

■ Original Article

# Association between water intake and abdominal obesity: the Korea National Health and Nutrition Examination Survey 2019–2021

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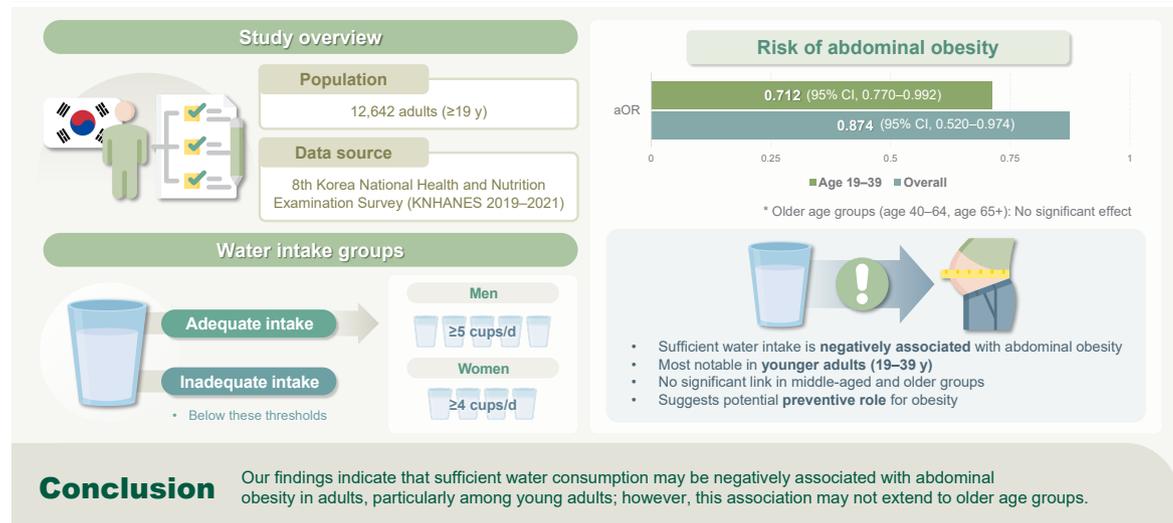
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**ABSTRACT**

**Background:** This study aimed to determine the link between water consumption and abdominal obesity in individuals aged 19 years and above, utilizing a sample from the 8th Korea National Health and Nutrition Examination Survey.

**Methods:** Participants were divided into two groups based on their water intake: those meeting adequate intake ( $\geq 5$  cups for men and  $\geq 4$  cups for women) and those with inadequate intake ( $< 5$  cups for men and  $< 4$  cups for women). Multivariate logistic regression analysis was used to estimate odds ratios (ORs) and 95% confidence intervals (CIs), adjusted for potential confounders.

**Results:** Compared with the inadequate water intake group, the adequate water intake group showed a lower adjusted OR for abdominal obesity (adjusted OR, 0.874; 95% CI, 0.770–0.992). In the subgroup analysis, the adjusted OR for abdominal obesity in the 19–39 age group was 0.712 (95% CI, 0.520–0.974). However, no significant association was observed in the 40–64 and 65 or higher age groups.

**Conclusion:** Our findings indicate that sufficient water consumption may be negatively associated with abdominal obesity in adults, particularly among young adults; however, this association may not extend to older age groups.

**Keywords:** Drinking Water; Drinking; Abdominal Obesity; Korea National Health and Nutrition Examination Survey

**Introduction**

Abdominal obesity results from visceral fat accumulation around the organs, such as the liver, intestines, and abdominal muscles. It is a global public health concern as it heightens the risk of metabolic diseases, including diabetes and cardiovascular disease [1]. For every additional two inches of waist circumference, mortality rates increase by 7% for men and 9% for women [2]. Although typically more prevalent among middle-aged and older individuals due to a decline in basal metabolic rate with age, it is also observed in younger, less active people who exhibit a higher incidence of visceral fat-type obesity [3]. Combining aerobic exercise and a healthy diet is effective in reducing abdominal obesity [1].

