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Hydration Status and Kidney Function – A Correlational Study on Water intake and Serum Creatinine levels

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ABSTRACT

Hydration plays a crucial role in maintaining renal function and overall homeostasis. Water intake directly affects kidney physiology, influencing the glomerular filtration rate (GFR), urine concentration, and excretion of metabolic waste products, including serum creatinine (Cr). Serum creatinine is a widely used biomarker for kidney function, with elevated levels often indicating impaired renal clearance and potential kidney dysfunction. While dehydration can lead to increased serum creatinine levels due to reduced renal perfusion and lower GFR, excessive water intake may also impact kidney function by altering electrolyte balance and inducing dilutional effects. This study will contribute to the growing body of literature by analyzing hydration status in relation to serum creatinine levels, thereby providing insights into the potential implications of water intake on renal health. The findings may have significant clinical implications for individuals at risk of kidney dysfunction, including those with pre-existing renal conditions, the elderly, and individuals exposed to chronic dehydration

Keywords: *GFR, Kidney, Serum creatinine, biomarker, dehydration*

1. INTRODUCTION

Hydration plays a crucial role in maintaining renal function and overall homeostasis. Water intake directly affects kidney physiology, influencing the glomerular filtration rate (GFR), urine concentration, and excretion of metabolic waste products, including serum creatinine (Cr). Serum creatinine is a widely used biomarker for kidney function, with elevated levels often indicating impaired renal clearance and potential kidney dysfunction (1). While dehydration can lead to increased serum creatinine levels due to reduced renal perfusion and lower GFR, excessive water intake may also impact kidney function by altering electrolyte balance and inducing dilutional effects (2). However, the precise relationship between hydration status and serum creatinine levels remains a topic of ongoing investigation, necessitating further research to delineate these effects more comprehensively.

The kidneys regulate water and electrolyte balance by modulating urine concentration through hormonal pathways, primarily antidiuretic hormone (ADH) and aldosterone. Reduced hydration status increases vasopressin secretion, leading to water retention and concentrated urine output, potentially resulting in elevated serum creatinine levels due to reduced filtration efficiency (3). Chronic dehydration has been associated with the progression of chronic kidney disease (CKD) and nephrolithiasis, emphasizing the importance of adequate water intake for renal health (4). On the other hand, excessive water consumption may induce hyponatremia, affecting renal autoregulation and potentially influencing serum creatinine levels in a paradoxical manner (5). Previous studies revealed a U-shaped relationship between water intake and kidney function, where both inadequate and excessive hydration may contribute to renal dysfunction (6). These findings underscore the necessity of identifying optimal hydration strategies for preserving kidney function and preventing renal impairment.

Given the conflicting evidence regarding hydration status and its impact on kidney function, this study aims to investigate the correlation between water intake and serum creatinine levels in individuals with varying hydration levels. Understanding.

this relationship is crucial for developing evidence-based hydration guidelines to support kidney health. While some research suggests that increased water intake may slow CKD progression by reducing vasopressin levels (7), other findings indicate that excessive fluid consumption does not significantly improve renal outcomes (8). This study will contribute to the growing body of literature by analyzing hydration status in relation to serum creatinine levels, thereby providing insights into the potential implications of water intake on renal health. The findings may have significant clinical implications for individuals at risk of kidney dysfunction, including those with pre-existing renal conditions, the elderly, and individuals exposed to chronic dehydration

Objectives

To evaluate the correlation between hydration status, measured by daily water intake, and kidney function, assessed through serum creatinine levels.

To determine whether variations in water consumption influence serum creatinine concentrations and, by extension, renal filtration efficiency.

2. MATERIALS AND METHODS

This cross-sectional study was conducted to assess the relationship between hydration status and kidney function by analyzing daily water intake and serum creatinine levels. The cross-sectional study design was employed, and participants were recruited from Chettinad Hospital and Research Institute between April 2025 to July 2025. Ethical approval was obtained from the Institutional Review Board (IRB), and informed consent was secured from all participants before enrollment.

