

Correlation Between Physical Activity and Kidney Stones Formation: A Literature Review

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**ABSTRACT**

Background: Kidney stones or nephrolithiasis is a disease where crystals form in kidney due to increased excretion of stones-forming components such as calcium, oxalate, uric acid, cystine, xanthine, and phosphate, or reduced urine volume. In addition, poor eating and drinking habits along with lack of physical activity put individuals at a high risk of developing kidney stones. Previous studies showed that physical activity can both reduce and increase the risk of kidney stones.

Purpose: This study aims to determine the relationship between physical activity and formation of kidney stones.

Method: A literature review design was used by conducting a journal search through PubMed, Science Direct, and Google Scholar databases using the keywords ("kidney stone" OR nephrolithiasis OR urolithiasis OR "renal calculi") AND ("physical activity" OR exercise)".

Results: The results showed a total of 15 articles that discussed correlation between physical activity and kidney stones formation. Ten articles explained that physical activity reduced kidney stones formation, while four reported no significant effect. The last article stated that physical activity increased kidney stones formation

Conclusion: Kidney stones formation occurred through the exacerbation of hypercalciuria in the absence of physical activity. Moderate physical activity reduced formation of kidney stones by decreasing calcium excretion in the urine. Meanwhile, excessive physical activity increased the occurrence of kidney stones in the absence of adequate fluid intake.

Keywords: physical activity; kidney stone; nephrolithiasis

INTRODUCTION

Kidney stones or nephrolithiasis is a disease where crystals form in kidney due to the increased excretion of stones-forming components such as calcium, oxalate, uric acid, cystine, xanthine, and phosphate, or reduced urine volume¹. These crystals can travel through the genitourinary system, leading to a condition called urolithiasis².

Kidney stones cases affect 12% of the global population and continue to increase. This condition is most common in countries with tropical climates and high levels of dehydration³. In Indonesia, the prevalence of kidney stones is 0.6%⁴ and is more common in men than women with a ratio of 2:1. This is because men pay less attention to their body conditions, leading to a higher risk of developing kidney stones. Factors such as obesity, poor eating, and drinking habits, as well as low physical activity levels also contribute to the higher risk in men. Conversely, women have a lower risk due to their desire to maintain an ideal body shape, which will encourage exercise and following a balanced diet⁵.

Several studies have identified the risk factors that may increase the incidence of kidney stones. These include inadequate fluid intake, high consumption of animal-based protein, oxalate, and salt, as well as lack of citrate and calcium intake⁶. According to, D'Alessandro, et al.,⁵ one of the risk factors for kidney stones is excessive exercise. Sufficient and regular physical activity can be recommended for people with kidney stones or those at high risk of developing this condition. Physical activity reduces various risks such as diabetes mellitus, hypertension, and obesity. This must be followed by adequate fluid intake in accordance with sweat expenditure during these activity, because if hydration is not sufficient there will be a risk of stone formation itself. Jones, et al.⁷ stated that excessive exercise and sweating can lead to dehydration, triggering formation of kidney stones.

Based on the above description, this study was conducted to analyze correlation between physical activity and kidney stones formation.

METHODS

This study used the literature review method which involved searching and reviewing books, journals, and other publications related to the topic⁸.

The search was conducted through databases such as Google Scholar, PubMed, and Science Direct, while the keywords used were ("kidney stone" OR nephrolithiasis OR urolithiasis OR "renal calculi") AND ("physical activity," OR exercise)". The articles retrieved were in English or Indonesian, and the publication period was between 2017-2021. This study was approved by the Ethics Commission of Fakultas Kedokteran Universitas Muhammadiyah Surakarta under number 3967/C.1/KEPK-FKUMS/I/2021.

According to Piercy, et al.,⁹ the intensity of physical activity was determined by the level of energy expenditure, where sitting at rest had a value of 1 MET (Metabolic Equivalent of Task). There were 3 divisions of physical activity intensity. The first one, namely Low-Intensity Activity required less than 3.0 MET, and included walking slowly, cooking, or light household chores. The second one was Moderate-Intensity Activity such as brisk walking or playing doubles tennis required 3.0 to 6.0 MET. Meanwhile, High-Intensity Activity required more than 6.0 MET and involved running, single tennis, or dance aerobics.

