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# Relationship between breakfast skipping and hyperuricemia in Korean adults: results from KNHANES 2016–2023

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**Hyperuricemia is increasingly recognized not only due to its globally increasing prevalence trend but also its correlation with several metabolic disorders. Despite dietary and nutritional factors as contributors to hyperuricemia, the role of meal timing, particularly breakfast consumption, remains understudied. We aimed to investigate the association between breakfast skipping and hyperuricemia in Korean adults. This study included 36,274 Korean adults aged ≥ 19 years from nationally representative data. Participants were classified based on self-reported weekly breakfast consumption frequency into two groups: non-breakfast skippers (≥ 5 days/week) and breakfast skippers (< 5 days/week). Hyperuricemia was defined as serum uric acid levels > 7.0 mg/dL in men and > 6.0 mg/dL in women. Multivariate logistic regression models and Poisson regression analyses were employed to evaluate the association between breakfast skipping and hyperuricemia after adjusting for demographic, lifestyle, and clinical variables. Breakfast skippers demonstrated a significantly higher risk of hyperuricemia compared to non-breakfast skippers (adjusted odds ratio: 1.220; 95% confidence interval: 1.118–1.319; $p < .001$). A dose-response relationship was observed between breakfast frequency and hyperuricemia risk, with prevalence decreasing progressively with increasing breakfast consumption (from 17.5% in non-consumers to 10.5% in frequent consumers). Poisson regression analyses confirmed a significant inverse association between breakfast frequency and serum uric acid levels (estimate: −0.0088; 95% confidence interval: −0.0133–−0.0047; $p = .0002$). This study identified an association between breakfast skipping and a higher prevalence of hyperuricemia. Thus, regular breakfast intake (≥ 3–4 times/week) showed an inverse association with hyperuricemia in this study, suggesting further longitudinal studies to clarify this correlation.**

**Keywords** Breakfast skipping, Hyperuricemia, Serum uric acid, Meal frequency, Meal skipping

Hyperuricemia, defined as elevated serum uric acid (SUA) level above the saturation threshold, has emerged as a critical global public health issue. Although it was merely considered a precursor of gout, hyperuricemia is now recognized as a significant risk factor and potential mediator for various cardiometabolic conditions, including hypertension, diabetes, metabolic syndrome, and chronic kidney disease (CKD)[1–3]. The prevalence of hyperuricemia has increased alarmingly worldwide, exceeding 10% in many Asian countries, including China, Japan, and South Korea, and surpassing 20% in Western nations, such as the US and Ireland[4–7]. This tendency supports the emerging significance of identifying modifiable risk factors of hyperuricemia.

Increased SUA can be caused either by increased production, decreased excretion of uric acid, or both. Various factors, such as genetic factors, medical conditions, medication usage, or dietary habits, can increase SUA levels. Among these factors, dietary habits are well-documented contributors to hyperuricemia through purine and renal uric acid metabolism[8,9]. Despite extensively examining food components such as alcohol, red meat, and seafood in previous studies, meal *timing* and *frequency*—key regulators of metabolic homeostasis—have received comparatively little attention[10]. Breakfast, often described as "the most important meal of the day", influences satiety, circadian rhythms, insulin sensitivity, and lipid metabolism, all of which are intricately linked

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to uric acid production and excretion[11]. Skipping breakfast is associated with adverse outcomes, such as obesity, inflammation, and impaired glucose regulation[12–14]yet its role in hyperuricemia remains poorly defined.

Currently, limited evidence exists on the association between breakfast habits and hyperuricemia. Previous studies either lacked statistical power due to small sample sizes or failed to comprehensively adjust for confounders[15]. Importantly, a significant knowledge gap regarding the dose-response relationship between breakfast frequency and SUA levels remains. Thus, addressing this gap has critical implications since breakfast consumption represents a simple and modifiable behavioral intervention to mitigate hyperuricemia risk.

Accordingly, we investigated the association between breakfast skipping and hyperuricemia using data from the Korea National Health and Nutrition Examination Survey (KNHANES) in 2016–2023 to address this academic gap. We hope to aid the development of strategies addressing the burden of hyperuricemia and its associated diseases by delivering insights into the impact of breakfast consumption on hyperuricemia.

## Materials and methods

### Data collection and study participants

Data from the KNHANES from 2016 to 2023 were used to investigate the relationship between skipping breakfast and hyperuricemia. KNHANES is a nationwide cross-sectional study of the health and nutritional status of South Korean residents, being conducted annually since 1998 by the Korea Centers for Disease Control and Prevention (KCDC)[16]. The survey comprises health questionnaires, medical examinations (including blood tests), and nutritional surveys. Each year, a new sample (approximately 10,000 individuals aged ≥ 1 year) is included. The KNHANES data are publicly available on its website. SUA, as the main variable, has been measured since 2016. Therefore, we used KNHANES data from 2016 to 2023, the most recent year available.