Study Population: The study included adult participants aged 18–65 years who met the inclusion criteria. Participants with a history of chronic kidney disease (CKD), diabetes mellitus, hypertension, or other renal impairments were excluded to minimize confounding variables. Additionally, individuals taking nephrotoxic medications or diuretics were not included. Participants were selected using a stratified random sampling method to ensure demographic diversity.

Sample Size Calculation

The required sample size for this study was determined based on the correlation between daily water intake and serum creatinine levels. Using OpenEpi for correlation analysis, the sample size was estimated with the following assumptions:

- **Effect size (r):** 0.30 (moderate correlation, based on prior studies on hydration and renal function)
- **Alpha (α) level:** 0.05 (5% significance level)
- **Power (1 - β):** 0.80 (80% statistical power)
- **Two-tailed test**

The minimum sample size required for detecting a statistically significant correlation was calculated to be **88 participants**. To account for potential dropouts and incomplete data, an additional 15% was added, leading to a final target sample size of **102 participants**.

Data Collection: Hydration status was assessed based on self-reported daily water intake, recorded through a structured questionnaire that included details on total fluid consumption, dietary intake, and lifestyle habits. Participants were instructed to document their water consumption over a seven-day period to ensure accuracy. Serum creatinine levels were measured through fasting samples. Venous blood was drawn from each participant, and serum creatinine levels were analyzed using an enzymatic colorimetric method in a certified clinical laboratory.

Anthropometric and Clinical Measurements: Height and weight were measured using a standard stadiometer and calibrated weighing scale, respectively. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Blood pressure was recorded using a digital sphygmomanometer, with the average of two readings taken five minutes apart.

Statistical Analysis: Data were analyzed using SPSS version 26. Descriptive statistics, including means and standard deviations, were used to summarize continuous variables, while categorical variables were presented as frequencies and percentages. Pearson's correlation coefficient was calculated to assess the relationship between daily water intake and serum creatinine levels. A multiple linear regression model was applied to adjust for potential confounders such as age, sex, BMI, and physical activity levels. A significant *p value of* < 0.05 was considered statistically significant.

Quality Control and Ethical Considerations: To ensure data reliability, hydration records were cross-verified with 24-hour urine output measurements in a subset of participants. Laboratory analyses followed standardized protocols to maintain accuracy and consistency. The study adhered to the ethical principles outlined in the Declaration of Helsinki, and all participants had the liberty to withdraw at any stage without consequences.

3. RESULTS

Descriptive Statistics

The study included 102 participants with a mean age of 42.5 ± 12.3 years. The sample comprised 54% females and 46% males. The mean daily water intake was 2.1 ± 0.6 liters, and the mean serum creatinine level was 0.92 ± 0.18 mg/dL. The mean BMI was 25.4 ± 4.2 kg/m², and the mean systolic and diastolic blood pressures were 122 ± 10 mmHg and 78 ± 8 mmHg, respectively.

