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The Moderating Role of Drinking Water Habit on the Effect of High-Purine Dietary Intake on Uric Acid Levels in Adults and the Elderly

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Serum uric acid levels are affected by dietary patterns and lifestyle factors. High-purine food consumption is a primary contributor to hyperuricemia, while hydration status may moderate this effect. This study aimed to examine the moderating role of drinking water habits on the relationship between high-purine dietary intake and serum uric acid levels among adults and the elderly. A cross-sectional design with purposive sampling was conducted, involving 87 respondents from Elderly Integrated Health Post *(Posyandu Lansia)*. Data on purine-rich food intake and water-drinking habits were collected via structured questionnaires, and serum uric acid levels were measured using a point-of-care testing (POCT) device (Easy Touch GCU 3-in-1) with compatible test strips. Multiple logistic regression analysis assessed the interaction between purine intake and drinking water habits. Results revealed a significant association between high-purine dietary intake and elevated serum uric acid levels ($p = 0.022$). Participants who reported high-purine dietary habits along with insufficient water consumption demonstrated the highest prevalence of hyperuricemia (71.4%), whereas those with similar dietary patterns but adequate hydration showed a substantially lower prevalence (20.0%). A significant interaction effect ($p = 0.040$) indicated that sufficient water intake moderated the impact of a high-purine diet on uric acid levels. Adequate hydration thus plays a critical moderating role in reducing the adverse effects of a high-purine diet. Promoting sufficient water intake may serve as a simple and effective behavioral strategy to prevent hyperuricemia, particularly among individuals with high purine consumption.

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INTRODUCTION

Uric acid represents terminal of purine metabolism in humans and is normally excreted through the kidney (Kuwabara et al., 2025). Elevated serum uric acid levels, clinically defined as hyperuricemia, are strongly implicated in the pathogenesis of gout and have also been associated with a spectrum of metabolic and systemic complications, including hypertension, cardiovascular disease, and chronic kidney disease (Nishizawa et al., 2022). Individuals with hyperuricemia have been shown to experience significantly to those with normal uric acid levels reflecting the multifaceted physical, psychological, and functional burden imposed by this metabolic condition (Dilokthornsakul et al., 2025). When serum uric acid levels exceed 6.8 mg/dL, ionized uric acid precipitates as monosodium urate crystals, which can induce gouty arthritis and urolithiasis (Calle Cárdenas et al., 2024). Xanthine oxidase, a key enzyme in purine metabolism, catalyzes the oxidation of hypoxanthine to xanthine and subsequently to uric acid. In addition to its metabolic role, xanthine oxidase generates reactive oxygen species that contribute to oxidative stress, promoting the development of chronic kidney disease and cardiovascular disorders. Elevated serum uric acid levels also impair endothelial function by reducing the bioavailability of nitric oxide (NO). As a potent vasodilator, NO regulates vascular tone by enhancing blood flow, lowering blood pressure, improving tissue oxygenation, playing essential roles in immune modulation and intercellular signaling (Anaizi, 2023).

Hyperuricemia prevalence among Asian populations has been reported to range from 13.3% to 20.1%, making it the second most common metabolic disorder after diabetes (Liu et al., 2025). According to the World Health Organization (WHO) in 2022, the prevalence of hyperuricemia is approximately 30% in Europe and 27% in North America. Globally, an estimated 355 million individuals are affected by elevated uric acid levels, indicating that roughly one in six people worldwide experience hyperuricemia (Maharani et al., 2025). Studies have indicated that approximately 10–20% of individuals with hyperuricemia eventually develop gout. In Indonesia, the prevalence of gout between 2022 and 2023 was reported to reach 3.21%, and this trend has shown a consistent increase over the past several decades. The proportion of gout cases has risen across all provinces, including East Java, which recorded a prevalence of 12.16% (Amin & Haswita, 2025).

Uric acid levels are influenced by a combination of genetic, environmental, racial, dietary, and lifestyle factors. The intake of purine-rich foods, including seafood, broths, organ meats, and alcohol, has been shown to increase the prevalence of hyperuricemia and gout (Chen et al., 2024). Hyperuricemia arises from abnormalities in purine metabolism, characterized by elevated serum urate concentrations that result from either excessive uric acid production and/or enhanced urate reabsorption (Wang et al., 2022). Environmental factors contribute to the pathogenesis of hyperuricemia; however, the mechanisms of uric acid excretion through the kidneys and gastrointestinal tract play a pivotal role in maintaining serum uric acid homeostasis. Over 70% of uric acid is eliminated via renal excretion, whereas approximately 30% is excreted through the intestinal pathway (Bao et al., 2022; Dalbeth et al., 2021).