Figure 1 shows that 49,309 Korean adults aged ≥ 19 years from the KNHANES 2016–2023 were initially selected as the participants (21,783 men and 27,526 women). The research was conducted with adults ≥ 19 years because certain health questionnaires were aimed at those ≥ 19 years, although blood tests and nutritional surveys were performed for individuals aged ≥ 10 and ≥ 1 year, respectively. Subjects with missing data for frequency of breakfast consumption ($n = 6,141$) and SUA ($n = 2,813$) were excluded. Additionally, individuals with missing data on the relevant covariables were excluded ($n = 4,081$). Finally, 36,274 participants (15,509 men and 20,765 women) were included.

### Independent variable: breakfast skipping

The independent variable of this study was breakfast skipping. The frequency of breakfast consumption was assessed by the following question: "How many days per week did you eat breakfast over the past year?" The question had multiple-choice responses, which included: 5–7, 3–4, 1–2, and 0 days (rarely). Based on the

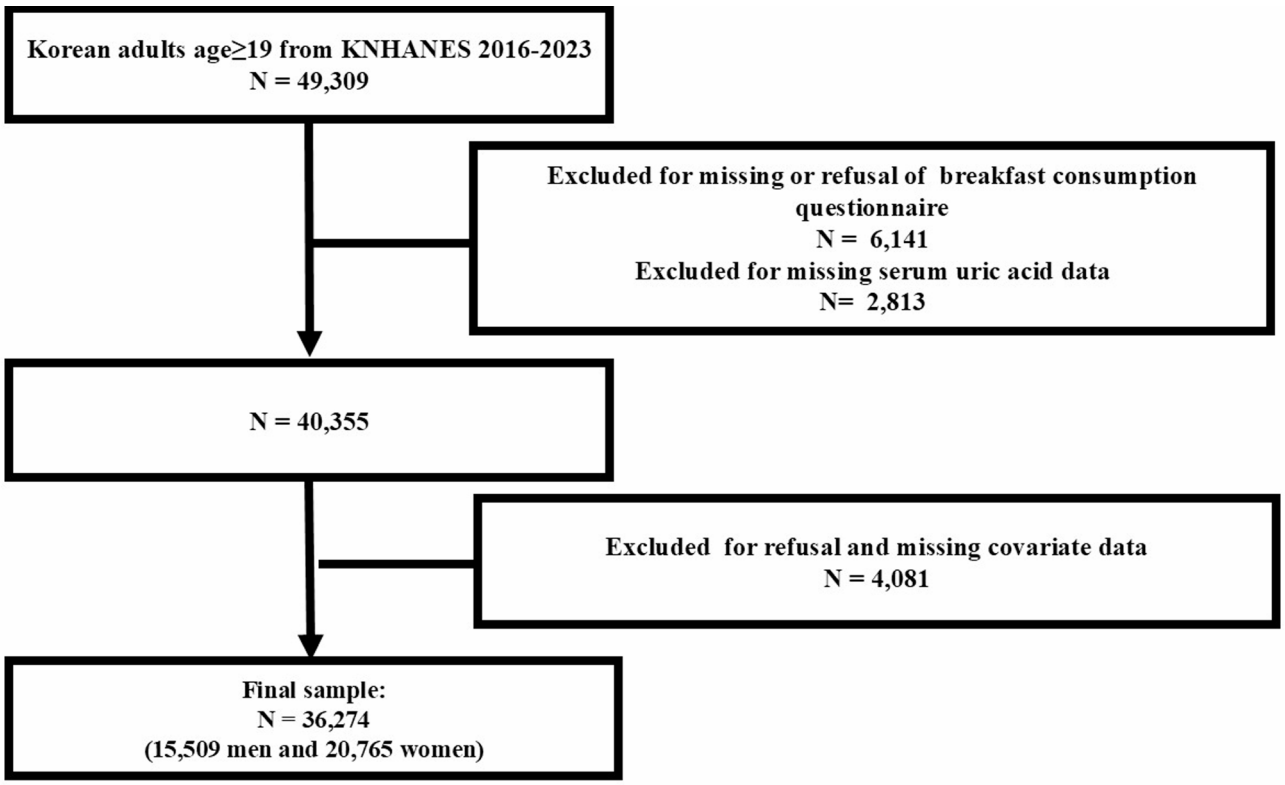


**Fig. 1**. The schematic diagram depicting the study population.

responses, participants were categorized into two groups: (1) non-breakfast skippers (who had breakfast 5–7 days a week) and (2) breakfast skippers (who had breakfast < 5 days a week)[17].

