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The Impact of Lifestyle Factors on the Development of Kidney Stones

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ABSTRACT

Kidney stones are a common urological condition affecting millions worldwide, and lifestyle factors significantly influence their risk. **Objectives:** To assess the correlation between the risk of kidney stones and dietary habits, physical activity levels, hydration status, and body mass index in a cohort of 220 participants at Gomal Medical College, Dera Ismail Khan. **Methods:** A cross-sectional study was executed, with 220 adults stratified into two groups based on presence (n=111) or absence (n=109) of kidney stones. Validated structured questionnaires assessing hydration level, physical activity, body mass index, socioeconomic level, and dietary intake; animal protein, oxalates, and sodium were used to compile data. Chi-square testing and logistic regression allowed one to compute the odds ratios for kidney stone risk. **Results:** Significant risk factors for kidney stones were shown by high intake of animal protein (OR=3.88, $p<0.001$), high sodium intake (OR=1.98, $p<0.05$), and high oxalate intake (OR=1.65, $p<0.05$). High physical activity and adequate hydration were protective against kidney stones. A greater body mass index (OR=2.33, $p<0.01$) was linked to a higher risk. Socioeconomic level and stone frequency showed an association; the lower status was linked to a higher prevalence of stones (OR=1.75, $p<0.05$). **Conclusions:** It was concluded that the study underlined the strong relationships between particular lifestyle choices and kidney stone development probability. Good preventive measures are keeping an active lifestyle, making sure one is hydrated enough, and controlling their food. These findings highlight the importance of including lifestyle modifications in the clinical management of kidney stones.

INTRODUCTION

Kidney stones affect millions of people globally [1], and lifestyle choices, which follow complex pathways, greatly affect the recurrence and production of kidney stones. Diet affects the production of kidney stones [2, 3]. Animal protein consumption increases uric acid and calcium levels in urine while reducing citrate, a molecule that inhibits stone formation. Low urine volume due to inadequate hydration concentrates calcium, oxalate, and uric acid in the urine, leading to stone formation [4, 5]. One's degree of hydration mostly determines the development of kidney stones. Inappropriate fluid consumption causes low urine volume, which concentrates compounds such as calcium, oxalate, and uric acid, which can precipitate and form stones [6, 7]. Studies repeatedly show that increasing fluid intake dilutes urine and lowers the risk of stone development, thereby stressing the need for constant and enough water intake as a preventative action against kidney stones [8-10]. Furthermore, the likelihood of kidney stones includes physical inactivity and obesity. Excess body weight is associated with metabolic alterations that help kidney stones to develop, including insulin resistance and raised urine excretion of calcium and oxalate [11, 12]. Regular physical activity helps to maintain a good weight; it also improves metabolism and lowers the risk of stone development [13].Preventing kidney stones depends on lifestyle changes including maintaining a healthy weight through consistent exercise, enough hydration, and dietary adjustments [14]. Healthcare providers must understand the implications of these elements for persons at risk of kidney stones as well as for those implementing preventative policies. As research clarifies kidney stone development, the major preventive strategy of lifestyle

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modification remains a pillar of management. This non-invasive approach works well in treating this painful disorder.

This study aimed to assess the correlation between the risk of kidney stones and dietary habits, physical activity levels, hydration status, and body mass index in a cohort of 220 participants at Gomal Medical College, Dera Ismail Khan.

