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Association between Cigarette Smoking Duration and Renal Dimensions in Adults: A Sonographic Study from Sudan

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Abstract | **Original Research Article**

Background: Cigarette smoking is an established, modifiable risk factor for renal damage, yet its impact on renal morphology remains under-investigated the aim of this study was to assess the relationship between the duration of cigarette smoking and renal dimensions (length, width, parenchymal thickness, and cortical thickness) among Sudanese adults using ultrasound imaging. ***Methods:*** A descriptive cross-sectional study was conducted in Khartoum, Sudan, from January to September 2022. The study included 106 adults: 46 cigarette smokers and 60 non-smokers (controls). Renal dimensions were measured for both kidneys using ultrasonography. Data on smoking duration were collected from the smokers. The Mann-Whitney U test was used to compare dimensions between groups, and Pearson's correlation was used to assess the relationship between smoking duration and renal measurements. ***Results:*** Smokers had a significantly greater left kidney width compared to non-smokers ($p = 0.048$). There were no other significant differences in the real dimensions between the groups. A statistically significant negative correlation was found between the duration of smoking and the length of the right kidney ($r = -0.303$, $p = 0.041$) and the left kidney ($r = -0.368$, $p = 0.012$). Other renal dimensions did not show a significant correlation with smoking duration. ***Conclusion:*** This study demonstrates that a longer duration of cigarette smoking is associated with a decrease in renal length in Sudanese adults. This finding suggests a chronic, subclinical impact of smoking on renal morphology, highlighting the importance of smoking cessation in preserving kidney health.

Keywords: Cigarette smoking, Renal dimensions, Ultrasound imaging, Kidney health, Sudanese adults.

1. INTRODUCTION

Cigarette smoking remains one of the leading preventable causes of morbidity and mortality worldwide, contributing to a wide range of chronic diseases [1]. While its adverse effects on the cardiovascular and respiratory systems are well-documented, the impact of smoking on the kidneys is an area of growing concern. Accumulating evidence from large-scale epidemiological studies has established cigarette smoking as an independent and significant risk factor for the development and progression of chronic kidney disease (CKD) [2].

The pathogenic mechanisms of smoking-induced renal injury are complex and multifactorial. They include acute hemodynamic changes in renal blood flow and glomerular filtration rate, induction of oxidative stress and inflammation, and promotion of endothelial dysfunction, which can culminate in glomerulosclerosis and tubulointerstitial fibrosis over time [3] These structural changes ultimately lead to a loss of renal function.

Renal ultrasonography is a fundamental, non-invasive imaging modality used to evaluate kidney structure. Sonographic measurements of renal dimensions, including kidney length, width, and parenchymal thickness, serve as significant indicators of renal health. A reduction in kidney size, particularly length, is a well-recognised marker of parenchymal loss and is often associated with advanced CKD and diminished renal function [4]

Despite the established link between smoking and CKD, few studies have specifically investigated the direct effect of smoking duration on sonographically

measured renal dimensions. Existing research has yielded varied results, with some reporting a significant decrease in kidney size with prolonged smoking history[5], while others have not identified a clear association. Moreover, there is a lack of such studies within African populations, particularly in Sudan, where tobacco consumption poses a significant public health challenge.

This study, therefore, aimed to evaluate the association between the duration of cigarette smoking and renal dimensions (length, width, parenchymal thickness, and cortical thickness) in a sample of Sudanese adults using ultrasound imaging.

2. METHODS

2.1. Study Design and Population

A descriptive cross-sectional study was conducted in Khartoum, Sudan, between January and September 2022. A total of 106 adult participants were recruited. The study population was divided into two groups: a smoker group consisting of 46 male adults who were active cigarette smokers, and a control group of 60 non-smokers (44 males, 16 females). Inclusion criteria for the smoker group required being an active smoker for at least one year. Exclusion criteria for all participants included a known history of diabetes mellitus, hypertension, chronic kidney disease, urinary tract obstruction, solitary kidney, or any other systemic illness known to affect renal morphology.

2.2. Data Collection and Ethical Considerations

The study was conducted following the ethical principles of the Declaration of Helsinki. After obtaining informed consent from all participants, a structured questionnaire was used to gather demographic data (age, sex) and details of smoking habits, including the duration of smoking in years and the number of cigarettes smoked per day. Height and weight were measured to calculate the Body Mass Index (BMI).