### Definition of hyperuricemia

Hyperuricemia is commonly defined as a serum uric acid (SUA) level exceeding 7.0 mg/dL in men and 6.0 mg/dL in women[5,18]though definitions vary widely across studies. In this study, we primarily adopted SUA thresholds of > 7.0 mg/dL for men and > 6.0 mg/dL for women to identify hyperuricemia, reflecting their widespread use in epidemiological research and association with clinical outcomes such as gout. For additional analyses, we explored alternative cutoffs: >6.8 mg/dL for both sexes[19,20] and > 7.0 mg/dL for men paired with > 5.7 mg/dL for women[6,21]to assess consistency across definitions. SUA levels were measured using an enzymatic colorimetric assay on a Cobas 8000 analyzer with UA2 reagent (Roche Diagnostics, Germany), a validated method ensuring high precision.

### Definition of other covariables

Marital status was defined as married/living with a partner, widow/divorced/separated, or single[22]. Household income was categorized into four quartiles (low, middle-low, middle-high, and high). Education was classified into four categories according to the highest level completed: (1) elementary school or less, (2) middle school or less, (3) high school or less, and (4) college or more[23].Physical activity was defined as engaging in at least 150 min of moderate-intensity aerobic activity, 75 min of vigorous-intensity aerobic activity, or an equivalent combination of both per week[24].Current smoking was defined as having smoked at least 5 packs (100 cigarettes) in one's lifetime and actively smoking conventional cigarettes at the time of the study. High-risk drinking was defined as drinking≥7 standard drinks for men and ≥ 5 for women on ≥ 2 occasions per week. Obesity was defined with a cut-off level of body mass index (BMI) of 25 $kg/m^2$,[25]. Diabetes status was categorized into three groups: normal, prediabetes, and diabetes. Diabetes was defined as a fasting plasma glucose level ≥ 126 mg/dL, use of antidiabetic medications or insulin, a physician's diagnosis, or an HbA1c level ≥ 6.5%. Prediabetes was defined as a fasting plasma glucose level of 100–125 mg/dL or an HbA1c level of 5.7–6.4%. Individuals with a fasting plasma glucose level < 100 mg/dL and an HbA1c level < 5.7%, measured after an overnight fast per KNHANES protocol, were classified as normal. Hypertension status was categorized into four groups: normal, elevated blood pressure, stage 1 hypertension, and stage 2 hypertension[26,27]. Stage 2 hypertension was defined by a systolic blood pressure of ≥ 140 mmHg, a diastolic blood pressure of ≥ 90 mmHg, or currently using antihypertensive drugs. Stage 1 hypertension was defined as systolic blood pressure of 130–139 mmHg or diastolic blood pressure of 80–89 mmHg. Elevated blood pressure was defined as systolic blood pressure of ≥ 120 mmHg and < 130 mmHg with diastolic blood pressure of < 80 mmHg. Normal blood pressure was defined as systolic blood pressure of < 120 mmHg and diastolic blood pressure of < 80 mmHg. CKD was defined as reduced kidney function assessed by an estimated glomerular filtration rate (eGFR) of < 60 mL/min per 1.73 $m^2$[27–32]. The assessment of dietary intake was conducted using data obtained from the nutritional survey component of KNHANES. The distribution of major nutrients was calculated as the daily energy intake (kcal) and the percentage of total daily energy intake of carbohydrates, protein, and fat for participants.

### Statistical analysis

The student's t-test and chi-square test were used for continuous variable and categorical variables, respectively, to compare patients' characteristics. Multivariate logistic regression analysis was performed to assess the association between breakfast skipping and hyperuricemia. Four different logistic regression models were used: unadjusted model adjusted just for breakfast skipping; Model 1 additionally adjusted for age and sex; Model 2 additionally adjusted for socioeconomic variables such as marital status, household income, education level, and occupation; Model 3 additionally adjusted for regular physical activity, smoking status, high-risk drinking status, obesity, diabetic status, hypertension status, CKD, and total energy intake. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated with adjustment for the covariables. We performed two further analyses to investigate the relationship between breakfast frequency and the risk of hyperuricemia. Poisson regression analysis of hyperuricemia risk according to breakfast frequency was conducted. We also estimated the weighted prevalence and 95% CI of hyperuricemia according to breakfast frequency. All statistical analyses were performed by SAS version 9.4 (SAS Institute, Cary, NC, USA). A p-value < 0.05 in both tails indicated statistical significance.

