030.[1 2] The characteristic that defines obesity is a body mass index (BMI) ≥30 kg/m^2 or an excess of adipose tissue (25% in men and 30% in women) of enough magnitude to cause an increase in the individual's morbidity and mortality, due to its role in the development of other comorbidities such as hypertension (HTA), type 2 diabetes (DM2) and dyslipidemia as well as severe functional limitations in quality of life.[3 4] Prevention and management of obesity represent great health challenges due to the cost of the disease itself as well as the associated comorbidities.

There is an increasing interest in assessing the population's hydration status and determining the long-term impact of hypohydration on health outcomes. Nevertheless, there is no agreement regarding the best and most affordable indicator of the hydration status. Many studies have focused on quantification of total daily water intake as well as biomarkers like plasma osmolality, urinary specific gravity (USG) and urine osmolality. However, all these studies have been focused on general population. There is a gap in the literature concerning how obesity is associated with hydration status. Recent evidence suggests that obese people are hypohydrated.[5 6] Water intake promotes weight loss by two mechanisms. First, decrease in food intake and increase in both the thermogenesis and the caloric expenditure. Second, through the reduction of serum osmolality improves metabolic cell efficiency, activating lipolysis and fat loss with subsequent weight loss and decreased waist circumference.[7 8]

The aim of the present study is to determine the hydration status measured by plasma osmolality, urinary osmolality and USG and its correlation with the BMI in a hospital-based outpatient population, in order to determine the best and most affordable indicator of the hydration status.

PATIENTS AND METHODS

Study design and patients

Cross-sectional study conducted in obese, outpatient population (H2Ob STUDY, water formula—H_2O and obesity). Patients were enrolled in three different Spanish Hospitals (Zafra County Hospital, Badajoz; Regional University Hospital of Malaga, Málaga and Regional University Hospital Lozano Blesa, Zaragoza) and categorized by BMI according to WHO Obesity classification[3]: normoweight: BMI <24.9 kg/m^2; overweight: BMI 25–29.9 kg/m^2; obesity grade I: BMI 30–34.99 kg/m^2;

obesity grade II: BMI 35–39.99 kg/m^2; obesity grade III: BMI ≥40 kg/m^2. All participants provided written informed consent before enrollment. The study was conducted in accordance with the Declaration of Helsinki and International Conference on Harmonization/Good Clinical Practice guidelines.

Urine sample collection and urinary biomarker determination

First morning urine samples were collected. The following three urine biomarkers were analyzed: plasma osmolality, urinary osmolality and USG.

Statistical analysis

Qualitative and categorical data are expressed as absolute number and percentage, and to compare them in univariate analysis we have used X^2 test. Quantitative data are expressed as 20% trimmed mean and median absolute deviation and to compare them we used analysis of variance when they were normally distributed with the approximate Welch's t-test in the case of inequality of variances. Brunner-Dette-Munk test was used for remainder. We have applied robust statistical methods which are resistant to errors in the results produced by deviations of assumptions. Logistic regression analysis was used to investigate whether hydration variables were associated with the obesity status (dependent variable, BMI ≥30 kg/m^2). The model was adjusted for potential confounders as follow: gender, the presence of hypertension, DM2 and dyslipidemia, age, systolic blood pressure, Charlson Index, high-density lipoprotein cholesterol, triglycerides, glucose, USG, urine and plasma osmolality. All the statistical analyses were done with R V.3.3.2. A P value of <0.05 was considered statistically significant.

RESULTS

From 1 January to 31 March 2017, a total of 260 patients (31.1% males), average age: 56.5±15.7 were enrolled. Baseline characteristics are shown in table 1. A significant increase in urine osmolality (P=0.05), USG (P=0.05) and plasma osmolality (P=0.05) associated with an increase in weight category was observed. Regarding treatments, patients with obesity had a higher proportion of treatments with metformin and glucagon-like peptide-1 receptor agonists, sodium glucose co-transporter 2 (SGLT2) inhibitor, beta blockers and diuretics compared with non-obese patients (data not shown). In this regard, no significant differences were found in urine osmolality between these groups of treatment. No significant differences were found in the case of ACE inhibitors (ACEIs), angiotensin receptor blockers (ARB), antidepressants and antipsychotic drugs (data not shown). The multivariate analysis shown that plasma osmolality (OR 1.09; 95% CI 1.02 to 1.17, P=0.009), urine osmolality (OR 1.00; 95% CI 1.00 to 1.01, P=0.05) and USG (OR 1.02; 95% CI 1.00 to 1.04, P=0.05) were independent variables associated with obesity along with age and waist circumference (table 2).