Water (H<sub>2</sub>O) plays a crucial role in maintaining homeostasis and various physiological functions [4]. It constitutes the largest portion of the human body, comprising 60% of body weight, approximately 70% of muscle mass, and approximately 83% of blood [4]. Approximately 65% of the body's water is within cells, whereas 35% is outside cells, influenced by factors such as body temperature, exercise, heat exposure, diarrhea, skin burns, injury, and water intake [5]. Also, different tissues have varying water contents, with muscles having higher levels and body fat having lower levels [6]. Moreover, total body water varies across age groups: newborns have a body water content of 75%, adults between 60% and 65%, and older adults, with substantially reduced muscle mass, between 45% and 50% [5]. In 2020, the Ministry of Health and Welfare of Korea released a specific standard for adequate water intake of the population based on sex and age [7]. According to this standard, the proportion of adults meeting the recommended water intake showed a decline over recent years: 42.7% in 2015, 44.8% in 2016, 42.1% in 2017, and 39.6% in 2018 [6].

Previous studies have suggested that water potentially plays a crucial role in decreasing calorie intake, consequently aiding in the prevention of obesity [8]. However, limited evidence exists concerning the link between water consumption and abdominal obesity [9]. Therefore, this study aimed to examine the association between water intake

and abdominal obesity using nationwide data from the Korea National Health and Nutrition Examination Survey (KNHANES).

**Methods****Study design**

This cross-sectional study utilized data from the 8th KNHANES, carried out between January 2019 and December 2021. Out of the initial 22,559 individuals in the 8th KNHANES, we excluded 3,868 participants under 19 years old, 48 pregnant women, 1,296 individuals with activity restrictions, 11 participants consuming more than 25 cups of water per day, and 4,694 participants with missing variables. Finally, a total of 12,642 participants were included in the analysis (Figure 1). Participants who answered “yes” to the activity restriction question in the KNHANES questionnaire were defined as activity-restricted.

The 2019–2021 KNHANES was approved by the Institutional Review Board of the Korea Disease Control and Prevention Agency (2018-01-03-C-A, 2018-01-03-2C-A, and 2018-01-03-5C-A). Informed consent was obtained from all individual participants included in the study.

**Water intake**

The Ministry of Health and Welfare published recommendations for

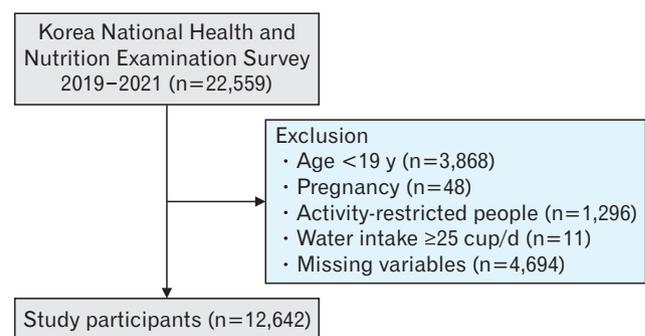


Figure 1. Participant selection process.

water intake by sex and age based on the adequate water intake (AWI) calculated from the 2020 Korean Nutrient Intake Standards [10]. According to the report of the Ministry of Health and Welfare of Korea [6], the AWI for men is 981 mL/d and 957 mL/d for those aged 19–29 years and 30–39 years, respectively. For women in the same age groups, the AWI is 709 mL/d and 772 mL/d, respectively.

Water intake data from the participants was obtained through the dietary assessment part of the 8th KNHANES. Individual water intake was assessed using the 24-hour recall method and quantified as the number of cups (200 mL) consumed per day. We classified partici-

pants into two groups based on their daily water intake: men who consumed  $\geq 5$  cups (1,000 mL) and women who consumed  $\geq 4$  cups (800 mL) of water daily were classified as having adequate water intake. In contrast, men who consumed  $< 5$  cups (1,000 mL) and women who consumed  $< 4$  cups (800 mL) were classified as having inadequate water intake.

