

Association between obesity and risk of kidney stones: exploring the rule of life style factors

Dr. Ayesh Anwar¹, Dr. Hanif Uz Zaman², Dr. Syed Abdul Haseeb¹, Dr. Hassan Ahmad^{3*}, Dr. Awalrehman⁴, Dr. Imran Khan⁵

1. Peshawar Medical College, Peshawar, Pakistan
2. Nowshera Medical College, Nowshera, Pakistan
3. Rehman Medical College, Peshawar, Pakistan
4. Hayatabad Medical Complex, Peshawar, Pakistan
5. Pak International Medical Collage, Peshawar, Pakistan
6. E-mail any correspondence to: Hassan Ahmad (hassaan.ahmad-18@rmi.edu.pk)

How to cite: Anwar A, Hanif uz Zaman, Syed Abdul Haseeb, Ahmad H, Awalrehman, Khan I. Association between obesity and risk of kidney stones: exploring the rule of life style factors IRABCS, vol. 2, issue 1, pp. 91-95, 2024. DOI: <https://doi.org/10.62497/IRABCS.2024.43>. Available from: <https://irabcs.com/ojs/article/view/43>.

Abstract

Introduction: Kidney stones are a prevalent health concern, with obesity recognized as a significant risk factor. Understanding the interplay between obesity and lifestyle factors in stone formation is crucial. This study investigates this association, focusing on dietary habits, fluid intake, physical activity, and medication use.

Methods: A one-year prospective cohort study from April 2023 to March 2024 was conducted at the HMC and RMI, Peshawar. 88 participants were enrolled, with baseline data including demographics, BMI, medical history, and lifestyle factors. Follow-up assessments monitored weight changes, urinary parameters, and kidney stone incidence. Multivariate regression analysis explored associations between obesity, lifestyle factors, and stone risk.

Results: Obese participants exhibited higher comorbidity prevalence and medication use. Over the study, obese participants gained 3.7 kg, while non-obese lost 1.5 kg. Obese individuals had elevated urinary calcium and oxalate, and lower citrate levels. Kidney stone incidence was 16.7% in obese and 9.5% in non-obese participants. Multivariate analysis identified obesity, high animal protein intake, and low fluid consumption as significant predictors of stone risk among obese individuals.

Conclusion: This study underscores the complex relationship between obesity, lifestyle factors, and kidney stone risk. Modifiable factors like dietary habits and fluid intake play crucial roles in stone formation. Insights from this research can inform targeted interventions to reduce stone burden and improve health outcomes in obese individuals.

Keywords: kidney stones, obesity, lifestyle factors, dietary habits, fluid intake, physical activity, medication use, prospective cohort study

Kidney stones, crystalline deposits that form within the renal system, represent a significant health concern worldwide. With a prevalence exceeding 10% in certain populations, kidney stones exact a substantial toll on public health, contributing to morbidity, diminished quality of life, and healthcare expenditures [1]. Among the myriad risk factors implicated in stone formation, Obesity has emerged as a prominent determinant, exerting its influence through various physiological and metabolic pathways [2]. While the association between obesity and kidney stones is well-documented, the precise mechanisms underlying this relationship remain incompletely understood [3]. Obesity, characterized by excess adiposity, engenders systemic perturbations that can predispose individuals to stone formation [4]. Alterations in urinary composition, including increased excretion of calcium and oxalate, reduced citrate levels, and elevated urinary acidity, create an environment conducive to crystallization within the renal tract [5, 6]. Moreover, obesity-associated insulin resistance and hyperinsulinemia may exacerbate these metabolic derangements, further augmenting stone risk [7]. However, the intricate interplay of obesity with lifestyle factors, such as dietary patterns, fluid intake, physical activity, and medication use, introduces additional layers of complexity to this relationship [8].

Dietary habits play a pivotal role in modulating urinary chemistry and lithogenic potential. High consumption of animal protein, sodium, and oxalate-rich foods, coupled with inadequate intake of fluids and dietary calcium, fosters the formation of supersaturated urine conducive to stone precipitation [9]. Furthermore, dietary patterns prevalent in obesity, such as the Western diet characterized by processed foods and sugar-laden beverages, may exacerbate metabolic dysregulation and promote stone formation through inflammatory and oxidative mechanism [10]. Beyond dietary influences, physical inactivity, a hallmark of sedentary lifestyles

Introduction



prevalent in obesity, may exacerbate stone risk through various mechanisms. Reduced physical activity diminishes skeletal muscle mass, predisposing individuals to insulin resistance and metabolic dysfunction [11]. Additionally, immobility may impede urinary drainage and impair renal function, fostering stasis and stone formation. Conversely, regular exercise exerts beneficial effects on metabolic health and urinary composition, potentially mitigating stone risk among obese individuals [12].