DISCUSSION

The relationship between inadequate hydration and obesity is controversial, often with discordant results. Recent longitudinal studies and randomized clinical

Table 1 Principal findings by obesity group

Variable	Normoweight BMI <24.9 kg/m^2	Overweight BMI 25–29.99 kg/m^2	Obesity grade I BMI 30–34.99 kg/m^2	Obesity grade II BMI 35–39.99 kg/m^2	Obesity grade III BMI >40 kg/m^2	P value
N	55	39	54	57	55	
Age	53.1 (19.3)	60.3 (13.3)	57.9 (20)	58.2 (13.3)	56.8 (11.9)	0.41
Gender (males)	9 (13.4)	17 (43.6)	19 (35.2)	22 (38.6)	14 (22.4)	0.02
HTA	20 (36.3)	17 (43.6)	23 (42.6)	29 (50.8)	36 (65.4)	0.03
DM2	7 (12.7)	13 (33.3)	20 (37)	30 (52.6)	24 (43.6)	0.0007
Dyslipidemia	13 (23.6)	14 (35.9)	25 (46.3)	35 (62.5)	32 (58.2)	0.0002
WC (cm)	80.8 (11.8)	96.4 (13.3)	109 (10.4)	120.8 (7.4)	133.2 (11.9)	0.0000
SBP (mm Hg)	126.3 (14.8)	133.4 (16.3)	127.8 (16.3)	133.2 (14.8)	137.1 (14.8)	0.03
DBP (mm Hg)	70.2 (14.8)	74 (14.8)	68.8 (14.1)	67.2 (8.9)	68.5 (5.9)	0.19
Charlson index	0.2 (0)	0.7 (0)	1 (15)	1.3 (1.5)	1.5 (1.5)	0.0000
Glucose (mg/dL)	86.5 (14.8)	107.5 (23.7)	107.3 (28.1)	108.3 (28.1)	95.2 (11.9)	0.0001
Creatinine (mg/dL)	0.81 (0.3)	0.82 (0.13)	0.83 (0.20)	0.76 (0.19)	0.75 (0.17)	0.13
Uric acid (mg/dL)	4.9 (1.2)	5.4 (1.0)	5.1 (1.5)	4.9 (1.4)	4.9 (1.4)	0.3
Total cholesterol (mg/dL)	172.2 (47.4)	168.8 (47.4)	168.9 (45.2)	180.9 (48.9)	176.9 (38.5)	0.63
HDL cholesterol (mg/dL)	56.3 (16.3)	49.1 (8.9)	48.6 (14)	44.5 (14.8)	44.1 (8.9)	0.0003
LDL cholesterol (mg/dL)	97 (25.2)	94.4 (27.8)	105 (31.1)	107.8 (35.6)	107.1 (37)	0.18
Triglycerides (mg/dL)	93.2 (23.7)	118.5 (44.4)	122.4 (42.9)	134.3 (59.3)	132.2 (45.9)	0.00000
U Osm (mosm/kg)	670.8 (133.4)	705 (132.3)	776.8 (186)	670.9 (183.8)	672.3 (222.4)	0.03
Specific urinary gravity (g/L)	1015.5 (7.4)	1017.3 (4.4)	1025.5 (14.8)	1020.5 (8.89)	1020.2 (0)	0.0000
P Osm (mosm/kg)	290.8 (5.6)	293.8 (9.4)	295.9 (5.3)	298.5 (6.6)	298.3 (6.3)	0.0000

Continuous variables are shown as 20% trimmed mean (MAD, median absolute deviation) and compared by Brunner-Dette-Munk test (heteroscedastic rank-based test); qualitative variables are shown as number (proportion) and compared by X^2 test.
BMI, body mass index; DBP, diastolic blood pressure; DM2, type 2 diabetes; HDL, high-density lipoprotein; HTA, hypertension; LDL, low-density lipoprotein; P Osm, plasma osmolality; SBP, systolic blood pressure; U Osm, urinary osmolality; WC, waist circumference.