### Abdominal obesity

The outcome variable was the incidence of abdominal obesity. In the KNHANES 2019–2021, waist circumference was measured by an-

**Table 1.** Participants characteristics

Characteristic	Adequate water intake group (N=7,786)	Inadequate water intake group (N=4,856)	P-value
Daily water intake (cup)	6.8±2.7	2.6±0.9	<0.001
Age (y)	51.6±16.3	52.3±17.4	<0.001
Sex			0.692
Men	3,371 (43.3)	2,085 (42.9)	
Women	4,415 (56.7)	2,771 (57.1)	
Employment status			0.009
Employed	4,863 (62.5)	2,917 (60.2)	
Unemployed	2,917 (37.5)	1,929 (39.8)	
Marital status			0.088
Married	6,389 (82.1)	3,926 (80.8)	
Single	1,397 (17.9)	930 (19.2)	
Educational level			<0.001
Elementary school or lower	1,215 (15.6)	943 (19.5)	
Middle school	754 (9.7)	424 (8.8)	
High school	2,726 (35.0)	1,547 (31.9)	
College or higher	3,084 (39.6)	1,929 (39.8)	
Missing	7 (0.0)	13 (0.0)	
Cigarette smoking			<0.001
Current smoker	1,316 (16.9)	681 (14.0)	
Former smoker	1,761 (22.6)	1,105 (22.8)	
Non-smoker	4,704 (60.5)	3,065 (63.2)	
Missing	5 (0.0)	5 (0.0)	
Alcohol consumption			<0.001
$\geq 2$ times/wk	1,614 (20.7)	882 (18.2)	
1–4 times/mo	2,507 (32.2)	1,527 (31.5)	
$< 1$ time/mo	1,446 (18.6)	937 (19.3)	
Non-drinker	2,214 (28.5)	1,505 (31.0)	
Missing	5 (0.0)	5 (0.0)	
Dietary supplements intake ( $\geq 2$ wk/y)			<0.001
Yes	5,362 (68.9)	2,856 (58.8)	
No	2,424 (31.1)	2,000 (41.2)	
Coffee consumption			0.856
$\geq 1$ time/d	217 (2.8)	138 (2.8)	
$< 1$ time/d	7,569 (97.2)	4,718 (97.2)	
Physical activity			<0.001
Yes	3,666 (47.2)	1,761 (36.4)	
No	4,106 (52.8)	3,075 (63.6)	
Missing	14 (0.0)	20 (0.0)	
Total calorie intake (kcal/d)	1,883.1±860.6	1,783.4±781.1	0.001
Water intake from food (g/d)	1,106.2±635.9	1,002.0±598.2	0.001
Sodium intake (mg/d)	3,309.5±1991.2	3,088.9±1829.2	<0.001
Body weight (kg)	65.6±13.2	62.8±12.3	<0.001
Abdominal obesity <sup>a)</sup>			<0.001
Yes	2,944 (38.0)	1,588 (32.8)	
No	4,811 (62.0)	3,252 (67.2)	
Missing	16 (0.0)	31 (0.0)	

Values are presented as mean±standard deviation or number (%).

<sup>a)</sup>Defined as waist circumference of  $\geq 90$  cm in men, and  $\geq 85$  cm in women.

thropometry. Abdominal obesity was defined as waist circumference  $\geq 90$  cm for men and  $\geq 85$  cm for women, according to the Korean Society for the Study of Obesity [11].

### Covariates

Potential confounders were identified by reviewing articles describing risk factors for abdominal obesity [12]. Demographic characteristics included sex and age, whereas socioeconomic characteristics included marital status, educational status, and economic activity status. Marital status was categorized as single or married. Educational status was categorized as primary school or lower, middle school, high school, and university or higher. Employment status was categorized as employed and unemployed.