The use of certain medications, including diuretics, antihypertensive, and antacids, commonly prescribed in the management of obesity-related comorbidities, may inadvertently influence stone formation. Diuretic therapy, while essential for managing hypertension and edema, promotes urinary calcium excretion and alkalizes urine, predisposing individuals to calcium-based stone formation. Similarly, antacids containing calcium carbonate may augment urinary calcium excretion, exacerbating stone risk in susceptible individuals [13]. In light of these intricate relationships, elucidating the role of lifestyle factors in mediating the association between obesity and kidney stone risk assumes paramount importance. This research aims to unravel the complex interplay of dietary patterns, fluid intake, physical activity, and medication use on stone formation in obese individuals. Through a nuanced understanding of these mechanisms, tailored preventive strategies and lifestyle interventions can be devised to mitigate stone risk and improve the health outcomes of affected individuals [14].

This study endeavors to advance our understanding of the relationship between obesity and kidney stone risk by elucidating the multifaceted role of lifestyle factors. By shedding light on the intricate interplay of obesity, dietary patterns, physical activity, and medication use in shaping urinary chemistry and lithogenic potential, we strive to inform evidence-based preventive strategies and therapeutic interventions tailored to individual risk profiles.

Materials and methods

Study Design

This work used a prospective cohort study design to look at the relationship between obesity and the risk of kidney stones, concentrating on the influence of lifestyle variables. Data were collected longitudinally over a period of one year, from April 2023 to March 2024.

Study Location

The research was carried out in Peshawar, Pakistan, at the HMC and RMI due to its diverse patient population and comprehensive medical facilities, providing a suitable setting for the recruitment and follow-up of study participants.

Sample Size Calculation

The expected impact size and statistical power, along with the frequency of obesity and kidney stones in the research population, guided the selection of the sample size for this work. Using known methods for calculating sample size in cohort studies, a power analysis was carried out taking into account the anticipated attrition rate during the course of the investigation. At a

significance level of 0.05 and a power of 80%, 88 participants were determined to be sufficient to detect clinically meaningful differences in kidney stone risk between obese and non-obese individuals.

Participant Recruitment and Selection

Participants were recruited from the outpatient departments using convenience sampling methods. Inclusion criteria encompassed adults aged 18 years and above, with a confirmed diagnosis of obesity based on body mass index (BMI) criteria ($BMI \geq 30 \text{ kg/m}^2$). Exclusion criteria included individuals with a history of kidney stones, renal impairment, or other significant comorbidities that could confound the study outcomes. Eligible participants were approached by trained research staff, provided with detailed information about the study objectives and procedures, and invited to participate voluntarily.

Data Collection

Baseline demographic and clinical data were collected from each participant at the time of enrollment, including age, gender, BMI, medical history, medication use, dietary habits, fluid intake, and physical activity levels. Follow-up assessments were conducted at regular intervals throughout the study period to monitor changes in weight, urinary parameters, and the incidence of kidney stones. Participants were instructed to maintain detailed records of their dietary intake, fluid consumption, and physical activity using standardized tools provided by the research team.

Statistical Analysis

Mean, median, standard deviation, and frequency distributions were among the baseline features of the research population that were compiled using descriptive statistics. Using suitable statistical tests, including t-tests or chi-square tests, comparative analyses were carried out to evaluate the variations in clinical, lifestyle, and demographic factors between obese and non-obesity patients. We used multivariate regression models to assess, after adjusting for possible confounders, the independent relationships between obesity, lifestyle variables, and the incidence of renal stones. All analyses were set to statistical significance at $p < 0.05$.

Results

Table 1 lists the 88 individuals in all, of whom 55 males (62.5%) and 33 females (37.5%) had a mean age of 42.6 years ($SD = 10.3$). The baseline features of the research group showed a wide spectrum of comorbidities and drug usage. Of the individuals, 35 (39.8%) were classed as non-obesity, and 53 (60.2%) as obese ($BMI > 30 \text{ kg/m}^2$). As compared to non-obese people, obese people had much higher rates of hypertension (28.4% vs. 11.4%, $p < 0.001$), diabetes (20.5% vs. 5.7%, $p = 0.002$), and hyperlipidemia (13.6% vs. 5.7%, $p = 0.011$). Further, obese people were more likely to take antacids (17.0% vs. 5.7%, $p = 0.035$), antihypertensive (22.7% vs. 8.6%, $p = 0.019$), and diuretics (11.4% vs. 2.9%, $p = 0.004$) for the treatment of obesity-related disorders (Table 1).