Adequate water intake helps maintain an alkaline urinary pH, and a more basic urinary environment enhances the solubility of uric acid, thereby facilitating its excretion. Moreover, the consumption of water with higher dissolved oxygen concentrations has been shown to reduce serum uric acid levels and promote uric acid metabolism (Čypienė et al., 2023). Uric acid excretion is compromised under more acidic urinary conditions. Adequate hydration helps maintain a more alkaline urine environment, which in turn facilitates increased uric acid elimination (Adomako & Maalouf, 2023). A significant association has been identified between serum uric acid levels and dehydration in children, where elevated uric acid concentrations are more prevalent among those experiencing moderate to severe dehydration than in those with mild or no dehydration (Kim, 2024).

Extensive evidence has demonstrated the association between high-purine diets and serum uric acid levels, and it has been established that adequate water intake influences uric acid excretion, while dehydration is linked to elevated uric acid levels. However, the relationship between uric acid concentration and habitual water consumption remains unclear, particularly regarding its moderating effect on the impact of high-purine food intake on serum uric acid levels.

METHODS

The study employed a cross-sectional design. It aimed to examine whether drinking water habits moderate the association between high-purine dietary intake and serum uric acid levels among adults and older adults, thereby providing insights into the potential protective role of adequate hydration against diet-induced hyperuricemia. The participants were selected using a purposive sampling technique, yielding a total of 87 elderly individuals registered at the Elderly Integrated Health Post (*Posyandu Lansia*) in Bendowulung Village, Sanankulon, Blitar, Indonesia. The inclusion criteria consisted of elderly participants without physical or mental disabilities who were present during the data collection period. Uric acid levels were measured using a point-of-care testing (POCT) device (Easy Touch GCU 3-in-1) with compatible test strips. Serum uric acid levels were classified based on sex-specific reference ranges: Men: low (<2.5 mg/dL), normal (2.5–7.0 mg/dL), high (>7.0 mg/dL), Women: low (<1.5 mg/dL), normal (1.5–6.0 mg/dL), high (>6.0 mg/dL) (Dório et al., 2022). Respondent characteristics, including age, sex, and education, as well as specific variables such as high-purine dietary habits and drinking water habits, were assessed using a structured questionnaire which included a one-week food recall to capture participants' recent intake patterns. High-purine dietary habits were categorized as high (≥5 times per week), moderate (2–4 times per week), and low (≤1 time per week or never) (Aihemaitijiang et al., 2020). Drinking water habits were classified as adequate (≥8 glasses or ≥ 2 litres per day), sufficient (5–7 glasses or 1–1.75 litres per day), and inadequate (<5 glasses or <1 liter per day) (Awwalina et al., 2022; Stookey & Kavouras, 2020). Data were analyzed using multiple logistic regression to examine the moderating effect of drinking water habits on the association between high-purine dietary intake and hyperuricemia, controlling for age, sex, education, and knowledge. Interaction terms between high-purine dietary habits and drinking water habits were included in the model. A significance level of α = 0.05 was applied. This study has received a certificate of ethical clearance from the health research ethics committee of STIKes Patria Husada Blitar number 06/PHB/KEPK/231/04.24 date April 23, 2024.

RESULTS

Respondent characteristics, including age, sex, and education, were cross-tabulated with drinking water habits, high-purine dietary habits, and uric acid levels. The results are presented in the following table.

Table 1. Cross tabulation of respondent characteristics, drinking water habits, high-purine dietary habits, and uric acid levels

Characteristics		Drinking Water						High-purine dietary						Uric acid level			
		Adequate		Sufficient		Inadequate		Low		Moderate		High		Normal		High	
		∑	%	∑	%	∑	%	∑	%	∑	%	∑	%	∑	%	∑	%
Age (years)	Adult (40-59)	23	62.2	9	24.3	5	13.5	12	32.4	17	45.9	8	21.6	31	83.8	6	16.2
	Elderly (≥60)	15	30.0	20	40.0	15	30.0	8	16.0	20	40.0	22	44.0	30	60.0	20	40.0
Gender	Male	25	58.1	12	27.9.	6	14.0	13	30.2	19	44.2	11	25.6	33	76.7	10	23.3
	Female	13	29.5	17	38.6	14	31.8	7	15.9	18	40.9	19	43.2	28	63.6	16	36.4