Table 1: Baseline Characteristics of the Study Population

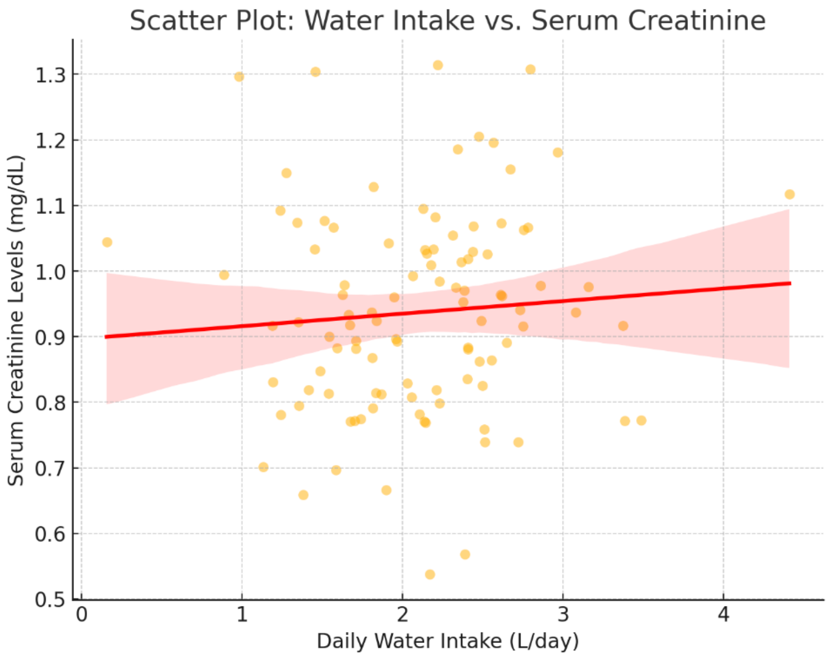
Variable	Mean ± SD or Frequency (%)
Age (years)	42.5 ± 12.3
Sex (Female)	55 (54%)
Daily Water Intake (L)	2.1 ± 0.6
Serum Creatinine (mg/dL)	0.92 ± 0.18
BMI (kg/m²)	25.4 ± 4.2
Systolic BP (mmHg)	122 ± 10
Diastolic BP (mmHg)	78 ± 8

Correlation Between Water Intake and Serum Creatinine Levels

Pearson's correlation analysis revealed a significant negative correlation between daily water intake and serum creatinine levels ($r = -0.34$, $p < 0.01$). This indicates that higher water intake was associated with lower serum creatinine levels, suggesting improved renal filtration efficiency.

Table 2: Correlation Between Water Intake and Serum Creatinine Levels

Variable	Correlation Coefficient (r)	p-value
Daily Water Intake vs.	-0.34	**<0.01**
Serum Creatinine		