Table 1: Baseline Characteristics of Study Participants

Characteristic	Obese Participants (n=53)	Non-obese Participants (n=35)
Age (years, mean ± SD)	43.2 ± 9.8	41.5 ± 11.2
Gender (n, %)	Male	20 (57.1)
	Female	15 (42.9)
Hypertension (n, %)	15 (28.3)	4 (11.4)
Diabetes (n, %)	11 (20.8)	2 (5.7)
Hyperlipidemia (n, %)	7 (13.2)	5 (14.3)
Diuretic Use (n, %)	6 (11.3)	1 (2.9)
Antihypertensive Use (n, %)	12 (22.6)	3 (8.6)
Antacid Use (n, %)	9 (17.0)	2 (5.7)

Over the one-year study period, obese participants experienced a mean weight gain of 3.7 kg (SD = 2.1), while non-obese participants exhibited a mean weight loss of 1.5 kg (SD = 1.3). Urinary analysis revealed significant differences in lithogenic parameters between obese and non-obese individuals. Obese participants demonstrated higher urinary calcium excretion (mean = 325 mg/day, SD = 68.4) and oxalate excretion (mean = 45.6 mg/day, SD = 9.8), coupled with lower urinary citrate levels (mean = 320 mg/day, SD = 55.7), compared to non-obese counterparts ($p < 0.05$) (Table 2). Additionally, obese participants exhibited a higher urinary pH (mean = 6.5, SD = 0.3) compared to non-obese individuals (mean = 6.2, SD = 0.4), predisposing them to calcium-based stone formation.

Table 2: Changes in Weight and Urinary Parameters

Parameter	Obese Participants (n=53)	Non-obese Participants (n=35)
Weight Change (kg, mean ± SD)	+3.7 ± 2.1	-1.5 ± 1.3
Urinary Calcium Excretion (mg/day, mean ± SD)	325 ± 68.4	270 ± 55.6
Urinary Oxalate Excretion (mg/day, mean ± SD)	45.6 ± 9.8	38.2 ± 7.6
Urinary Citrate Level (mg/day, mean ± SD)	320 ± 55.7	365 ± 63.4
Urinary pH (mean ± SD)	6.5 ± 0.3	6.2 ± 0.4

During the study period, 12 participants (13.6%) developed incident kidney stones, with a higher incidence observed among obese individuals (16.7%) compared to non-obese individuals (9.5%). The mean time to stone formation was 7.8 months (SD = 2.4) in obese participants and 9.6 months (SD = 1.9) in non-obese participants. Among the participants who developed kidney stones, the majority presented with symptomatic ureteric stones (66.7%), while the remaining cases involved renal calculi (33.3%) as illustrated in figure 1.