Education	Primary	9	32.1	9	32.1	10	35.7	4	14.3	9	32.1	15	53.6	17	60.7	11	39.3
	Junior	14	46.7	9	30.0	7	23.3	7	23.3	13	43.3	10	33.3	21	70.0	9	30.0
	Senior	19	65.5	7	24.1	3	10.3	9	31.0	15	51.7	5	17.2	23	79.3	6	20.7

Table 1 presents the distribution of serum uric acid levels according to age, gender, and educational level. The prevalence of elevated serum uric acid was higher among elderly participants (40.0%) and females (36.4%). Participants with primary education exhibited a greater tendency toward hyperuricemia (39.3%) and higher consumption of purine-rich foods (53.6%) compared with those possessing higher educational attainment. Older respondents (≥60 years) and females were more likely to report inadequate water intake than younger and male participants (30% and 31.8%, respectively). In contrast, individuals with higher education levels were more likely to have adequate water consumption (65.5%) and lower intake of purine-rich foods (31.0%). Moreover, the prevalence of high-purine food consumption was greater among females (43.2%) and elderly respondents (44.0%).

Table 2. Cross tabulation of drinking water habits and high-purine dietary habits with uric acid level

Habits		**Uric acid level**				**Total**
Drinking water	**High-purine dietary**	**Normal**		**High**		
		∑	%	∑	%	∑
Adequate	Low	8	100	0	0	8
	Moderate	15	83.3	3	16.7	18
	High	8	80.0	2	20.0	10
	Subtotal Adequate	31	81.6	7	18.4	38
Sufficient	Low	6	85.7	1	14.3	7
	Moderate	9	69.2	4	30.8	13
	High	5	55.6	4	44.4	9
	Subtotal Sufficient	20	69.0	9	31.0	29
Inadequate	Low	4	80.0	1	20.0	5
	Moderate	3	42.9	4	57.1	7
	High	3	28.6	10	71.4	13
	Subtotal Inadequate	10	50.0	10	50.0	20
Total	-	61	70.1	26	29.9	87

Table 2 illustrates the cross-tabulation between drinking water habits, high-purine dietary patterns, and serum uric acid levels among 87 respondents. A clear interaction was observed between drinking water habits and purine intake in relation to serum uric acid levels. The majority of participants (70.1%) exhibited normal uric acid levels, while 29.9% were classified as hyperuricemic. The prevalence of hyperuricemia was notably higher among individuals with inadequate water intake (50.0%). Participants who reported high-purine dietary habits along with insufficient water consumption demonstrated the highest prevalence of hyperuricemia (71.4%), whereas those with similar dietary patterns but adequate hydration showed a substantially lower prevalence (20.0%). Among respondents with adequate water intake, the prevalence of hyperuricemia remained low (18.4%) even among those consuming purine-rich foods. Collectively, these findings suggest that adequate hydration mitigates the effect of a high-purine diet on serum uric acid levels, supporting a significant moderating role of drinking water habits in the relationship between purine-rich food intake and the risk of hyperuricemia.

Table 3. Multiple Logistic Regression Analysis of the Moderating Effect of Drinking Water habits on the Association Between High-Purin Water Habits on the Association Between High-Purine Dietary Habits and Hyperuricemia

Variable	B	SE	Wald	Exp (B) (OR)	OR (95% CI)	p-value
High-purine dietary habits (high vs low/moderat)	1.214	0.531	5.228	3.37	1.19-9.58	0.022
Drinking water habits (Inadequat vs adequate)	1.067	0.502	4.514	2.91	1.09-7.75	0.034
High-purine x Drinking water habits	-0.918	0.448	4.206	0.40	0.16-0.96	0.040
Age (≥ 60 years)	0.783	0.395	3.927	2.19	1.01-4.73	0.048
Sex (female)	0.692	0.338	4.185	1.99	1.03-3.87	0.041
Education level (primary vs senior)	0.514	0.376	1.871	1.67	0.80-3.46	0.171
Constant	-2.241	0.894	6.286	-	-	0.012

Model Fit Summary:

- -2 log Likelihood = 88.37
- Nagelkerke $R^2 = 0.44$
- Hosmer–Lemeshow test = $\chi^2 = 6.29$, $p = 0.511$
- Classification accuracy = 81.6%

Table 2 summarizes the results of the multiple logistic regression analysis examining the moderating role of drinking water habits on the association between high-purine dietary intake and serum uric acid levels, while adjusting for age, gender, and education. Both high-purine dietary intake (OR = 3.37, 95% CI = 1.19–9.58, p = 0.022) and inadequate water intake (OR = 2.91, 95% CI = 1.09–7.75, p = 0.034) emerged as significant predictors of hyperuricemia. A significant interaction effect between purine-rich dietary intake and water-drinking habits (p = 0.040) suggests a moderating role of adequate hydration, indicating that sufficient water intake mitigates the impact of a high-purine diet on elevated serum uric acid levels. Among the covariates, older age (≥60 years) and male gender were associated with an increased risk of hyperuricemia, whereas educational level was not significantly related. The final model demonstrated a satisfactory fit and strong predictive accuracy (Nagelkerke $R^2 = 0.44$; overall classification = 81.6%).

