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한국 성인 남성에서 요 비중과 비만과의 관련성: 제5기 국민건강영양조사 2010–2012년 자료 이용

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The Association between Urine Specific Gravity and Obesity in Men in Korea: The Fifth Korean National Health and Nutrition Examination Survey in 2010–2012

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Background: As the prevalence of obesity is increasing worldwide, improving hydration status as a strategy to overcome weight-related problems is attracting attention. However, the relationship between hydration status and obesity remains uncertain. We aimed to investigate the association between inadequate hydration and obesity among men in Korea using urine specific gravity as a hydration marker.

Methods: In this study, we used data acquired from the Korean National Health and Nutrition Examination Survey, which was conducted during 2010–2012, and included men aged 20–59 years. The primary outcome of interest was body mass index, which is measured in continuous values and categorized as either obese (body mass index ≥25 kg/m^2) or normal (body mass index <25 kg/m^2). Individuals with urine-specific gravity values of ≥1.020 were considered inadequately hydrated. Linear and logistic regression analyses were performed with continuous body mass index and obesity status as the outcomes, respectively. Models were adjusted for known confounders, including age, regular exercise status, current smoking status, habitual coffee consumption, and regular alcohol intake.

Results: In this nationally representative sample (n=4,404), 48.02% of participants were inadequately hydrated. Individuals with inadequate hydration had a higher body mass index (P=0.048) than those who were adequately hydrated. After adjustment for potential confounding variables, the odds ratio (95% confidence interval) of the inadequate hydration group for obesity was 1.05 (0.84–1.32).

Conclusion: Inadequate hydration is positively associated with a higher body mass index but not with obesity.

Keywords: *Inadequate Hydration; Body Mass Index; Obesity; Urine Specific Gravity*

INTRODUCTION

The increasing prevalence of obesity and its relationship with major health issues including life expectancy decline, is becoming a global concern.[1)] Previous studies have identified the risk and protective factors for obesity.[2)] Water intake is deemed to be a means for losing weight, but evidence-based studies have yielded inconsistent results. Adequate water intake is essential for all body functions, including homeostasis, circulation, metabolism, thermoregulation, and other physiological processes.[3)] Drinking plain water helps to achieve satiety and results in lower total

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calorie intake compared with the consumption of sugar-containing beverages.[4] A recent study revealed that drinking plenty of water can reduce the possibility of being obese by preventing overeating.[5] As the prevalence of obesity is increasing worldwide, improving hydration status as one of the strategies to overcome weight-related problems is attracting attention. Recently, a nationwide study on inadequate hydration, body mass index (BMI), and obesity among adults from the United States was conducted using urine osmolality as a hydration marker.[6] Urine indices, particularly urine osmolality and urine-specific gravity (USG), were used as potential indicators of hydration status in a large-sample study.[7,8] A linear and positive correlation between USG and urine osmolality has been reported.[9,10] To date, a population-level study on hydration status-related weight outcomes using urine indices in Korean adults remains to be conducted. This study aimed to investigate the association between adequate hydration and obesity among adult Korean men using USG as a hydration marker.

METHODS

1. Survey Overview and Study Population

This cross-sectional study was based on the data acquired from the Korean National Health and Nutrition Examination Survey (KNHANES), which was conducted during 2010–2012 by the Korea Centers for Disease Control and Prevention. The KNHANES collects nationally representative data on health indicators using complex survey designs to assess the health and nutritional status of Koreans. The survey includes a health interview, as well as nutritional and health examination surveys. The target population of the survey was the civilian non-institutionalized population of South Korea. The sampling units consisted of households systematically chosen using multistage stratification by geographical area, sex distribution, and age. Sampling weights representing sample probabilities were assigned to each participant to ensure that the results are representative of the entire South Korean population.

A total of 25,534 participants were included in the KNHANES V conducted from 2010 to 2012. Our study used data from 5,571 men aged 20–59 years. From this population, we excluded those without USG and/or BMI data (n=681). Among the remaining participants, those with a spot urine protein level, urine albumin–creatinine ratio, and/or estimated glomerular filtration rate (eGFR) of ≥1+, ≥30, and <60, respectively, were also excluded (n=156). Participants who had a history of diabetes mellitus and/or a plasma glucose level ≥126 mg/dL were also excluded (n=330) from the study. Finally, the data obtained for the final 4,404 participants were analyzed. All participants provided written informed consent prior to enrollment in the survey.