Health-related characteristics included aerobic physical activity, cigarette smoking, alcohol consumption, dietary supplement intake, coffee and coffee drinks consumption, total calorie intake, water intake from food, sodium intake, and body weight. Aerobic physical activity was categorized as “yes” if participants undertook at least 2.5 hours of moderate-intensity physical activity, at least 1 hour and 15 minutes of vigorous-intensity physical activity, or a combination of moderate- and vigorous-intensity physical activity (1 minute of vigorous-intensity physical activity equals 2 minutes of moderate-intensity physical activity) per week, and “no” if the above criteria did not apply. Smoking was measured by lifetime and current smoking. Participants were categorized into never-smokers, current smokers, and former smokers not currently smoking. Alcohol consumption was measured by the frequency of drinking over the previous year. Participants were categorized into lifetime non-drinkers and those who had not consumed alcohol in the previous year, those who drank less than once per month, those who drank 1–4 times per month, and those who drank 2–3 times per week or more. Dietary supplements were categorized as “yes” (used dietary supplements for more than 2 weeks per year) and “no.” Coffee (unsweetened and sweetened) and coffee drink consumption were categorized as less than once a day and more than once a day. Total calorie intake, water intake from food, and sodium intake from the food consumption survey were also included as covariates. Yun et al. [13]. demonstrated the validity of the Food Frequency Questionnaire.

### Statistical analysis

Continuous variables were presented as means and standard deviations, whereas categorical variables were presented as percentages. The participants’ characteristics were compared according to water intake adequacy using the independent t-test for continuous variables and the chi-square test for categorical variables. To examine the association between adequate water intake and abdominal obesity, a multivariable logistic regression analysis model was used while controlling for confounding variables that could influence water intake, such as sex, age, marital status, educational status, economic activity status, aerobic physical activity, cigarette smoking, alcohol consumption, dietary supplements intake, coffee and coffee drinks consumption, total

calorie intake, water intake from food, sodium intake, and body weight. We also conducted a “P for interaction” analysis to determine if there was an interaction between the covariate variables and water intake. Data analysis was performed using IBM SPSS Statistics ver. 21.0 (IBM Corp.) at a significance level of  $P=0.05$ .

## Results

### Participants characteristics

Table 1 shows the participants’ characteristics according to the water intake adequacy. Among the 12,642 participants, 7,786 (61.6%) fell into the category of adequate water intake, whereas 4,856 (38.4%) were classified into the category of inadequate water intake. The mean  $\pm$  standard deviation daily water intake was  $6.8 \pm 2.7$  cups for those with adequate intake and  $2.6 \pm 0.9$  cups for those without. Among the 7,186 women (56.8%), the mean age was  $51.8 \pm 53.0$  years. Notably, significant differences were found between the groups regarding various covariates, excluding gender, marital status, and coffee consumption.

Abdominal obesity was present in 4,532 participants (35.8%), whereas 8,063 (63.8%) were classified as normal. The adequate water intake group had more individuals with abdominal obesity—2,944 (38%) compared to 1,588 (32.8%) in the inadequate intake group.

### Association of water intake with abdominal obesity

Logistic regression analysis was performed to examine the association of water intake with abdominal obesity. Logistic regression analysis revealed a significant association between adequate water intake and abdominal obesity, showing lower odds in participants with adequate water intake than those with inadequate water intake. The odds ratios (ORs) for the prevalence of abdominal obesity were 0.874 (95% confidence interval [CI], 0.770–0.992) (Table 2).

### Subgroup analysis

In the subgroup analysis, the ORs for abdominal obesity for the 19–39 years group were 0.712 (95% CI, 0.520–0.974). The ORs for abdominal obesity for the 40–64 years group were 0.876 (95% CI, 0.731–1.051). The ORs for abdominal obesity for the 65 years and older group were 0.969 (95% CI, 0.778–1.207) (Table 3). Furthermore, Table 3 shows that

**Table 2.** Association of water intake with abdominal obesity adjusting for covariates<sup>a)</sup>

Group	Inadequate water intake	Adequate water intake	P-value
Age and sex aOR (95% CI)	1 (Reference)	1.301 (1.204–1.407)	<0.001
Multivariable aOR (95% CI) <sup>b)</sup>	1 (Reference)	0.874 (0.770–0.992)	0.038

aOR, adjusted odds ratio; CI, confidence interval.