RESULTS

The screening process of the articles obtained was presented through the PRISMA Flowchart (Figure 1). The articles were published between 2017 and 2021, and were obtained from PubMed, Science Direct, and Google Scholar were 67, 1486, and 8390, respectively. All PubMed articles were accessible, but only 998 from Science Direct and 960 from Google Scholar were accessible. Therefore, the total number of articles analyzed in this study was 2025.

The first stage of the extraction process involved listing all the titles of the articles obtained in Microsoft Excel and sorting alphabetically. A total of 219 duplicates were removed, leaving only 1806 articles. Furthermore, the screening process was carried out by reading the titles and abstracts. A total of 1716 articles had irrelevant titles and 48 had unrelated abstracts. From the 42 remaining articles, the extraction process was continued by reading the full text, and only 15 were found to meet the inclusion and exclusion criteria.

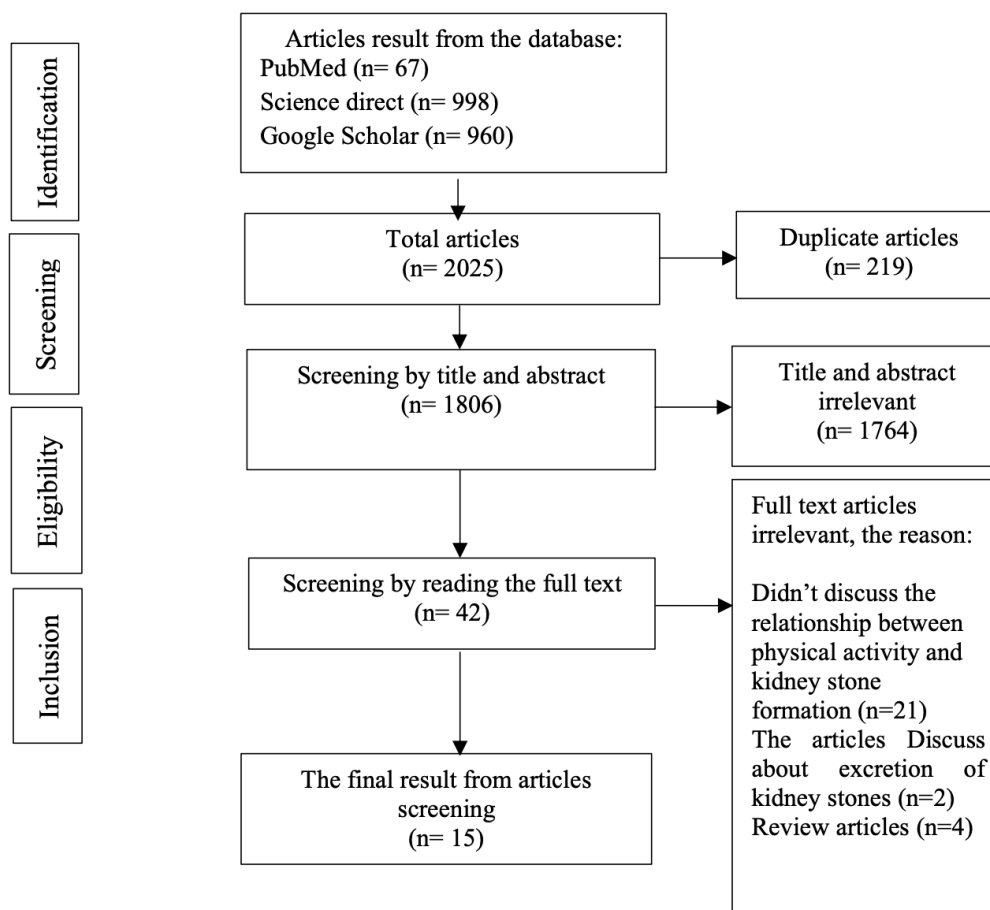


Figure 1. Flow Chart Article

A total of 15 articles were found to discuss correlation between physical activity and kidney stones formation. Ten articles explained that physical activity reduced kidney stones formation, while four found no significant correlation. The last article stated that physical activity increased kidney stones formation. To simplify the analysis, a summary of the appropriate articles was carried out by making a table containing the title, author, year, design, and results of each article in Table 1