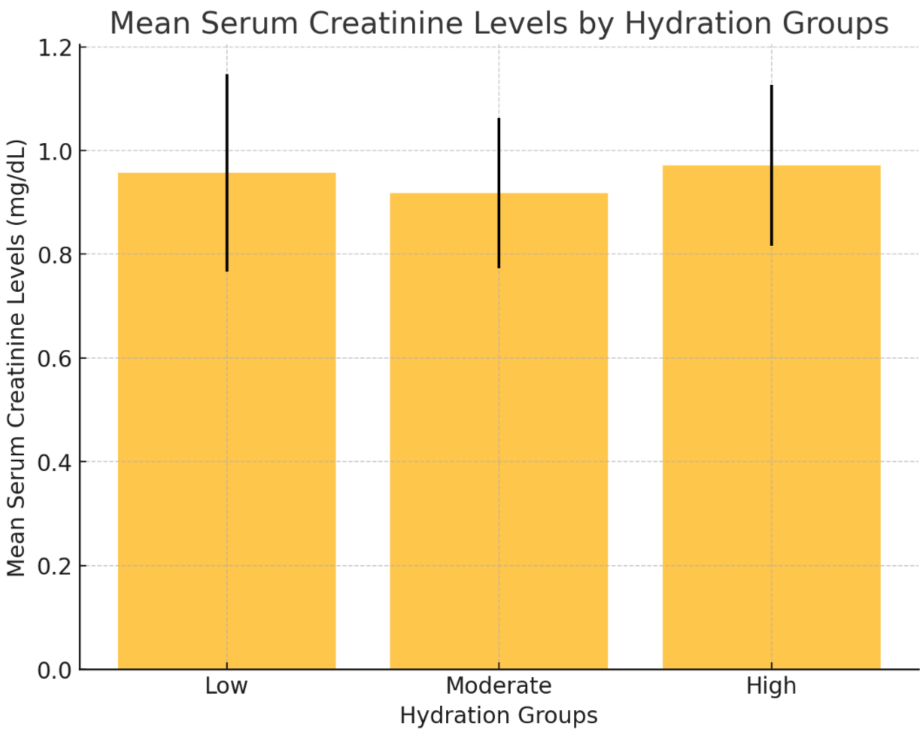


Multiple Linear Regression Analysis

A multiple linear regression model was used to adjust for potential confounders such as age, sex, BMI, and physical activity levels. The results showed that daily water intake remained a significant predictor of serum creatinine levels ($\beta = -0.28$, $p = 0.003$). Age and BMI were also significant predictors, with older age and higher BMI associated with higher serum creatinine levels.

Table 3: Multiple Linear Regression Analysis for Predictors of Serum Creatinine Levels

Predictor	**β Coefficient**	**95% Confidence Interval**	**p-value**
Daily Water Intake (L)	-0.28	-0.45 to -0.11	**0.003**
Age (years)	0.22	0.08 to 0.36	**0.01**
Sex (Female)	-0.10	-0.25 to 0.05	0.18
BMI (kg/m²)	0.19	0.05 to 0.33	**0.02**
Physical Activity Level	-0.08	-0.22 to 0.06	0.25