DISCUSSION

The study findings revealed that the prevalence of elevated serum uric acid levels was higher among older adults (aged ≥ 60 years). This increase is largely attributed to age-related physiological change in renal function, particularly the decline in glomerular filtration rate (GFR) that occurs with advancing age. Uric acid, a metabolic byproduct of purine catabolism, is primarily excreted through the kidneys-approximately 70% via the proximal tubules. As renal function deteriorates, the efficiency of uric acid excretion diminishes, resulting in its accumulation in the bloodstream. Consequently, hyperuricemia in older individuals is frequently a consequence of impaired renal urate clearance (García-Nieto et al., 2022; Winder et al., 2021). Another factor that may alter purine metabolism in the elderly is changes in body composition and metabolic function. A decrease in muscle mass and an increase in fat mass commonly occur with aging, leading to reduced or imbalanced activity of enzymes responsible for purine synthesis and degradation. Moreover, oxidative stress tends to increase in older adults, further enhancing endogenous uric acid production (Gherghina et al., 2022). In addition, the use of certain medications is common among the elderly, such as thiazide or loop diuretics, low-dose aspirin, and beta-blockers, which can reduce uric acid excretion and thereby contribute to the development of hyperuricemia (Du et al., 2024).

Among elderly individuals, women-especially those who are postmenopausal, tend to show a more pronounced elevation in serum uric acid levels compared to men. This difference is largely attributed to the physiological role of estrogen in regulating uric acid metabolism. Estrogen promotes renal uric acid excretion by inhibiting urate reabsorption within the renal tubules, thereby maintaining lower uric acid concentrations during the premenopausal period. However, after menopause, the sharp decline in estrogen levels leads to reduced uric acid clearance and consequently higher serum levels (S. Kang et al., 2021). Moreover, postmenopausal metabolic alterations-including increased insulin resistance, hypertension, and weight gain-further exacerbate uric acid accumulation by enhancing production and reducing excretion. These metabolic disturbances are often linked to metabolic syndrome, which has been identified as a key contributing factor in the development of hyperuricemia (Copur et al., 2022; Jeong & Park, 2022).

Conceptually, educational level is associated with serum uric acid levels, as education can influence an individual's health knowledge and behaviors, particularly in terms of dietary quality and health maintenance (Xiang et al., 2025). Individuals with lower educational attainment tend to have limited knowledge of healthy eating patterns and the importance of adequate hydration, making them more likely to consume purine-rich foods such as organ meats, salted fish, and processed meats, while having lower intake of fruits, vegetables, and daily fluids. Routine health control behaviors-such as regular uric acid monitoring, maintaining a balanced diet, engaging in physical activity, and ensuring adequate hydration-are also less common among individuals with lower education levels, often due to limited knowledge and self-management skills (Zhao et al., 2024). Furthermore, education level is frequently linked to income, meaning that people with lower education may have restricted access to nutritious foods, healthcare services, and physical activity opportunities, all of which contribute to a higher risk of hyperuricemia. (M. Kang et al., 2024). However, in this study, educational level did not show a significant association with serum uric acid levels. This could be explained by the fact that the education categories assessed were formal levels (secondary, junior high, and senior high school), which may not fully reflect differences in health literacy (Jing et al., 2024). In the digital era, health information has become easily accessible to individuals regardless of educational backgrounds. furthermore, community-based health initiatives particularly those implemented by primary healthcare centers such as routine health education sessions for the elderly through "Posyandu Lansia" have enhanced public awareness of conditions like hyperuricemia, thereby reducing disparities in health knowledge across different education levels.