Table 1. Article Analysis

No.	Author, Year	Article Title	Study Design	Samples	Result	Physical Activity	p-Value
1	Azimi, <i>et al.</i> (2020) ¹⁰	The Comparison of Major Dietary Patterns in People with and without Calcium Oxalate Kidney Stone: A Case-Control Study	Case-control study	317 kidneys stones patients (267 male and 50 female) in the treatment group. 317 healthy people (165 men and 152 women) served as controls. Both groups were aged between 18-65 years old.	Patients with kidney stones had lower physical activity than those in the control group.	Mean MET = low Mean MET = moderate	p < 0.001

2	Baharudi <i>n, et al.</i> (2017) ¹¹	Dietary and Lifestyle Factors and Its Risk to Kidney Stone Disease: A Case-Control Study at UKM Medical Centre	Case-control study	81 kidneys stones patients (45 males and 36 females) aged 18-80 years as the experiment group. 81 people without kidney stones (45 men and 36 women) in the same age group (± 5 years) served as controls.	The results did not show a significant correlation between physical activity and kidney stones formation.	Low intensity High intensity	Male p= 0.8; female p = 0.36 Male p= 0.96; female p = 0.34
3	Bazyar, <i>et al.</i> (2019) ¹²	The Association Between Dietary Intakes and Stone Formation in Patients with Urinary Stones in Shiraz	Cross-sectional study	110 kidneys stones patients (73 male and 37 female) aged 18-60 years.	Women with low physical activity were more at risk for developing kidney stones. Meanwhile, in men, the highest risk of developing kidney stones was found in people with high physical activity.	Low intensity (62.2% female) High intensity (43.8% male)	-
4	Chen, <i>et al.</i> (2017) ¹³	Association Between Recreational Physical Activity and The Risk of Upper Urinary Calculi	Cross-sectional study	1517 kidney stones patients (901 males and 616 females) aged > 18 years as the experiment group. 1782 healthy people (1004 men and 778 women) aged > 18 years as controls.	26% of kidney stones sufferers and 53% of controls exercise regularly every week. The possible risk was lowest at 5-9.9 METs/week (OR=0.11) and the protective effect weakened as physical activity increased.	4.9 METs/week 5 - 19.9 METs/week 20 - 29.9 METs/week >30 METs/week	p < 0.001 p = 0.020 p = 0.339
5	Fagagnini, <i>et al.</i> (2017) ¹⁴	Risk Factors for Gallstones And Kidney Stones In A Cohort Of Patients With Inflammatory Bowel Diseases	Cohort study	2323 IBD patients, 1333 of them had Crohn's disease, and 999 patients had ulcerative colitis.	Physical activity every month showed an OR value of 0.57, physical activity every week or every day had an OR value of 0.36, and hospitalization caused an increase in the incidence of kidney stones (26.5% in	every month Every week or every day Little/no activity (hospitalization)	p = 0.02 p < 0.001 p < 0.001