The protocol for KNHANES V was approved by the Institutional Review Board of the Korea Centers for Disease Control and Prevention (IRB no. 2010-02CON-21-C, 2011-02CON-06-C, and 2012-01EXP-01-2C).

2. Anthropometric and Biochemical Measurements

In the 2010–2012 KNHANES, the participants were informed that their household had been randomly selected to participate voluntarily in a nationwide representative survey conducted by the Korea Centers for Disease Control and Prevention. They were also informed that they had the right to withdraw at any time based on the National Health Enhancement Act supported by the National Statistics Law of Korea.

Trained medical staff conducted the anthropometric measurements by following a standardized procedure. The height and body weight of the participants wearing light clothing without shoes were measured to the nearest 0.1 cm and 0.1 kg, respectively.

USG was determined through a refractometer using an automatic analyzer (Urisys 2400; Roche, Mannheim, Germany). Urine protein was assessed via dipstick urinalysis, and the results were reported using a semi-quantitative scale ranging from negative 4 to 4+. The serum and urine creatinine and urine albumin levels were measured through kinetic colorimetry and turbidimetric assays on an automatic analyzer (Hitachi 7600; Hitachi Co., Tokyo, Japan). The eGFR was estimated using the Chronic Kidney Disease Epidemiology Collaboration equation.[11] Fasting plasma glucose was measured via enzymatic methods using commercially available kits (Sekisui Chemical Co., Ltd., Tokyo, Japan) on an automatic analyzer (Hitachi 7600; Hitachi Co.).

3. Definitions of Variables

BMI was calculated as the ratio of body weight to height squared (kg/m^2). We defined the cutoff point for obesity as a BMI of ≥25 kg/m^2 based on the Asia-Pacific regional guidelines of the World Health Organization and International Obesity Task Force.[12] We chose a USG value of ≥1.020 to be in indicator of inadequate hydration. Previous studies used a urine osmolality of >800 mOsm/kg as a cutoff value for inadequate hydration.[7,13] Some authors found that urine osmolality and USG could be good alternatives in hydration status assessments because USG is strongly correlated with urine osmolality.[7,14] Physical activity was assessed through a 7-day recall method using the Korean version of the short form of the International Physical Activity Questionnaire.[15] Based on the responses to the questionnaire, individuals who took part in any vigorous-intensity physical activity lasting ≥20 minutes per session for more than 3 times per week or participated in moderate-intensity physical activity lasting ≥30 minutes per session for more than 5 times per week were categorized into the regular exercise group. The current smoker group was formed based on affirmative responses to the survey question on smoking status. A regular drinker was defined as an individual who consumed alcoholic beverages at least twice a week during the last year. A habitual coffee consumer was defined as a person who drinks more than 1 cup of coffee a day.

4. Statistical Analyses

Sampling weights were used to account for the complex KNHANES survey design. Therefore, we obtained valid estimates that represented the overall South Korean population to avoid biased estimates. The study participants' characteristics were determined through a weighted t-test and weighted chi-square test for continuous and categorical variables, respectively.

The associations between BMI and variables, including hydration status, age, smoking, alcohol use, and exercise, were investigated using linear regression. The odds ratios (ORs) and 95% confidence intervals (CIs) for obesity were assessed using multiple logistic regression analyses after adjusting for age and lifestyle behaviors (exercise and smoking status, coffee consumption, as well as alcohol intake). Statistical analyses were conducted using SPSS statistical software (Version 23.0; IBM Co., Armonk, NY, USA). A P-value of <0.05 was considered statistically significant.

RESULTS

Table 1 shows the characteristics of study participants based on hydration status which was assessed using USG. A total of 4,404 men aged 20–59 years were included in the study. Inadequate hydration had a prevalence rate of 48.02%. Individuals with inadequate hydration showed higher BMIs than those who were adequately hydrated. However, no statistical significance was observed in terms of obesity tendency.