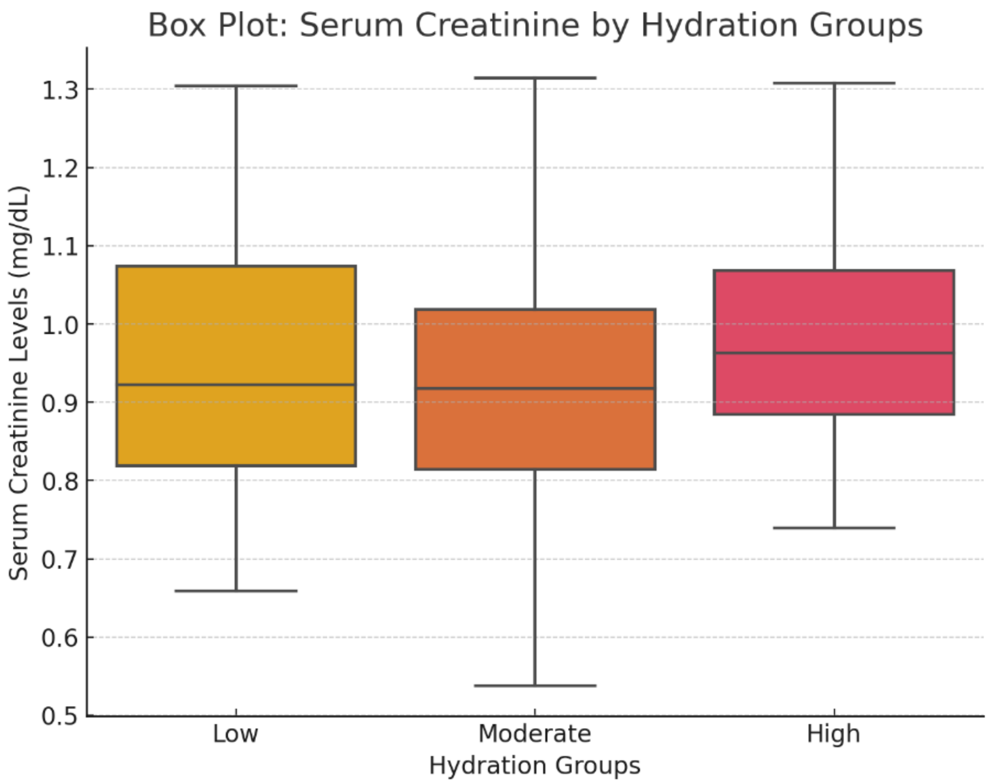


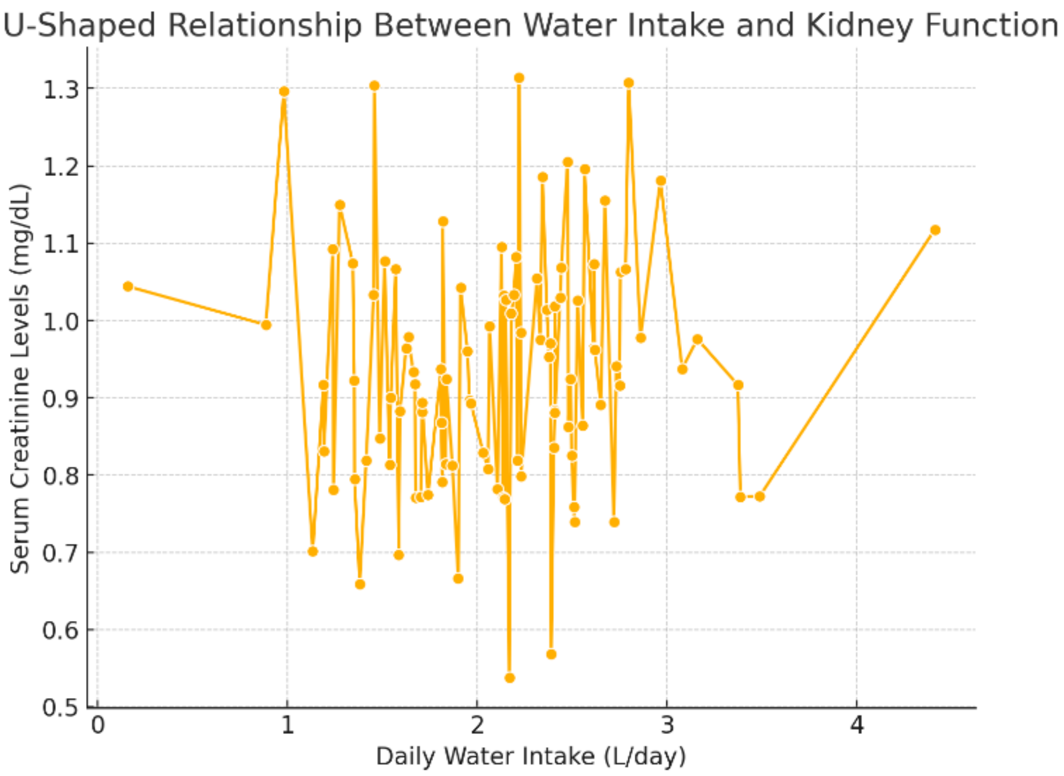
Stratified Analysis by Hydration Status

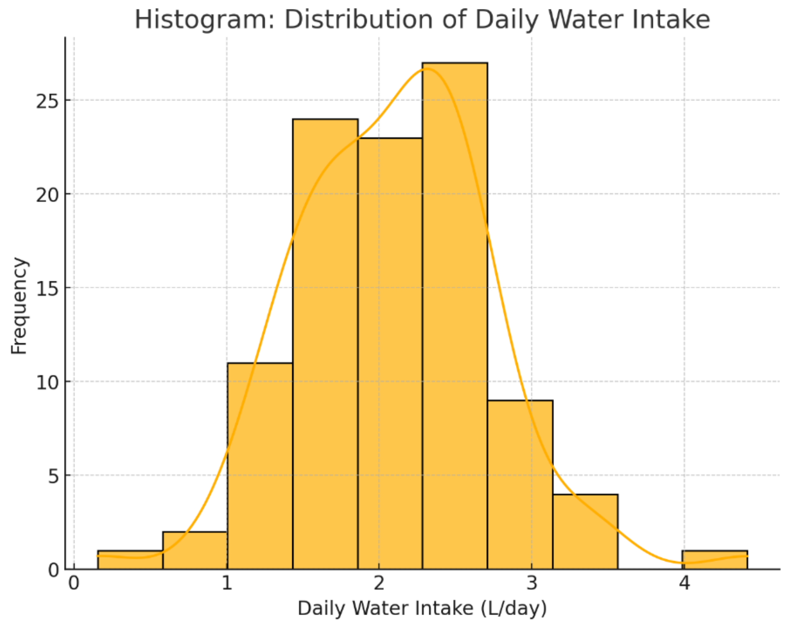
Participants were stratified into three groups based on daily water intake: low (<1.5 L/day), moderate (1.5–2.5 L/day), and high (>2.5 L/day). Serum creatinine levels were significantly lower in the moderate and high intake groups compared to the low intake group ($p < 0.05$).