<sup>a)</sup>Defined as a waist circumference of  $\geq 90$  cm in men and  $\geq 85$  cm in women.

<sup>b)</sup>Adjusted for age, sex, marital status, educational status, employment status, aerobic physical activity, cigarette smoking, alcohol consumption, dietary supplement intake, coffee and coffee drinks consumption as categorical variables, and total calorie intake, water intake from food, sodium intake, and body weight as continuous variables.

**Table 3.** Subgroup analyses for the associations of water intake with abdominal obesity adjusting for covariates<sup>a),b)</sup>

Characteristic	Inadequate water intake	Adequate water intake	P-value	P for interaction
Age (y)				0.376
19–39 (n=3,336)	1 (Reference)	0.712 (0.520–0.974)	0.034	
40–64 (n=5,942)	1 (Reference)	0.876 (0.731–1.051)	0.155	
≥65 (n=3,364)	1 (Reference)	0.969 (0.778–1.207)	0.780	
Sex				0.732
Female (n=7,186)	1 (Reference)	0.866 (0.722–1.039)	0.122	
Male (n=5,456)	1 (Reference)	0.892 (0.744–1.068)	0.212	
Aerobic physical activity				0.751
Yes (n=5,427)	1 (Reference)	0.865 (0.707–1.060)	0.162	
No (n=7,181)	1 (Reference)	0.876 (0.744–1.032)	0.114	
Cigarette smoking				0.654
Current smoker (n=1,997)	1 (Reference)	0.866 (0.629–1.194)	0.380	
Former smoker (n=2,866)	1 (Reference)	0.963 (0.751–1.234)	0.763	
Non-smoker (n=7,769)	1 (Reference)	0.839 (0.709–0.993)	0.041	
Alcohol consumption				0.732
Drinker (n=8,913)	1 (Reference)	0.917 (0.787–1.069)	0.270	
Non-drinker (n=3,719)	1 (Reference)	0.786 (0.625–0.988)	0.039	

Values are presented as adjusted odds ratio (95% confidence interval), unless otherwise stated.

<sup>a)</sup>Defined as a waist circumference of ≥90 cm in men and ≥85 cm in women. <sup>b)</sup>Results are presented as odds ratios and 95% confidence intervals from the logistic regression model adjusted for age, sex, marital status, educational status, employment status, aerobic physical activity, cigarette smoking, alcohol consumption, dietary supplement intake, coffee and coffee drinks consumption as categorical variables, and total calorie intake, water intake from food, sodium intake, and body weight as continuous variables.

the ORs for abdominal obesity were 0.866 (95% CI, 0.722–1.039) for women and 0.892 (95% CI, 0.744–1.068) for men.

## Discussion

This study investigated the association between water intake and abdominal obesity in young adults aged 19 years and older using the KNHANES. A greater number of participants in the adequate water intake group than in the inadequate water intake group was observed. Multivariate logistic regression analysis, adjusting for demographic characteristics, lifestyle behaviors, and health status, revealed that adequate water intake was negatively associated with abdominal obesity (adjusted OR, 0.874; 95% CI, 0.770–0.992). When examined by age range, the noteworthy finding was observed within the 19–39 age group.

Table 1 shows that the adequate water intake group had a higher rate of abdominal obesity (2,944 [38.0%]). It was speculated that this may be because obese people tend to eat larger meals and consume more water at mealtimes. However, to correct this observation, we adjusted for a number of confounding variables, in particular total calorie intake and water intake from food. We present the adjusted results in Table 2, showing a lower rate of abdominal obesity in the adequate water intake group.

The results were only significant in the younger adult group (19–39 years). Possibly, as metabolism declines with age, the calorie burn from water intake is reduced compared to younger adults. This could explain why the relationship between abdominal obesity and water intake was more pronounced in the younger adult group. These observations are significant because age-related changes in metabolic rate can affect dietary behavior and body composition. Therefore, they may have a crucial role in developing age-specific health and nutrition

recommendations.