Table 2 shows the effects of inadequate hydration and other potential confounding factors on BMI based on linear regression analysis results. Inadequate hydration was positively associated with BMI (P=0.048). Regular alcohol consumption and habitual coffee consumption were found to be significantly associated with BMI outcomes. However, other factors (age, smoking, and exercise) did not have a substantial effect on BMI.

Table 1. Characteristics of participants based on hydration status

Variable	Adequately hydrated*	Inadequately hydrated†	P-value
Number (%)	2,289 (51.97)	2,115 (48.02)	
Age (y)	40.8±0.3	36.7±0.3	<0.001
BMI (kg/m²)	24.0±0.1	24.3±0.1	0.048
Waist circumference (cm)	83.6±0.2	83.8±0.3	0.586
Systolic BP (mmHg)	119.4±0.4	117.5±0.3	<0.001
Diastolic BP (mmHg)	80.5±0.3	78.9±0.3	<0.001
Fasting glucose (mg/dL)	93.3±0.2	92.5±0	0.031
Total cholesterol (mg/dL)	189.7±1	188.6±1.0	0.420
Triglyceride (mg/dL)	164.2±3.8	144.5±3.0	<0.001
HDL-C (mg/dL)	49.7±0.3	49.9±0.3	0.652
Total calorie intake (kcal/d)	2,529.2±28.6	2,593.8±35.0	0.135
Regular exercise	23.3±1.1	24.6±1.2	0.427
Current smoker	49.4±1.3	50.7±1.4	0.502
Regular drinker	38.8±1.2	35.4±1.3	0.043
Habitual coffee consumer	75.9±1.7	72.4±1.8	0.127
Residence in rural area (%)	17.1±1.8	17.3±1.8	0.869
Overweight‡ (%)	39.4±1.5	40.5±1.6	0.609
Obesity§ (%)	35.8±1.2	36.5±1.3	0.711

Values are presented as mean±standard error or percentage±standard error.
BMI, body mass index; BP, blood pressure; HDL-C, high-density lipoprotein cholesterol.
P-values were obtained using weighted t-tests and weighted chi-square tests for continuous and categorical variables, respectively.
*Urine specific gravity ≤1.020. †Urine specific gravity >1.020. ‡Overweight was defined as 23≤ BMI <25. §Obesity was defined as BMI ≥25.

Table 2. Linear regression analysis of factors associated with body mass index

Variable	β (95% confidence interval)	P-value
Age	0.00 (-0.01–0.01)	0.806
Hydration		
Adequate hydration	Reference	
Inadequate hydration	0.27 (0.00–0.55)	0.048
Smoking		
Nonsmoker	Reference	
Current smoker	0.03 (-0.22–0.27)	0.839
Coffee		
Non habitual coffee consumer	Reference	
Habitual coffee consumer	0.71 (0.36–1.065)	<0.001
Alcohol		
Non regular drinker	Reference	
Regular drinker	0.44 (0.18–0.71)	0.001
Exercise		
Non-regular exerciser	Reference	
Regular exerciser	0.05 (-0.23–0.33)	0.733

Table 3. Odds ratios and 95% confidence intervals for obesity based on hydration status using urine specific gravity (USG)

Hydration status	Model 1	Model 2	Model 3
Adequate hydration (USG ≤1.020)	Reference	Reference	Reference
Inadequate hydration (USG >1.020)	1.03 (0.88–1.20)	1.04 (0.89–1.22)	1.05 (0.84–1.32)

Model 1: unadjusted. Model 2: adjusted for age. Model 3: adjusted for age, regular exercise status, smoking status, alcohol intake, coffee consumption and regular exercise status.

The relative obesity risk of inadequately hydrated individuals compared with that of adequately hydrated individuals was determined using multiple logistic regression analyses (Table 3). The ORs (95% CIs) were examined after adjusting for age in model 2. We also adjusted for additional potential confounding variables, such as lifestyle behaviors (exercise status, smoking status, coffee consumption, and alcohol intake), in model 3. After all these adjustments, the OR (95% CI) for obesity in the inadequate hydration group was 1.05 (0.84–1.32).