## Results

Table 1 presents the baseline participants' characteristics. A total of 22,889 (63.10%) participants were non-breakfast skippers, whereas 13,385 (36.90%) participants were breakfast skippers. Additionally, 32,095 (88.48%) participants had no hyperuricemia, while 4,179 (11.52%) participants had hyperuricemia. Male participants were more likely to have hyperuricemia (18.20%) than female participants (6.54%). Regarding marital status, single individuals had the highest prevalence of hyperuricemia, followed by divorced, widowed, or separated participants and those married or living with partners, who had the lowest prevalence. Other statistically significant variables related to hyperuricemia included occupational status, physical activity, current smoking, high-risk drinking, obesity, diabetes status, hypertension status, and CKD status. Participants who skipped breakfast had a significantly higher prevalence of hyperuricemia than those who had regular breakfast consumption (13.93% vs. 10.11%, $p < .0001$). Individuals with hyperuricemia had significantly higher total energy intake than those without hyperuricemia. The proportion of energy intake from carbohydrates was significantly lower in the hyperuricemia group compared to the non-hyperuricemia group. However, there were no significant differences in protein and fat intake proportions between the two groups.

| | Hyperuricemia | | |
|---|---|---|---|
| | No | Yes | *P*-value |
| Overall | 32,095 (88.48) | 4,179 (11.52) | |
| Age | 52.4 ± 0.1 | 50.0 ± 0.3 | < 0.0001 |
| Sex | | | < 0.0001 |
| Male | 12,687 (81.80) | 2,822(18.20) | |
| Female | 19,408 (93.46) | 1,357 (6.54) | |
| Marital status | | | < 0.0001 |
| Married/living with partner | 22,276 (89.74) | 2,547 (10.26) | |
| Widow, divorced, separated | 4,465 (88.21) | 597 (11.79) | |
| Single | 5,354 (83.80) | 1035 (16.20) | |
| Household income | | | 0.2124 |
| Low | 5,911 (87.74) | 826 (12.26) | |
| Middle low | 7,787 (88.66) | 996 (11.34) | |
| Middle high | 8,843 (88.70) | 1,127 (11.30) | |
| High | 9,554 (88.59) | 1,230 (11.41) | |
| Education level | | | 0.1062 |
| ≤Elementary | 6,006 (89.08) | 736 (10.92) | |
| Middle school | 3,149 (89.21) | 381 (10.79) | |
| High school | 10,497 (88.32) | 1,388 (11.68) | |
| ≥College | 12,443 (88.14) | 1,674 (11.86) | |
| Occupation | | | < 0.0001 |
| No | 12,729 (89.48) | 1,497 (10.52) | |
| Yes | 19,366(87.84) | 2,682 (12.16) | |
| Physical activity | | | 0.0292 |
| No | 18,120 (88.80) | 2,285 (11.20) | |
| Yes | 13,975 (88.06) | 1,894 (11.94) | |
| Current smoking | | | < 0.0001 |
| Never or past smokers | 27,386 (89.61) | 3,177 (10.39) | |
| Current smokers | 4,709 (82.45) | 1,002 (17.55) | |
| High risk drinking | | | < 0.0001 |
| No | 28,924 (89.47) | 3,405 (10.53) | |
| Yes | 3,171 (80.38) | 774 (19.62) | |
| Obesity | | | < 0.0001 |
| No | 21,703 (92.46) | 1,770 (7.54) | |
| Yes | 10,392 (81.18) | 2,409 (18.82) | |
| Diabetes | | | < 0.0001 |
| Normal | 15,860 (90.61) | 1,644 (9.39) | |
| Pre-diabetes | 11,571 (86.14) | 1,862 (13.86) | |
| Diabetes | 4,664 (87.39) | 673 (12.61) | |
| Hypertension | | | < 0.0001 |
| Normal | 14,628 (92.35) | 1,212 (7.65) | |
| Elevated blood pressure | 6,342 (86.57) | 984 (13.43) | |
| Stage 1 hypertension | 8,528 (84.34) | 1,584 (15.66) | |
| Stage 2 hypertension | 2,597 (86.68) | 399 (13.32) | |
| Chronic kidney disease | | | < 0.0001 |
| No | 31,313 (89.49) | 3,678 (10.51) | |
| Yes | 782 (60.95) | 501 (39.05) | |
| Dietary intake | | | |
| Energy intake (kcal) | 1850.48 | 1994.04 | < 0.0001 |
| Carbohydrate (% of energy) | 61.64 | 58.74 | < 0.0001 |
| Protein (% of energy) | 14.70 | 14.77 | 0.3278 |
| Fat (% of energy) | 20.69 | 20.99 | 0.0644 |
| Breakfast skipping | | | < 0.0001 |
| No | 20,575 (89.89) | 2,314 (10.11) | |
| Yes | 11,520 (86.07) | 1,865 (13.93) | |