						hospitalization and 2.5% in non-hospitalization). OR=13,9).		
6	Farooq, <i>et al.</i> (2018) ¹⁵	Dietary And Drinking Habits In Patients Admitted With Nephrolithiasis	Cross-sectional study	140 patients with kidney stones (80 males and 60 females) aged 8-75 years.	Most kidney stones patients were physically active for 6-10 hours.	1-5 hours (34.3%) 6-10 hours (57.1%) 11-15 hours (8.6%)		
7	Feng, <i>et al.</i> (2020) ¹⁶	Association Between Physical Activity and Kidney Stones Based on Dose-Response Analyses Using Restricted Cubic Splines	Cross-sectional study	8931 participants who took part in NHANES were > 20 years old (4329 men and 4602 women).	MET was lower in kidney stones patients compared to controls, and the OR of kidney stones decreased with increasing physical activity, reaching a steady state at 2480 MET-min/week (OR=0.75).	Mean MET = Low Mean MET control = moderate activity	p < 0.001	
8	Fitriyani & Wardi, (2020) ¹⁷	Risk Factors Related To The Crystalluria Case Among Workers At Welding Department Of Automotive Industry X Jakarta	Mixed methods (qualitative & quantitative)	220 workers from 1253 population in the automotive welding industry.	Physical activity was not associated with cases of crystalluria but affected BMI which served as a risk factor for crystalluria.	Low activity Moderate activity	Physical activity p = 0.498 BMI p = 0.031	
9	Fujishiro, <i>et al.</i> (2021) ¹⁸	Multiple Urolithiasis In Pediatric Acute Lymphoblastic Leukemia	Case report	A 5-year-old boy with acute lymphoblastic leukemia and multiple urolithiasis.	Long-term bed rest was suspected to cause multiple urolithiasis.	Absence or low physical activity		
10	Marić, <i>et al.</i> (2019) ¹⁹	Lifestyle Factors and Bone Mass in Recurrent Stone-Forming Patients: A Cross-Sectional Study In 144 Subjects	Cross-sectional study	56 patients with recurrent urolithiasis (47 aged ≤ 60 years and 9 aged > 60 years) were in the treatment group. 78 patients without a history of urolithiasis served as controls (67 aged ≤ 60 years and 11 aged > 60 years).	Current physical activity and previous exercise showed insignificant results.	High activity Moderately activity Low activity	Current physical activity p = 0.349 Sports before = 0.260	

11	Mathiyala gen, <i>et al.</i> (2017) ²⁰	A Case-Control Study on Environmental and Biological Risk Factors for Renal Calculi Persisting In A Coastal Union Territory, India	Case-control study	50 patients diagnosed with kidney stones (26 male and 24 female) were in the treatment group, while 50 served as controls (36 males and 14 females) aged >30 years.	Sedentary activity increased the risk of kidney stones.	Sedentary (low intensity)	p = 0.029
12	Nirooman d, <i>et al.</i> (2020) ²¹	Nutritional Habits In Patients With Urinary Tract Stones Referred To Imam Reza Hospital In 2019	Descriptive study	150 patients diagnosed with kidney stones.	Some kidney stones had low physical activity, did not exercise at all, and traveled by vehicle.	1/3 patients < 4 hours (low activity) 57.3% absence activity	
13	Ryu, <i>et al.</i> (2018) ²²	Dietary Risk Factors For Urolithiasis In Korea: A Case-Control Pilot Study	Case-control study	27 newly diagnosed patients with urolithiasis (19 males and 8 females) were in the treatment group. 20 participants without urolithiasis served as controls (11 males and 9 females).	The level of physical activity in the control group was higher than in cases of kidney stones patients.	Cases: Low activity Control: High activity	p = 0.012
14	Trinchier, <i>et al.</i> (2019) ²³	Anthropometric Variables, Physical Activity, And Dietary Intakes of Patients with Uric Acid Nephrolithiasis	Case-control study	33 male patients with anhydrous uric acid stones were in the treatment group. 49 men without a history of kidney stones served as controls Both groups were 50-85 years old.	There was no difference in physical activity between kidney stones sufferers and controls.	Moderate or high intensity	p = 0.579
15	Venugopal, <i>et al.</i> (2020)	Risk of Kidney Stone Among Workers Exposed to High Occupational Heat Stress-A Case Study from Southern Indian Steel Industry	Cross-sectional study	220 workers exposed to temperatures exceeding Threshold Limit Value (TLV) (134 males and 86 females) were in the treatment group. 120 workers exposed to temperatures less than TLV (112 males and 8 females) served as controls.	Strenuous physical activity caused high body temperature. Temperatures exceeding TLV led to dehydration, but sweat production persisted.	Excessive or too high intensity	Dehydration n p = 0.0001 Sweat production p = 0.193

DISCUSSION

Mathiyalagen, et al.²⁰ stated that sedentary activity such as bed rest may increase the risk of developing kidney stones. According to Fujishiro, et al.¹⁸ long-term bed rest can lead to urolithiasis due to exacerbations of hypercalciuria caused by immobilization. Fagagnini, et al.¹⁴ also found that hospitalized patients showed a higher incidence of kidney stones compared to non-hospitalized ones due to the extended period spent lying on the bed.