DISCUSSION

To our knowledge, this is the first study to demonstrate the association between hydration status using urine indices and BMI outcomes among Korean men using nationally representative data. In this cross-sectional study, we found that inadequate hydration was associated with a high BMI, but no significant relationship was found between obesity and hydration status. This finding is inconsistent with that of a previous study that examined the relationship between obesity and hydration status using urine osmolality values.[6] A possible explanation may be methodological differences between the studies; moreover, obesity is a complex disease and many factors contribute to its development. In previous studies, individuals with an osmolality value of ≥800 mOsm/kg were considered inadequately hydrated.[7,16,17] In contrast, some authors used the USG value as a hydration marker, in which values of ≥1.020 indicate relative dehydration.[13] A high linear and positive correlation between USG and urine osmolality was shown previously.[8] An osmolality value of 800 mOsm/kg is considered equivalent to approximately 1.020 USG units.[18] Owing to the unavailability of raw data for urine osmolality in the KNHANES, we selected USG, rather than urine osmolality, as a hydration marker in this study. Urine indices, especially urine osmolality and USG, are generally considered adequate tools for hydration status assessment in a large-sample study because they are non-invasive, convenient, rapid, and inexpensive. Furthermore, it should be considered that most previous studies using urine osmolality or USG as hydration markers were conducted under specific conditions, such as in acutely dehydrated or athletic individuals or industrial settings.[19]

Although a positive association between inadequate hydration and obesity has been reported, any causal relationship between hydration status and obesity remains unestablished. Several attempts to assess hydration status have been made, but no consensus on the physiologic definitions of hydration status has been reached because of the complicated human homeostatic regulation system for body fluid balance. Adequate hydration or euhydration status refers to the state of normal water balance in the body. However, euhydration or dehydration status is not a steady but a dynamic state.[8] Dehydration can be categorized based on the fluid compartment affected (intra- or extracellular dehydration), sodium concentration (hypernatremic dehydration), or fluid tonicity (hyper-/hypo-/isotonic dehydration).[20] Mild dehydration is associated with cognition decline, altered mood, and impaired physical performance.[7] Although hydration has been discussed in the context of its implications on homeostasis, health, and performance, further research regarding the behavioral characteristics of individuals with high BMIs is warranted to underpin the causal relationship between inadequate hydration and BMI outcomes. Chang et al.[6] suggested that obese individuals may behave in ways that result in inadequate hydration because those with high BMIs are unaware of their higher water requirement.

Drinking plenty of water is generally used as an approach for weight management; however, it is not included in guidelines as a management tool because of inconsistent results from several studies.[3] Plain water is the preferred beverage to meet the daily water needs based on recent guidelines from the United States. Consumption of sweetened beverages, such as soft drinks and juices, is suggested to be one of the dietary causes of obesity.[3] Drinking plain water, instead of sugar-containing beverages, has been shown to lead to satiety and lower total calorie intake[4] and diminish the possibility of becoming obese by preventing overeating.

Our findings have limitations that need to be considered when interpreting the results. First, this study was designed to be cross-sectional and cannot infer any causal relationship. Second, although urine indices are well known as standard non-invasive indexes for hydration status, dynamic hydration assessment is better accomplished using multiple indexes. In addition, USG is well correlated with urine osmolality, but a single USG measurement value in the KNHANES is limited in its capacity to represent urinary hydration in daily life compared with 24 hours urine collection. Third, we defined inadequate hydration as a USG value of ≥1.020; however, no generally acknowledged consensus exists on the cutoff value of urinary markers regarding hydration status. Finally, these results have been derived from men aged 20–59 years and thus are not generalizable to other age groups. Nevertheless, this study has several strengths. To the best of our knowledge, this is the first reported study to investigate the association between BMI outcomes and hydration status using USG among adult Korean men. In addition, this is a large population-based study using nationally representative data, which underpins the reliability of the result. Finally, the use of objective hydration laboratory values and anthropometric measurements is notable.

In conclusion, a positive association between inadequate hydration and obesity in Korean men was not observed. Further research may be warranted to evaluate the need to maintain adequate hydration for the management of weight-related problems in the general population for universal obesity prevention.

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