**Table 1**. Characteristics of study participants by hyperuricemia in KNHANES (2016–2023).

| Definition of hyperuricemia | | Odd ratio (95% confidence interval) | | | |
|---|---|---|---|---|---|
| | | Unadjusted | Model 1 | Model 2 | Model 3 |
| Non-breakfast skipping | | Reference | Reference | Reference | Reference |
| Serum uric acid level | > 7.0 for male and > 6.0 mg/dL for female | 1.440 (1.349–1.536) | 1.359 (1.258–1.468) | 1.330 (1.230–1.439) | 1.220 (1.118–1.319) |
| | > 6.8 mg/dL for both | 1.573 (1.471–1.682) | 1.379 (1.269–1.499) | 1.357 (1.248–1.476) | 1.254 (1.149–1.371) |
| | > 7.0 for male and > 5.7 mg/dL for female | 1.387 (1.305–1.474) | 1.342 (1.249–1.441) | 1.316 (1.224–1.415) | 1.210 (1.122–1.306) |

**Table 2**. Results of multivariate logistic regression for hyperuricemia by breakfast skipping. Model 1: Adjusted for age and sex; Model 2: Additionally adjusted for marital status, household income, education level, and occupation; Model 3: Further adjusted for regular physical activity, smoking status, high-risk alcohol consumption, obesity, diabetes, hypertension, chronic kidney disease, and total energy intake. Non-breakfast skipping was defined as eating breakfast for ≥ 5 days/week. All odds ratios are statistically significant ($p < .0001$) in every model.

| Variable | Estimate | 95% CI | | *p*-value |
|---|---|---|---|---|
| Breakfast consumption frequency | −0.0088 | −0.0133 | −0.0047 | 0.0002 |

**Table 3**. Poisson regression analysis to determine the association between the weekly breakfast consumption days and risk of hyperuricemia. Adjusted for age, sex, marital status, household income, education, working status, physical activity, present smoking status, high-risk drinking status, obesity, diabetic status, hypertension status, chronic kidney disease status, total energy intake, and macronutrient composition (% of daily intake).

Multivariate logistic regression was performed to identify the association between breakfast skipping and hyperuricemia (Table 2). Covariables that could affect hyperuricemia were included and adjusted in model 1, model 2, and model 3. The correlation between breakfast skipping and hyperuricemia remained significant ($p < .0001$) after adjusting for related covariables in models 1, 2, and 3. According to the first definition of hyperuricemia (SUA > 7.0 mg/dL for males and > 6.0 mg/dL for females), those who skipped breakfast had a 22% higher risk of hyperuricemia compared to non-breakfast skippers as indicated by an OR of 1.220 (95% CI: 1.118–1.319) from the final adjusted model. Under the second definition of hyperuricemia (SUA > 6.8 mg/dL for both genders), the OR was 1.254 (95% CI: 1.149–1.371), while the OR based on the third definition of hyperuricemia (SUA > 7.0 mg/dL for males and > 5.7 mg/dL for females) was 1.210 (95% CI: 1.122–1.306). Therefore, regardless of the type of applied hyperuricemia definition, a trend of higher prevalence of hyperuricemia among breakfast skippers was observed.

Furthermore, we performed a Poisson regression analysis to investigate whether breakfast consumption frequency has a significant association with SUA levels. Table 3 presents the relationship between breakfast consumption frequency and SUA level adjusted by age, sex, marital status, household income, education level, occupational status, regular physical activity, smoking status, high-risk drinking status, obesity, diabetes status, hypertension status, CKD status, total energy intake, and macronutrient composition (% of daily intake). The Poisson regression analysis revealed an inverse association between breakfast consumption frequency and SUA level (estimate: −0.0088; 95% CI: −0.0133–−0.0047; $p = .0002$).

Figure 2 shows the weighted prevalence of hyperuricemia according to the frequency of breakfast consumption. An inverse association was observed between breakfast consumption frequency and the weighted prevalence of hyperuricemia, with the prevalence decreasing as follows: 17.5% (95% CI: 16.8–18.3) in the 0-day group, 15.7% (95% CI: 14.9–16.4) in the 1–2 days group, 12.2% (95% CI: 11.5–12.9) in the 3–4 days group, and 10.5% (95% CI: 10.2–10.8) in the 5–7 days breakfast group.