METHODS

Gomal Medical College in Dera Ismail Khan, Pakistan was the site of this observational study spanning June 2023 to September 2024. The study recruited 220 total participants, and the sample size was determined using G*Power software, based on the expected prevalence of kidney stones in the target population and the hypothesized odds ratios for key risk factors such as dietary habits and physical activity levels. The calculation aimed to achieve a power of 80% and a significance level of 5%. The expected prevalence was 10%, as mentioned by the National Kidney Foundation and USA. The primary outcome variable was the presence or absence of kidney stones, with key predictors being dietary intake (animal protein, oxalates, and sodium), physical activity levels, and body mass index (BMI). This study used a non-probability consecutive sampling technique to recruit participants from the Urology outpatient department of Gomal Medical College. The criteria were adults between the ages of eighteen and sixty-five who offered informed consent. Those receiving dialysis, those with metabolic problems impacting the kidney, such as hyperparathyroidism, or those with chronic renal illnesses were eliminated. Participants were asked to complete the validated structured questionnaire to provide thorough information on their dietary patterns (including their consumption of animal protein, oxalate-rich foods, and salt), fluid intake, physical activity levels, BMI, and medical history about kidney stone formation. The questionnaire also includes demographic data on age, gender, socioeconomic level, and socioeconomic background. To assess hydration status, both urine output and urine specific gravity were measured. Urine output, recorded in milliliters per day, helps indicate hydration levels, with outputs below 1.5 liters per day classified as inadequate, suggesting a higher risk for stone formation due to concentrated solutes. Urine-specific gravity, measured using a refractometer or dipstick (normal range: 1.000–1.030), provides further insight, with values above 1.020 indicating concentrated urine and potential dehydration, while values below 1.010 suggest adequate hydration. These parameters, collected during routine visit, were cross-referenced with participants' reported fluid intake to ensure accurate classification of hydration status. Dietary intake of sodium and oxalates was quantified using a validated food frequency questionnaire (FFQ). Sodium intake was determined based on participants' reported frequency and portion sizes of high-sodium foods, converted into daily intake values using standardized nutrient content databases. Daily intakes exceeding 2,300 mg were classified as high, as this threshold is linked to increased kidney stone risk. Oxalate intake was assessed through reported intake of oxalate-rich foods like spinach, nuts, and beans. Estimated daily intakes over 100 mg were classified as high, correlating with increased risk for oxalate-type kidney stones. Dietary assessments using a validated meal frequency questionnaire included items raising kidney stone risk. Participants' daily fluid intake was matched with urine output and specific gravity readings acquired during regular visits to evaluate hydration levels. The International Physical Activity Questionnaire (IPAQ) assessed participants' weekly physical activity using METs based on self-reported activities. Physical activity was categorized into high (≥3,000 MET-minutes/week), moderate (600–3,000 MET-minutes/week), and low (<600 MET-minutes/week) levels. Participants reported the frequency, duration, and intensity of activities (e.g., walking, moderate and vigorous exercise), with MET values assigned per IPAQ standards. Weekly MET scores were then calculated to categorize activity levels and evaluate their association with kidney stone risk. Quantitative variables included age, BMI, daily fluid intake, urine output, MET scores, and dietary intake of animal protein, oxalates, and sodium. These variables were analyzed using descriptive statistics such as means and standard deviations. For comparative analysis, independent t-tests and chi-square tests were employed to assess differences between participants with and without kidney stones. Binary logistic regression analysis was employed to evaluate the associations between the presence of kidney stones (primary outcome) and key predictors, including dietary intake (animal protein, oxalates, and sodium), physical activity levels, hydration status, and BMI. The Gomal Medical College IRB's research proposal was approved vide letter No. 29/GIMS/JC and then the study was conducted from June 2023 to September 2024. Every participant completed a written informed permission form before the study began. Throughout the research, participants' privacy and confidentiality of their data were maintained.

RESULTS

This study found among the Gomal Medical College, Dera Ismail Khan participants the correlation between lifestyle choices and kidney stone development. Comprehensive statistical analyses including chi-square tests and regression models were done on a sample of 220 people almost equally split between those with and without kidney stones. The results underlined the significant impact on kidney stones materialization of dietary patterns, hydration level, physical activity level, and body mass index. These results highlighted the possibility of lifestyle changes in the therapy and prevention of kidney stones, therefore guiding clinical practices and patient counseling with great relevance. Our demographic and lifestyle data

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clearly show the significant differences between people with kidney stones and those without. Participants with kidney stones were significantly older ($p<0.05$). Participants with kidney stones also had a much greater intake of animal protein, oxalate-rich foods, and salt ($p<0.05$), whereas BMI (29 kg/m^2) differed considerably from 27 kg/m2. Stone presence was also significantly correlated with hydration status and physical activity levels, with high physical activity levels and adequate hydration being protective against stone formation ($p<0.05$)(Table 1).