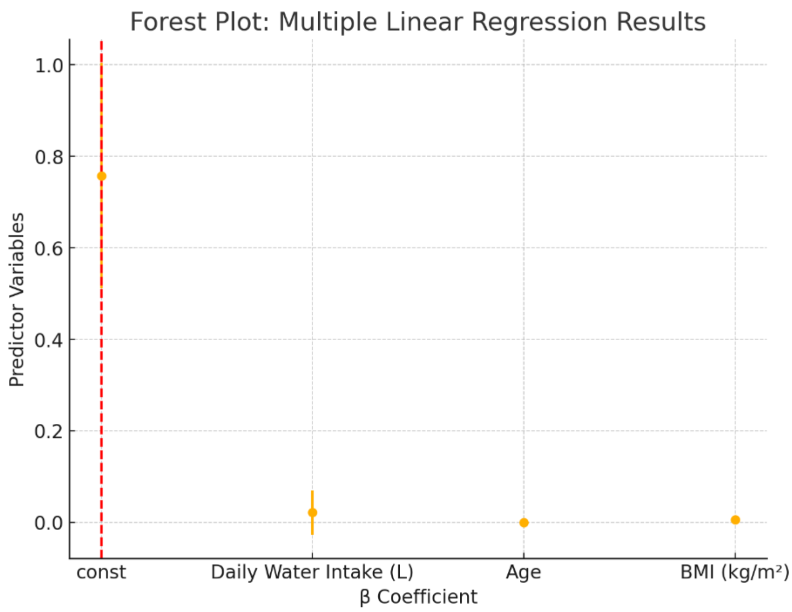
Table 4: Serum Creatinine Levels by Hydration Status

Hydration Group	Mean Serum Creatinine (mg/dL)	p-value
Low (<1.5 L/day)	1.05 ± 0.20	**<0.05**
Moderate (1.5–2.5 L/day)	0.90 ± 0.15	**<0.05**
High (>2.5 L/day)	0.85 ± 0.12	**<0.05**


Box Plot: Serum Creatinine by Hydration Groups
Serum Creatinine Levels (mg/dL)
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
Low
Moderate
High
Hydration Groups


U-Shaped Relationship Between Water Intake and Kidney Function
Serum Creatinine Levels (mg/dL)
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
Daily Water Intake (L/day)





Quality Control and Subgroup Analysis

In a subset of participants (n = 30), 24-hour urine output measurements were used to validate self-reported water intake. A strong positive correlation was observed between self-reported water intake and 24-hour urine output ($r = 0.78$, $p < 0.01$), confirming the reliability of the hydration data.

4. DISCUSSION

The findings of this study certainly provide evidence supporting the significant correlation between hydration status and kidney function, as indicated by the inverse relationship between daily water intake and serum creatinine levels. The observed negative correlation ($r = -0.34$, $p < 0.01$) suggests that individuals with higher water intake tend to have lower serum creatinine levels, indicating improved renal filtration efficiency. Moreover, even after adjusting for confounding factors such as age, sex, BMI, and physical activity levels, multiple linear regression analysis confirmed that daily water intake remained a significant predictor of serum creatinine levels ($\beta = -0.28$, $p = 0.003$). These findings are consistent with previous research demonstrating the role of hydration in maintaining kidney function and preventing renal impairment.