## Discussion

This study demonstrated a significant association between breakfast skipping and hyperuricemia in a nationally representative sample of Korean adults. Participants who skipped breakfast had a 22% higher risk of hyperuricemia compared to non-breakfast skippers, even after adjusting for key covariables, such as age, sex, socioeconomic factors, physical activity, and comorbidities. Furthermore, an inverse relationship between breakfast consumption frequency and hyperuricemia prevalence was observed, with a notable decrease in hyperuricemia prevalence when breakfast was consumed at least 3–4 times per week. These findings highlight the potential role of habitual breakfast consumption as a modifiable factor in managing uric acid metabolism and reducing hyperuricemia-related health risks, offering new insights into dietary strategies for preventing and treating hyperuricemia.

Some previous studies addressed breakfast skipping and hyperuricemia, but breakfast skipping was generally treated as part of dietary risk factors[33] or used as a component of independent variables composing a prediction model for hyperuricemia[34]. In a study about the impact of breakfast skipping on arterial stiffness in patients with type 2 diabetes[35,36]elevated SUA levels were addressed as one of several risk factors of arterial stiffness. That study showed that those eating breakfast < 4 times a week tend to have higher SUA levels. Additionally, another study examining the association between breakfast frequency and metabolic syndrome[37] addressed SUA as one of the metabolic parameters, demonstrating a positive relationship between breakfast frequency and SUA level.

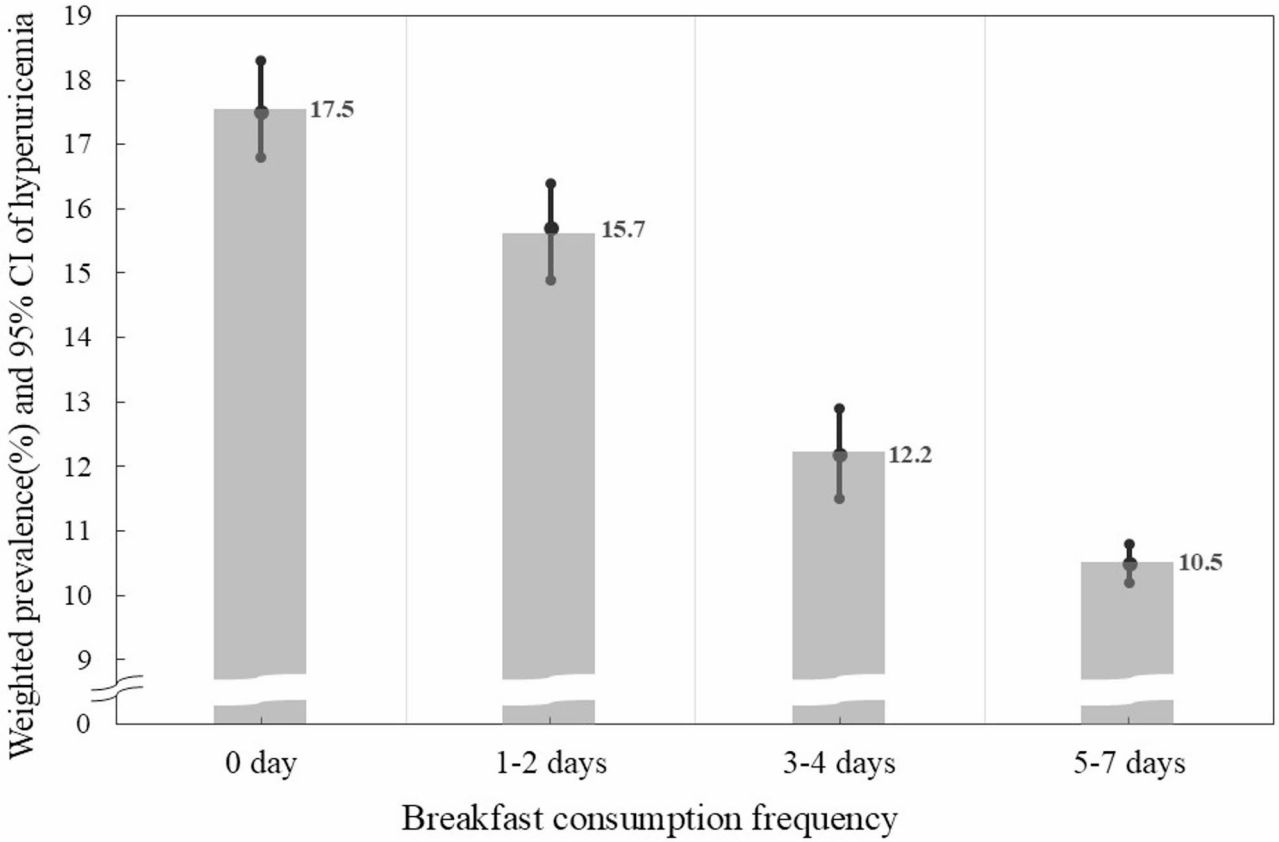


**Fig. 2**. The weighted prevalence and 95% confidence interval of hyperuricemia according to breakfast consumption frequency.