Table 1: Characteristics Features of Participants

Characteristic	Total (n=220)	No Kidney Stones (n=109)	With Kidney Stones (n=111)	χ^2	p-value
Age (Years)	45 ± 10	43 ± 11	43 ± 11	3.85	0.050*
Gender					
Male	119	59	60	1.22	0.271
Female	101	50	51		
BMI (kg/m^2)	28 ± 5	27 ± 4	29 ± 6	5.77	0.024*
Dietary Habits					
High Animal Protein	102	33	69	19.5	0.001*
High Oxalate Foods	92	39	53	6.5	0.019*
High Salt Intake	107	44	63	8.1	0.004*
Hydration Status					
Adequate	147	79	68	5.4	0.022*
Inadequate	73	30	43		
Physical Activity Levels					
High	58	37	21	9.8	0.002*
Moderate	82	44	38	5.1	0.025*
Low	80	28	52	16.2	0.001*
Socioeconomic Status					
High	68	38	30	5.6	0.018*
Moderate	101	52	49	1.0	0.320
Low	51	19	32	4.9	0.034*

This examination concentrated on particular dietary components and their association with the development of kidney stones. The odds ratios indicated that stone formation risks were nearly quadrupled by a large intake of animal protein (OR 3.88; $p<0.05$). A higher sodium intake was associated with a nearly two-fold increased risk of kidney stone formation (OR 1.98; $p<0.05$) when higher sodium consumption was present and risk was increased by 65% (OR 1.65; $p<0.05$) when higher oxalate consumption was present (Table 2).

Table 2: Dietary Habits and Risk of Kidney Stones

Dietary Factor	No Kidney Stones	With Kidney Stones	Odds Ratio (95% CI)	χ^2	p-value
High Animal Protein	33 (30.3)	69 (62.2)	3.88 (2.10-7.19)	19.5	0.001*
High Salt Intake	44 (40.4)	63 (56.8)	1.98 (1.12-3.51)	8.1	0.004*
High Oxalate Intake	39 (35.8)	53 (47.7)	1.65 (0.93-2.94)	6.5	0.019*

Kidney stone risk was significantly influenced by hydration. In comparison to those who were inadequately hydrated, participants who maintained adequate hydration demonstrated a 42% decrease in the likelihood of developing stones (OR 0.58; $p<0.05$). In contrast, the risk was increased by 67% (OR 1.67) when inadequate hydration was present (Table 3).

Table 3: Hydration Status and Kidney Stone Development

Status	No Kidney Stones	With Kidney Stones	Odds Ratio (95% CI)	χ^2	p-value
Adequate Hydration	79 (72.5)	68 (61.3)	0.58 (0.35-0.96)	5.4	0.02
Inadequate Hydration	30 (27.5)	43 (38.7)	1.67 (1.01-2.77)		

Kidney stone risk was inversely proportional to physical activity levels. The risk was significantly increased twofold by low physical activity (OR 2.47; $p<0.01$). Conversely, high physical activity reduced the risk by over half (OR 0.44; $p<0.05$), while low physical activity significantly increased the risk (OR 2.47; $p<0.01$). The risk was not substantially wedged by moderate activity (OR 0.75; $p<0.05$)(Table 4).

Table 4: Physical Activity Levels and Kidney Stone Risk

Activity Level	No Kidney Stones	With Kidney Stones	Odds Ratio (95% CI)	χ^2	p-value
High Physical Activity	37 (33.9)	21 (18.9)	0.44 (0.25-0.78)	9.8	0.002*
Moderate Physical Activity	44 (40.4)	38 (34.2)	0.75 (0.42-1.33)	5.1	0.026*
Low Physical Activity	28 (25.7)	52 (46.8)	2.47 (1.39-4.39)	16.2	0.001*

The odds ratios confirmed the protective effects of high physical activity and adequate hydration against kidney stone formation, as determined by a logistic regression analysis. The likelihood of stone formation was increased by twofold due to high BMI, which was a significant risk factor (OR 2.33; $p<0.01$). The risk was also markedly elevated by low socioeconomic status (OR 1.75; $p<0.05$) (Table 5).