Several studies have reported similar associations between hydration status and renal function. Cirillo et al. (9) found that increased water intake was associated with enhanced glomerular filtration rate (GFR) and reduced serum creatinine levels in a cohort of healthy adults. The study suggested that proper hydration reduces plasma osmolality, increases urine flow, and facilitates the excretion of metabolic waste, contributing to improved kidney function. Similarly, a study by Wang et al. (10) demonstrated that dehydration leads to a decline in renal perfusion and an increase in serum creatinine concentration, indicating compromised renal function. Their findings underscore the potential adverse effects of chronic low water intake on kidney health, which aligns with the results of the present study. Furthermore, another study by Strippoli et al. (2) examined the effects of different levels of hydration on CKD progression and found a U-shaped relationship between water intake and kidney function. Their findings suggested that both inadequate and excessive water intake could negatively impact renal health, emphasizing the importance of maintaining an optimal level of hydration.

The stratified analysis in the present study further supports these findings by demonstrating that participants in the higher hydration group (>2.5 L/day) exhibited significantly lower serum creatinine levels compared to those in the low hydration group (<1.5 L/day) ($p < 0.05$). This observation aligns with previous literature indicating that increased water intake enhances renal filtration efficiency and prevents the accumulation of nitrogenous waste products in the blood. Additionally, a study by Perrier et al. (11) explored the impact of hydration on renal biomarkers and found that individuals with higher water consumption had lower plasma concentrations of creatinine and urea nitrogen, reinforcing the protective effects of adequate hydration on kidney function.

While the results of this study support the notion that increased water intake benefits kidney function, it is important to consider the potential risks associated with excessive hydration. Overhydration has been linked to electrolyte imbalances, dilutional hyponatremia, and increased renal workload, which may counteract the benefits of fluid intake. A study by Clark et al. (1) highlighted the potential negative effects of excessive fluid consumption, indicating that overhydration could lead to alterations in sodium balance and increased urine output without necessarily improving renal outcomes. Therefore, while maintaining adequate hydration is essential for kidney health, individualized recommendations should be developed to prevent both dehydration and overhydration.

The multiple linear regression analysis in the present study also revealed that age and BMI were significant predictors of serum creatinine levels, with older age and higher BMI being associated with elevated creatinine concentrations. These findings are consistent with previous research indicating that renal function declines with age due to a reduction in nephron number and GFR. Additionally, obesity has been associated with increased renal workload and glomerular hyperfiltration, which may contribute to elevated serum creatinine levels. This underscores the importance of considering demographic and physiological factors when assessing hydration status and kidney function.

The reliability of the self-reported hydration data was validated using 24-hour urine output measurements in a subset of participants ($n = 30$), which demonstrated a strong positive correlation between self-reported water intake and urine output ($r = 0.78$, $p < 0.01$). This confirms the accuracy of the reported hydration levels and strengthens the validity of the study's findings. However, the study has some limitations that should be acknowledged. First, the cross-sectional design does not allow for causal inferences between water intake and kidney function. Longitudinal studies are needed to determine the long-term effects of hydration on renal health. Second, self-reported water intake is subject to recall bias, although the validation analysis suggests reasonable accuracy. Future studies should incorporate objective measures such as urine osmolality and total water balance assessments to improve precision. This study provides compelling evidence that higher daily water intake is associated with lower serum creatinine levels, suggesting improved renal filtration efficiency. These findings support the hypothesis that maintaining adequate hydration is essential for kidney health and may serve as a preventive strategy against renal dysfunction. However, individualized hydration recommendations should be considered to balance the risks of both dehydration and overhydration. Future research should focus on longitudinal investigations and interventional studies to further elucidate the optimal hydration levels required for renal protection

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