These mentioned studies briefly addressed breakfast skipping and SUA levels, yet none of them focused on the association as a main research idea. One study investigated the association between breakfast skipping and hyperuricemia as a main focus[15]comparing SUA levels of two groups: a group consuming 3 meals a day versus those skipping breakfast. That study confirmed the elevation in SUA levels due to breakfast omission. However, it had a limited sample size (30 participants). Additionally, other possible mechanisms might have played a role in increasing SUA level. Therefore, to the best of our knowledge, the current study bears significance as the first and largest study to directly examine the association between breakfast skipping and hyperuricemia in the Korean population.

Our study revealed that the prevalence of hyperuricemia was 11.5% among all participants, comprising 36,274 Korean adults (15,509 men/20,765 women), affecting 18.20% of men and 6.54% of women. Our results confirm the higher prevalence of hyperuricemia in participants who skip breakfast. Furthermore, both hyperuricemia prevalence and SUA level had a negative correlation with breakfast consumption frequency.

There are several putative mechanisms to explain this correlation between skipping breakfast and hyperuricemia. First, skipping breakfast increases cortisol levels[38,39]. Prolonged fasting leads to high cortisol excretion since fasting is regarded as a stressful state. Furthermore, cortisol gets released to increase glucose levels to compensate for low glucose levels due to fasting[40]. Cortisol has various functions: catabolic effects, an increase in blood pressure, and stimulation of internal antioxidants[41]. When cortisol level increases, it also increases protein catabolism that promotes purine metabolism, elevating the production of uric acid. Lipolysis also increases, leading to high free fatty acids (FFAs). These metabolites produced through the activated catabolism compete with uric acid in the kidney for excretion, decreasing uric acid excretion. Additionally, cortisol increases blood pressure by weak aldosterone and antidiuretic hormone effect, thereby upregulating arteriolar α1-receptor, leading to vasoconstriction. When blood pressure increases, renal function could be damaged by decreasing the glomerular filtration rate (GFR), whereas, as a result, damaged renal microvasculature could reduce blood flow to the kidney. Therefore, SUA excretion diminishes, increasing its levels in the plasma. Furthermore, cortisol stimulates internal antioxidants, leading to increased oxidative stress. This stimulates xanthine oxidase (XO), an enzyme catalyzing hypoxanthine to xanthine and xanthine to uric acid. Therefore, increased cortisol level increases SUA levels by both increasing production and decreasing excretion of uric acid through various mechanisms.

Another putative mechanism for the association between breakfast skipping and hyperuricemia is insulin resistance. Skipping breakfast might lead to excessive consumption of lunch or dinner due to the loss of appetite control, which is normally achieved by breakfast, or might also lead to prolonged fasting[42]. Excessive

consumption of meals impairs normal glycemic control, increasing the risk of insulin resistance. Furthermore, even without overeating, the FFA level increases as a metabolite of lipolysis to compensate for energy deficiency in fasting, and elevated FFA level is also a well-known risk factor of insulin resistance[43]. Insulin resistance increases the reabsorption of uric acid in the kidney by promoting the expression of protein transporters, such as uric acid transporter 1 (URAT1) on the apical membrane of renal proximal tubule cells and glucose transporter 9 (GLUT9) on the basolateral membrane[44]. Additionally, insulin resistance can impair renal function decreasing uric acid excretion.

Third, the increased inflammatory response might increase SUA levels. As mentioned already, breakfast skipping increases cortisol secretion, impairing insulin sensitivity and leading to insulin resistance. These two factors trigger inflammation, increasing inflammatory cytokines IL-6, CRP, and TNF-α, which are positively associated with SUA[45]. Additionally, circadian rhythm is closely related to inflammatory responses. Although the discrete mechanism of time-dependent variations in inflammatory reactions still needs further investigation due to the complex interactions of various processes, hormones such as cortisol and melatonin are involved in this mechanism[46]. Therefore, skipping breakfast disrupts the circadian rhythm and increases the inflammatory response. Subsequently, it causes cellular damage, degrading intracellular nucleotides, including adenine and guanine, which are purines metabolized into uric acid by the purine degradation pathway. Therefore, the inflammation-related increase in intracellular nucleotide degradation elevates the production of uric acid, the final product of purine metabolism.