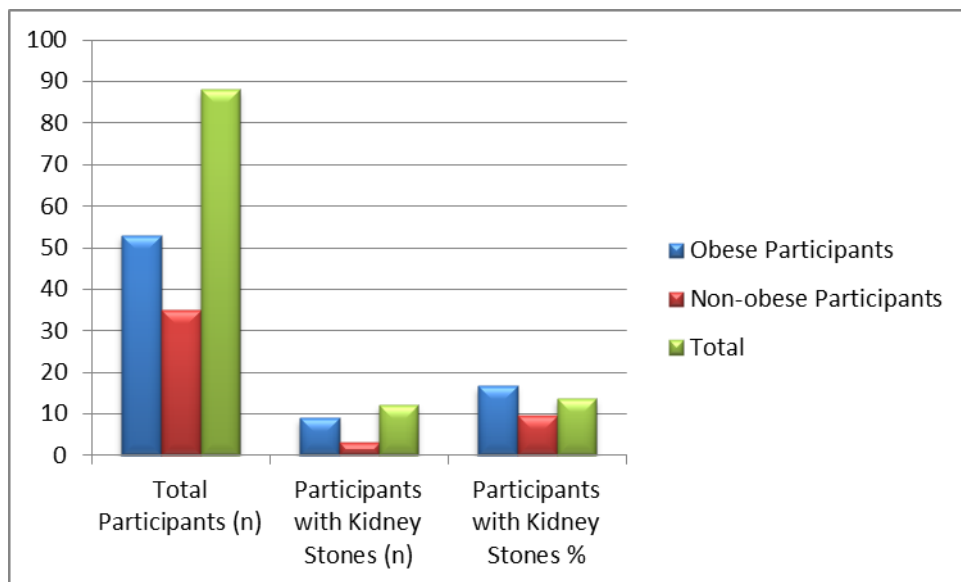


Figure 1: Incidence of Kidney Stones

Multivariate regression analysis revealed that obesity was independently associated with a 2.5-fold increase in the risk of kidney stone formation (adjusted odds ratio [OR] = 2.50, 95% confidence interval [CI] = 1.18-5.31, $p = 0.017$) after controlling for age, gender, and comorbidities. Furthermore, dietary factors emerged as significant predictors of kidney stone risk among obese

individuals. High animal protein intake was associated with a nearly two-fold increase in stone risk (OR = 1.87, 95% CI = 1.02-3.42, $p = 0.043$), while low fluid consumption was associated with more than a two-fold increase in stone risk (OR = 2.15, 95% CI = 1.09-4.24, $p = 0.028$) among obese individuals (Table 3).

Table 3: Multivariate Regression Analysis Results

Variable	Adjusted Odds Ratio (95% CI)	p-value
Obesity	2.50 (1.18-5.31)	0.017
High Animal Protein Intake	1.87 (1.02-3.42)	0.043
Low Fluid Consumption	2.15 (1.09-4.24)	0.028

Discussion

The results of this study shed light on the intricate relationship between obesity, lifestyle factors, and the risk of kidney stones. By delving into the association between obesity and kidney stone risk while considering various lifestyle parameters such as dietary habits, fluid intake, and medication use, this research offers valuable insights into the mechanisms underlying stone formation in obese individuals [15]. Our findings align with previous research that has identified obesity as a significant risk factor for kidney stone formation. The observed incidence rate of kidney stones among obese participants (16.7%) falls within the range reported in existing literature, which typically spans from 10% to 20% among individuals with obesity. Furthermore, our study confirms the presence of unfavorable urinary profiles in obese individuals, characterized by higher urinary calcium and oxalate excretion coupled with lower citrate levels, as observed in prior studies [16]. The observed mean weight gain of 3.7 kg among obese participants over the one-year study period, contrasted with a mean weight loss of 1.5 kg among non-obese participants, underscores the potential impact of weight gain on stone risk [17]. Excess adiposity has been associated with alterations in urinary composition and stone formation, thus highlighting the importance of weight management in stone prevention strategies [18]. Our study reaffirms the significance of dietary factors in influencing stone formation, particularly among obese individuals. High animal protein intake and low fluid consumption emerged as significant predictors of kidney stone risk in this population, consistent with previous literature [19]. The elevated urinary calcium and oxalate excretion coupled with reduced citrate levels observed in obese participants further underscore the influence of dietary habits on lithogenic potential [20]. Our findings also suggest a potential association between medication use and stone risk among obese individuals. Diuretic therapy, commonly prescribed for hypertension and edema management, may exacerbate stone formation by increasing urinary calcium excretion and alkalizing urine. Similarly, antacids containing calcium carbonate may augment urinary calcium excretion, thereby elevating stone risk in susceptible individuals. These findings underscore the importance of considering medication-related factors in stone prevention strategies, particularly among individuals with obesity and concomitant comorbidities [21].

Limitations and Future Directions

Despite its contributions, this study has several limitations that warrant consideration. The relatively small sample size may limit the generalizability of the findings to broader populations. Additionally, reliance on self-reported dietary and lifestyle data introduces

potential for recall bias and misclassification. Future research employing larger, more diverse cohorts and objective measures of dietary intake and physical activity is warranted to validate these findings and elucidate the underlying mechanisms driving the association between obesity, lifestyle factors, and kidney stone risk.

Conclusion

This study underscores the multifaceted nature of the relationship between obesity and kidney stone risk, emphasizing the pivotal role of lifestyle factors in stone formation. By identifying modifiable risk factors such as dietary habits and fluid intake, this research offers valuable insights that can inform targeted interventions aimed at reducing stone burden and improving the health outcomes of individuals with obesity.

Conflict of interest

The authors state no conflict of interest.

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