Table 2 Multivariate analysis

Variable	OR	95% CI	P value
Waist circumference	1.16	1.11 to 1.20	0.0004
Age	0.96	0.92 to 0.99	0.01
Plasma osmolality	1.09	1.02 to 1.17	0.009
Urine osmolality	1.00	1.00 to 1.01	0.05
USG	1.02	1.00 to 1.04	0.05

The covariates included were sex, the presence of hypertension, DM2 and dyslipidemia, age, systolic blood pressure, Charlson Index, HDL cholesterol, triglycerides, glucose, USG, urine and plasma osmolality.
DM2, type 2 diabetes; HDL, high-density lipoprotein; USG, urine specific gravity.

trials have revealed an inverse relationship between hydration status and BMI.[9] Findings from three prospective cohort studies (the Nurses' Health Study I and II and the Health Professionals Follow-Up Study) have indicated that greater water intake is inversely associated with weight gain.[10] So far, only two studies, Chang *et al* and Rosinguer *et al*, which correlate urine biomarkers with obesity have been published.[5 6] Both studies have been conducted in a general population and only urine osmolality was determined.[5 6] The present study tries to clarify these previous findings in a hospital-based outpatient population.

Our aim was to further analyze these markers: USG, plasma osmolality and urine osmolality. A statistically significant increase in urine osmolality (P=0.03), USG (P=0.001) and plasma osmolality (P=0.001) was associated with an increase of weight-status categories, greater in the case of plasma osmolality, therefore extending the previous findings in other populations such as hospital-based outpatients.

But what is the gold standard? On one hand, many studies have focused on quantification of total daily water intake, utilizing recall-based methods such as 24 hours diet recall and food frequency questionnaires that usually underestimate intake. On the other hand, plasma osmolality is a good marker for acute dehydration but is tightly regulated and rarely varies by more than 2% around a set point of 280–290 mosm/kg.[11] Other previous studies have usually used the first morning urine samples when urine is more concentrated, although USG values could be higher and therefore could distort the results. However, urinary osmolality, being an objective laboratory measure and that is not subject to recall bias, reflects in a better way the state of hydration compared with others. We are aware that spot urine samples are not representative of 24 hours urine samples but previous research have shown that late-afternoon spot samples can approximate 24 hours urine osmolality and recent findings have shown only minimal differences in the mean urine osmolality for morning to early evening sessions overall.[6 12] Based on this, urinary biomarkers, mainly urine osmolality, have been shown to be a reliable indicator of daily hydration status and highly correlate with the other ones, provided that confounding factors as DM2 status (HbA1c 7.5%), use of diuretics, ACEIs, SGLT2 inhibitors or physical activity are taken into account.[13] Our results contribute to reinforce previous findings by illustrating that urine osmolality, being an objective laboratory measurement, could be useful to determine the hydration state in obese population.[5 6] In spite of the fact that our results have shown a more accurate relationship between plasma osmolarity with all BMI categories, urine osmolarity could also be a reliable marker. This finding may have clinical implications that must be confirmed in further studies.

Studies have described an association between chronic hypohydration and elevated levels of angiotensin II, the main body fluid regulating hormone, in several chronic diseases, including obesity, DM2, cancer or cardiovascular diseases.[7] Obese people have higher water requirements, estimated according to basal metabolism, body composition and body weight. Despite its importance, recommendations regarding water intake are often lacking in dietary recommendations.[14] Several methods of estimating fluid needs used in clinical settings are weight dependent. Water requirements of healthy individuals are among 40 and 50 mL/kg a day.[15] In this way, water requirements for obese people versus healthy weight would differ by more than 1 L. Clinicians are likely not aware of this greater water requirement among those with higher BMIs and thus may not provide adequate counseling to meet this requirement.

Among the limitations of the present study are the type of study, a cross-sectional study, that does not allow to infer causality, and therefore all the relations found should be viewed as associations.

The conclusions of the present study contribute to the literature as one of few studies, in a hospital-based outpatient population, that have examined the association between weight status and three hydration biomarkers: USG, plasma osmolality and urine osmolality. We could recommend the usage of all the three markers to assess the osmolarity in obese people on daily clinical practice.

Contributors All authors contributed to the data collection. The manuscript was written by JCG. The statistical analysis was performed by JCAL. JCAL, RG-H and JEM have contributed to the editing of the manuscript.

Competing interests None declared.

Patient consent Obtained.

Ethics approval Ethics committee of University Hospital 'Infanta Cristina', Badajoz, Spain.

Provenance and peer review Not commissioned; externally peer reviewed.

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