Our study had several limitations. First, we could only verify the association due to the cross-sectional nature of this study, limiting our ability to draw causal inferences. Therefore, further prospective longitudinal or experimental studies are needed. Second, this study was based on self-reported data that could include recall bias. Third, as the widely accepted definition of hyperuricemia remains unsettled, the standardized cutoff value of uric acid level was absent. Although we applied three different hyperuricemia definitions in our logistic regression analysis, a clear and unified criterion for hyperuricemia is essential for comparing studies and further research. Fourth, KNHANES data lack medication status, which is a well-known influential factor for SUA levels. The effect of breakfast skipping on SUA might have been overrated since drugs such as low-dose aspirin, ethambutol, pyrazinamide, and nicotinamide can reduce uric acid excretion, increasing SUA levels. Fifth, although nutrition data were available, they were not included in the main analysis due to concerns about potential recall bias and the limitations of single-day 24-hour recall data in accurately capturing habitual intake. Moreover, since this study focused on breakfast frequency as a behavioral pattern rather than comprehensive nutritional profiling, incorporating full dietary data was considered beyond the primary scope of the analysis. Lastly, the categorical format of the survey for breakfast consumption frequency (0, 1–2, 3–4, and 5–7 days per week) might have limited a more in-depth analysis in our Poisson regression and weighted prevalence analysis.

Nevertheless, this study had several strengths. First, it guarantees representativeness as it utilizes data from KNHANES, a comprehensive nationwide survey. Second, we applied the 3 most recent and commonly used definitions in our logistic regression model to overcome the ambiguity of defining hyperuricemia. Independent of the applied definition, all 3 models confirmed significant associations. Third, our study did not only simply associate breakfast skipping with hyperuricemia but also revealed a negative correlation between breakfast frequency and SUA levels through Poisson regression analysis, leading to a deeper understanding of the two variables. Fourth, as covariables were properly adjusted while adding more variables, odds ratios showed a gradually decreasing trend in the multiple logistic regression model (Table 2). Lastly, the most notable decrease in the weighted prevalence of hyperuricemia was shown between the 1–2 and 3–4 days categories (Fig. 2), suggesting that consuming breakfast at least 3–4 days per week could be beneficial in reducing hyperuricemia risk.

An important clinical implication of this study is that skipping breakfast is associated with a higher prevalence of hyperuricemia. Subjects who were male, single, and currently smoking and high-risk drinkers had a notably higher prevalence of hyperuricemia. Given the higher prevalence of hyperuricemia observed among individuals with comorbidities such as diabetes, hypertension, CKD, and obesity, these populations may benefit from healthier dietary patterns, including regular breakfast consumption. Notably, a marked decrease in hyperuricemia prevalence was observed between those consuming breakfast 1–2 days and 3–4 days per week, suggesting that more frequent breakfast consumption may be associated with a lower risk of hyperuricemia. However, as this study is cross-sectional, the possibility of reversing causality and residual confounding cannot be ruled out. Therefore, longitudinal or interventional studies are needed to further clarify the causal relationship between breakfast habits and hyperuricemia.

In conclusion, this study highlights a significant association between breakfast skipping and hyperuricemia, with findings suggesting that individuals who skip breakfast may be approximately 23% more likely to have hyperuricemia. Additionally, the analysis revealed an inverse correlation between breakfast frequency and the prevalence of hyperuricemia; hence, regular breakfast consumption may provide a protective effect. These findings emphasize the importance of meal timing and frequency in managing uric acid metabolism and mitigating the burden of hyperuricemia. The results also underscore the need for further longitudinal and experimental research to establish causality and uncover the underlying mechanisms linking breakfast consumption and uric acid metabolism.

## Data availability

All data files are available from the Korea Centers for Disease Control and Prevention database through the following URLs: https://knhanes.cdc.go.kr/knhanes/sub03/sub03_02_02.do.

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## Author contributions

HJ, SYL, and WL designed the study. HJ performed statistical analyses and interpreted the results, designed the figures and drafted the manuscript. SYL and WL supervised data analysis and interpretation. All authors revised the manuscript and approved the final version. SYL and WL equally distributed in this study as corresponding authors.

## Declarations

## Competing interests

The authors declare no competing interests.

## Ethical approval

The study was performed in accordance with the ethical standards of the Declaration of Helsinki (1964) and its subsequent amendments. In 2016 and 2017, the survey was conducted with the Institutional Review Board (IRB) review exemption because the survey was considered as research directly conducted by the government for public welfare according to Article 2, Paragraph 1 of the Bioethics and Safety Act and Article 2, Paragraph 2, Subparagraph 2 of the Enforcement Rules of the same Act. Research review resumed in 2018, and the IRB of the KCDC approved the investigation of the KNHANES conducted from 2018 to 2023 (IRB approval numbers 2018-01-03-P-A, 2018-01-03-C-A, 2018-01-03–2 C-A, 2018-01-03–5 C-A, 2018-01-03–4 C-A, and 2022-11-16-R-A).

## Additional information

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