In the analysis, water intake was divided into quartiles. The highest water intake group (Q4 group; >7 cups) had a significantly lower incidence of abdominal obesity, with an OR of 0.797 (95% CI, 0.671–0.948) (Supplement 1). This result indicates that higher water intake is associated with a lower incidence of abdominal obesity. Therefore, these findings support the hypothesis that water intake is beneficial in preventing abdominal obesity.

Excessive fluid intake may also be limited by certain medical conditions. To investigate this, we excluded individuals with liver cirrhosis and kidney disease from the National Health and Nutrition Examination Survey. The corresponding statistics are presented in Supplement 2, showing that the ORs for abdominal obesity were 0.877 (95% CI, 0.772–0.996). As the results in Supplement 2 are significant, the study's conclusions are reliable.

Abdominal obesity rates are increasing in Korea [11], leading to the development of prevention and treatment strategies. These strategies emphasize lifestyle modifications such as reduced caloric intake, healthy diet, physical activity, reduced sedentary behavior, and stress management [14]. Sufficient water intake is also recommended to maintain healthy hydration levels [15]. Moderate water consumption can aid in weight loss and waist circumference reduction. Several studies have shown that water intake affects body weight. In a study by Vij et al. [8], 50 women who were overweight consumed 500 mL of water before breakfast, lunch, and dinner for 8 weeks. Participants' body weight, the sum of skinfold thickness, body fat, and appetite scores were significantly lower after 8 weeks [8]. Furthermore, the study established the role of drinking 1.5 L of excessive water in weight reduction, body fat reduction, and appetite suppression in overweight women [8]. One study reported a positive correlation between water intake and total body water and an inverse correlation between water

intake and body fat mass, particularly in men [16].

Nonetheless, trials with similar designs to ours have revealed different results. Salari-Moghaddam et al. [17] conducted a cross-sectional study among 7,958 adults in Isfahan, Iran. Daily water consumption was assessed using a pre-tested questionnaire, including questions about the average number of glasses of water consumed per day. Obesity was defined as a body mass index  $\geq 30.0$  kg/m<sup>2</sup>, whereas abdominal obesity was defined as a waist circumference  $>88$  cm for women and  $>102$  cm for men. After considering potential confounders, individuals consuming more than eight glasses of water per day had 78% greater odds of general obesity (OR, 1.78; 95% CI, 1.08–2.94) compared with those consuming less than two glasses of water per day. Individuals with increased water intake had no significantly greater odds of abdominal obesity. Differences in the thresholds set for adequate water intake, abdominal obesity, and obesity may lead to different results; therefore, this aspect should be noted.

Water intake can influence waist circumference and abdominal obesity through various mechanisms. Increasing water intake can have dual effects; it may help prevent weight gain by reducing total energy intake and promote weight loss by enhancing energy expenditure and increasing fat oxidation [18]. First, adequate water intake can increase stomach distention and satiety, reducing energy intake during subsequent meals. Moreover, drinking 500 mL of water before breakfast or a low-calorie meal can further decrease energy intake and aid in weight loss [8].

Second, increased water intake may enhance energy expenditure by improving insulin resistance, reducing glucose production, and enhancing postprandial glucose clearance [19]. Moreover, it can increase metabolic rate, energy expenditure, and fat oxidation by affecting sympathetic nerve activity and thermogenesis induction [14]. Water intake reduces osmotic stress in the cells, leading to sympathetic nerve activation and thermogenesis, thereby increasing energy expenditure. Compared with osmotic saline, water is hypoosmotic. Drinking water can cause a localized decrease in osmolality in the gastrointestinal tract, portal vein, and liver. This localized decrease in extracellular osmolality may impact body temperature regulation by affecting organ function and the activity of osmosensitive neural pathways or a combination of both. In human studies, the infusion of a hypoosmolar solution through a gastric tube resulted in a greater increase in sweat production and sympathetic responses than the infusion of an osmolar solution. To demonstrate how water intake increases energy expenditure, further corrected analyses of blood glucose and glycated hemoglobin were performed and are presented in Supplement 3. As the results in Supplement 3 are significant, the study's conclusions are reliable.