The average MET was lower in patients with kidney stones compared to the control group in a study conducted by Feng et al.¹⁶. This value showed the levels of physical activity. Based on the results, high physical activity stimulated sweating, causing an increase in water and sodium excretion. Decreased blood sodium activates the Renin Angiotensin Aldosterone (RAA) system, which stimulates water and sodium reabsorption in the distal convoluted tubule and collecting ducts. The subsequent production of angiotensin II causes thirst, prompting individuals to drink more water than the amount lost through sweat. Concurrently, an increase in the perfusion of renal blood flow occurs, which dilutes the urine. Physical activity also plays a role in bone calcium deposition and reduces its excretion in the urine, thereby preventing formation of kidney stones.

Chen, et al.¹³ showed that physical activity with 5-30 METs/week significantly reduced the risk of developing kidney stones. However, physical activity above 30 METs/week did not significantly reduce the risk, due to the increased sweat production which led to the release of more water and sodium. When this is not balanced by fluid intake, it can reduce the protective effect of physical activity on kidney stones formation. Maintaining a balance between fluid loss and intake is crucial to preserving the protective effect of physical activity against kidney stones formation, as excessive sweating without sufficient fluid intake can diminish the benefits¹⁶.

Farooq, et al.¹⁵ showed that 6-10 hours per week of physical activity had the highest percentage in patients with kidney stones, followed by 1-5 hours and 11-15 hours. However, the study did not explain how physical activity of 6-10 hours can increase the risk of developing kidney stones.

Niroomand, et al.²¹ and Azimi's, et al.¹⁰ reported that the majority of kidney stones patients had a low level of physical activity or even did not exercise at all. This was further reinforced by Chen, et al.¹³ highlighting that healthy people had higher physical activity levels compared to those with kidney stones. Fagagnini, et al.¹⁴ also stated that physical activity per day or week was associated with a lower risk compared to per month. This suggests that less physical activity may increase the risk of kidney stones.

Bazyar, et al.¹² found that women with low physical activity were more at risk for developing kidney stones, while in men, the highest risk was observed in those with high physical activity levels. However, the reasons behind these gender-related differences were not explained.

According to Venugopal, et al.,²⁴ heat exposure can result from the temperature of the surrounding environment and within the body. Strenuous physical activity potentially increases body temperature causing dehydration and excessive sweating, which are both risk factors for kidney stones formation. Farooq, et al.¹⁵ also found that marathon runners had a 3-5 times higher risk of developing kidney stones. This was due to prolonged, strenuous physical activity which led to dehydration from increased body heat, inadequate fluid intake, along with fluid loss through sweating¹⁶.

Trinchieri, et al.²³ and Baharudin, et al.¹¹ did not find a significant correlation between physical activity and kidney stones formation. Marić et al.¹⁹ also reported that there was no direct correlation between physical activity and kidney stones. However, physical activity prevented several systemic diseases such as diabetes, hypertension, and gout which served as risk factors for kidney stones. Fitriyani and Wardi¹⁷ also discovered that good physical activity can maintain an ideal Body Mass Index (BMI) which has a significant effect on preventing kidney stones. Azimi et al.¹⁰ stated that physical

activity also prevented obesity. The major limitation of this current study was the varying characteristics of the samples involved in each reviewed article.

CONCLUSION

Based on the results, there was correlation between physical activity and kidney stones formation. Lack of physical activity increased the risk of developing kidney stones through exacerbation of hypercalciuria^{14,18}. Meanwhile, adequate and regular-mild to moderate physical activity reduced the risk by lowering calcium excretion in the urine^{10,13,14,21}. Excessive physical activity may also increase the occurrence of kidney stones when not balanced with fluid adequate intake to compensate for the sweat loss^{14,15,23}.

CONFLICT OF INTEREST

The authors reported no competing interests.

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