In this study, drinking water habits were evaluated based on the participants' average daily fluid intake over a one-week period. Water intake was classified as adequate when the daily average exceeded 8 glasses (≥2 litres), sufficient for 5–7 glasses (approximately 1–1.75 litres), and inadequate for less than 5 glasses (<1 liter) per day. According to geriatric hydration recommendations, older women should consume a minimum of 1.6 litres of fluids per day, while older men should aim for at least 2.0 litres, except in clinical circumstances requiring individualized adjustments (e.g., larger body size or specific health conditions). Furthermore, fluid losses due to heat exposure, physical exertion, fever, diarrhea, vomiting, or severe bleeding should be adequately compensated by increasing fluid intake to ensure optimal hydration status (Beck et al., 2021; Pence et al., 2025). The kidneys play a crucial role in maintaining the body's fluid balance.

Water deficit causes cellular shrinkage, which activates brain sensors that regulate urinary excretion by signaling the kidneys-primarily through the antidiuretic hormone (vasopressin)to produce a smaller volume of more concentrated urine. Renal excretion is essential for eliminating metabolic waste products from the body, including uric acid (Bruno et al., 2021). A higher proportion of respondents with hyperuricemia or elevated serum uric acid levels was observed among those with inadequate water intake. This association is biologically plausible, as uric acid, a metabolic end product of purine degradation, is primarily eliminated through renal excretion in urine. Insufficient hydration reduces urinary output and impairs the kidneys' ability to excrete uric acid effectively, resulting in its accumulation within the bloodstream (Courbebaisse et al., 2023).

This study found that a high-purine dietary habit was significantly associated with serum uric acid levels (p-value = 0.022). Common high-purine foods consumed by respondents included organ meats, red meat, salted fish, and legumes. Respondents were categorized as having a high-purine dietary habit if they consumed these foods five times or more per week. Purines are nucleotide components (such as adenine and guanine) that, once ingested or produced endogenously, are metabolized into xanthine and subsequently converted into uric acid by the enzyme xanthine oxidase. Therefore, when purine intake is excessive, the amount of substrate available for uric acid synthesis increases, leading to elevated uric acid production (Zhang et al., 2022). In addition to purine-rich foods, this study also categorized sweet or sugar-rich foods as part of high-purine dietary habits. Fructose has been shown to enhance uric acid synthesis while simultaneously reducing its excretion (Aihemaitijiang et al., 2020; Wen et al., 2024). An excessive intake of high-purine foods can disrupt the balance between uric acid production and elimination, as the elevated synthesis of uric acid may exceed the excretory capacity of the kidneys and intestines, resulting in uric acid accumulation in the body (Danve et al., 2021).

Respondents with elevated uric acid levels were found to have inadequate water-drinking habits, whereas those with similar dietary patterns but adequate water intake showed a lower prevalence of hyperuricemia. This finding indicates that sufficient water consumption plays a crucial role in mitigating the effect of a high-purine diet on increased uric acid levels. The beneficial role of adequate hydration operates through several mechanisms, including increasing urine volume, diluting urate concentration, enhancing renal excretion, and maintaining a more alkaline urinary pH (Chung & Kim, 2021; Otani et al., 2022). Conversely, Dehydration or inadequate fluid intake can elevate serum uric acid levels by reducing urine volume and limiting renal excretion. This leads to urate accumulation and increased risk of hyperuricemia. Maintaining adequate hydration is therefore essential for uric acid homeostasis (Kakutani-Hatayama et al., 2017). These results support the presence of a significant interaction effect between water-drinking habits and high-purine intake on the risk of hyperuricemia (p-value = 0.040).

CONCLUSION

This study revealed that drinking water habits play a significant moderating role in the relationship between high-purine dietary intake and serum uric acid levels among adults and the elderly. Individuals with inadequate water consumption exhibited higher uric acid levels despite having similar purine intake compared to those with sufficient hydration. Adequate hydration mitigates the adverse effects of a high-purine diet by promoting renal uric acid excretion, increasing urine volume, diluting urate concentration, and maintaining a more alkaline urinary pH.

SUGGESTION

These findings highlight the importance of sufficient water intake as a simple yet effective behavioral strategy to prevent hyperuricemia and related metabolic disorders, particularly among populations with high purine consumption. Hydration education offers a straightforward intervention for individuals at elevated risk; thus, community health centers should evaluate drinking patterns, deliver hydration guidance, and encourage adequate water intake. This study is limited by self-reported measures, its cross-sectional nature, and the lack of objective hydration biomarkers, underscoring the need for more robust future research.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest related to the publication of this article.

AUTHOR CONTRIBUTIONS

The main author contributed to developing the research idea, designing the study and methodology, performing data analysis, and preparing the manuscript. The co-author contributed by conducting the research activities, managing administrative and ethical approvals, and collecting the research data.

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