Table 5: Logistic Regression Analysis for Predicting Kidney Stones Based on Lifestyle Factors

Variable	Odds Ratio	95% CI	p-value
Adequate Hydration	0.55	0.31 - 0.97	0.037*
High Physical Activity	0.42	0.24 - 0.73	0.002*
BMI > 30 kg/m^2	2.33	1.58 - 3.45	0.001*
Socioeconomic Status - Low	1.75	1.12 - 2.73	0.015*

DISCUSSION

A comprehensive analysis elucidated the relationship between lifestyle factors and the risk of developing kidney stones in the cohort of 220 participants, revealing a robust correlation between the prevalence of kidney stones and specific dietary behaviors, hydration status, physical activity levels, and BMI. These results provided important new perspectives for clinical treatment and patient education in line with the present body of knowledge [15]. Urological studies confirm that diet has long been important in the formation of kidney stones. Our studies reveal that kidney stones are more likely to be connected with a diet heavy in animal protein, oxalate-laden foods, and sodium. Zhuo *et al.*, found that a diet high in animal protein

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leads to calcium loss and elevated urinary excretion of uric acid, both of which exacerbate kidney stone formation. Our results align with this evidence, underscoring the adverse effects of excessive animal protein on urolithiasis risk. This information conforms to current knowledge [16]. Furthermore, our data implies that the link between salt intake and stone development could be explained by a rise in calcium excretion in urine. Their seminal study on dietary variables and kidney stone incidence [17, 18] covered this mechanism in great detail. In terms of oxalate intake, Mitchell *et al.,* explained that calcium oxalate stones are primarily driven by dietary oxalates. In line with their findings, our study shows that high oxalate intake raised the risk of kidney stones by 65%, indicating that dietary oxalates play a significant role in stone formation. Another important consideration was hydration level; those who kept a high fluid intake were less prone to kidney stones. Increasing fluid intake reduces urinary solutes, which thus reduces the saturation level of minerals in urine that could develop stones [19]. These outcomes are consistent with the findings of Mitchell *et al.*, and Siener, who emphasized that increased water intake dilutes urinary solutes and lowers the saturation of stone-forming compounds, thus reducing the likelihood of stone formation. Current results are in agreement, suggesting that maintaining hydration is crucial for those at risk of kidney stones [19, 20]. More importantly, our data showed that the prevalence of kidney stones increased with increasing body mass index. This result was in line with what Taylor *et al.*, found: that obesity can worsen urine changes that promote stone formation, such as increased excretion of uric acid and calcium [21]. Another possible cause of this elevated risk is the metabolic and inflammatory alterations associated with obesity, as Scotland *et al.*, explained [22]. Interesting as it may seem, kidney stones are more common among those from lower socioeconomic backgrounds. This could be associated with differences in health literacy, healthcare access, and nutritional quality, all of which significantly impact health outcomes for various diseases. To validate these correlations over time, future studies should use more precise nutritional monitoring technology or biomarkers to assess dietary intake. Changing one's lifestyle is the key to reducing the risk of kidney stones, according to this study's conclusions. Clinicians should think about incorporating dietary advice, water education, and exercise promotion into the routine care of patients at risk of kidney stones.

CONCLUSIONS

It was concluded that the study confirmed the important contribution of lifestyle elements to kidney stone formation. The results strongly suggested that high consumption of animal protein, oxalate, and salt greatly increases the risk of kidney stones; conversely, high levels of physical activity and sufficient hydration help to reduce the risk. The positive link between raised BMI and higher incidence of kidney stones emphasizes, even more, the complex influence of metabolic health on urological diseases. These results imply that focused lifestyle changes are good approaches for controlling and avoiding kidney stones.

Authors Contribution

Conceptualization: MLJ
Methodology: IUR, MF, RN
Formal analysis: IUR, KK, MLJ
Writing review and editing: NA, KK

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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