In addition, drinking water elevates right atrial pressure, increasing blood flow and atrial natriuretic peptide secretion. Atrial natriuretic peptide acts on adipose tissue by increasing current Good Manufacturing Practice (cGMP) production, thus activating the PKG (protein kinase G) pathway and promoting lipolysis. Furthermore, cGMP stimulates thermogenesis, resulting in increased energy expenditure.

Higher water intake was associated with improved mitochondrial function, indicating potential metabolic benefits [20]. The consumption of 500 mL of water may increase energy expenditure by an average of 100 kJ [21], and cold-water intake may be more effective at stimulating thermogenesis. Boschmann et al. [21] found that drinking 500 mL of water increased the metabolic rate by 30% in 14 healthy individuals, whereas drinking 2 L of water per day increased the energy expenditure by approximately 400 kJ. Boschmann et al. [22] also demonstrated a 24% increase in energy expenditure 60 minutes after drinking 500 mL of water in eight individuals with obesity and eight without. Overall, these findings underscore the crucial role of water intake in supporting weight management. Considering these proven mechanisms by which water intake aids weight loss, the hypothesis that adequate water intake is negatively associated with obesity or abdominal obesity is compelling.

This study has some limitations. First, adequate water intake was defined according to the general recommendations of the Ministry of Health and Welfare for 2020, which were not based on the individual health and occupation status or living conditions and lifestyles of the study participants. Because of the restriction of the KNHANES database, an adequate water intake standard was based solely on water intake, neglecting other sources such as food, water, and liquid intake (i.e., broth consumed in soups). Second, the assessment of beverage and alcohol intake by the KNHANES does not cover some types of beverages—such as milk, liquid fermented milk, natural fruit juice, and soy milk, potentially underestimating fluid intake. Third, recent rapidly changing food intake patterns and differences in water intake between age groups and individuals were not fully reflected in this study. Age-specific water intake standards based on the actual intake by life stage are essential. Fourth, relying on self-reported data from the KNHANES might have introduced misclassification. Fifth, because of the cross-sectional nature of this study, we could not establish a cause-and-effect relationship between the exposures and outcomes over time. Prospective studies are needed to demonstrate that adequate water intake (more than five cups for men and four cups for women) is important in treating and preventing abdominal obesity. Cross-sectional studies of diet and water intake and health status (metabolic disease) using data from the KNHANES have been reported [23]; however, the criteria for adequate water intake were different in each study, as well as from those used in the present study. To date, no prospective study has compared adequate water intake with abdominal obesity and general obesity in Koreans; thus, further research is needed. Finally, other confounding factors might not have been fully considered in this analysis. These limitations should be addressed in future studies to obtain more accurate and comprehensive insights into the associations between water intake, abdominal obesity, and general obesity.

In conclusion, our research indicates that sufficient water consumption may have a negative association with abdominal obesity in adults, particularly among young adults. However, this association may not extend to older age groups. Further research is needed to confirm this

finding and reveal the underlying mechanism.

## Article Information

### Conflict of interest

No potential conflict of interest relevant to this article was reported.

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### Data availability

Data of this research are available from the corresponding author upon reasonable request.

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### Author contribution

Conceptualization: YJK, SNO. Data curation: YJK, SNO. Investigation: YJK, SNO. Methodology: YJK, SNO. Project administration: SNO. Software: YJK. Visualization: YJK. Funding acquisition: SNO. Writing—original draft: YJK. Writing—review & editing: SNO, EKK, ESS. Final approval of the manuscript: all authors.

### Supplementary Materials

Supplementary materials can be found via <https://doi.org/10.4082/kjfm.23.0277>. Supplement 1. Association of water intake (quartile) with abdominal obesity adjusting for covariates. Supplement 2. Association of water intake with abdominal obesity adjusting for covariates (excluded participants with liver cirrhosis and chronic kidney disease). Supplement 3. Association of water intake with abdominal obesity adjusting for covariates (including fasting blood glucose or HbA1c).

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