2.3. Sonographic Examination

All ultrasound examinations were performed by an experienced radiologist blinded to the participants' smoking status, using a Mindray DC-8 system with a 3.5 MHz convex transducer. Participants were scanned in the supine and decubitus positions to obtain optimal images of both kidneys. The following renal dimensions were measured:

- Renal Length: The maximum bipolar length in the longitudinal plane.
- Renal Width: The maximum dimension in the transverse plane.
- Parenchymal Thickness: The distance from the outer edge of a medullary pyramid to the renal capsule.
- Cortical Thickness: The distance from the base of a pyramid to the renal capsule. Each measurement was performed three times, and the average value was recorded to ensure accuracy.

2.4. Statistical Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 25.0. Descriptive statistics (mean, standard deviation, frequencies) were used to summarize participant characteristics. Due to the non-normal distribution of some variables, the non-parametric Mann-Whitney U test was used to compare renal dimensions between smokers and non-smokers. Pearson's correlation coefficient (r) was calculated to assess the linear relationship between smoking duration (in years) and the various renal dimensions in the smoker group. A p-value of less than 0.05 was considered statistically significant.

3. RESULTS

3.1. Participant Characteristics

The study comprised 106 participants. The control group consisted of 60 non-smokers with a mean age of 25.75 ± 5.13 years. The smoker group included 46 male smokers with a mean age of 26.39 ± 7.02 years. The mean smoking duration for the smoker group was 8.52 ± 6.17 years. There was no significant difference in age or BMI between the two groups. Detailed demographic and descriptive data are presented in Table 1& 2.

Table 1: Descriptive statistic of participants demographic data smoker/control

Gender	categories	Frequency	Percent
Non-smoker(control)	female	16	26.7
	male	44	73.3
	Total	60	100.0
Smoker	male	46	100.0
Age group			
Non-smoker(control)	20-29	50	83.3
	30-39	7	11.7
	40-49	3	5.0
Total		60	100.0
Smoker	20-29	38	82.6
	30-39	5	10.9

Gender	categories	Frequency	Percent
	40-49	2	4.3
	>49	1	2.2
Total		46	100.0
Smoking duration			
Non-Smoker	0	60	100.0
Smoker	<5	6	13.0
	5-10	27	58.7
	11-15	8	17.4
	16-20	4	8.7
	>20	1	2.2
	Total	46	100.0

3.2. Descriptive of renal dimensions

The descriptive statistics presented in Table 2 highlight notable differences between smokers and non-smokers (control group) in terms of both demographic characteristics and renal measurements. Among the non-smokers (n = 60), the mean age was 25.75 years, with an average body mass index (BMI) of 20.26 kg/m². The average lengths of the right and left kidneys were 9.89 cm and 9.69 cm, respectively, while the mean cortical thicknesses were 6.66 mm (right) and 6.47 mm (left). In contrast, the smoker group (n = 46) exhibited a slightly higher mean age of 26.39 years and a higher average BMI of 21.42 kg/m². Although the right and left kidney lengths were similar to those in the control group (9.79 cm and 9.68 cm, respectively), smokers demonstrated a slightly greater average width of the kidneys—most notably in the left kidney (mean = 4.69 cm) compared to non-smokers (mean = 4.33 cm). The parenchymal thicknesses were comparable between groups; however, smokers had marginally higher values for left kidney cortex thickness (mean = 6.67 mm) compared to non-smokers (mean = 6.47 mm). Additionally, smokers reported a wide range of smoking duration (3 to 36 years), with a mean duration of 8.52 years. These data suggest subtle variations in renal morphometry that may be associated with smoking status.

Table 2: Descriptive Statistics of both kidneys' measurements smoker/control

Variables		N	Minimum	Maximum	Mean	Std. Deviation
Non- smokers(control)	Age	60	20	43	25.75	5.128
	Height	60	155	190	172.48	8.448
	Weight	60	39	80	60.60	10.537
	RT-K Length	60	9.0	11.6	9.893	.6106
	RT-K Width	60	3.00	6.00	4.3850	.71279
	RT-K Parenchymal Thickness	60	6.8	18.8	14.550	2.2313
	RT-K Cortex Thickness	60	4.00	16.20	6.6618	1.77330
	LT-K Length	60	8.9	11.5	9.692	.5694
	LT-K Width	60	3.2	5.9	4.328	.5714
	LT-K Parenchymal Thickness	60	11.0	20.0	15.367	1.9352
	LT-K Cortex Thickness	60	2.8	9.0	6.473	1.3748
	BMI	60	13.84	26.12	20.2632	2.56769
	Valid N (listwise)	60				
smoker	Age	46	20	55	26.39	7.019
	Height	46	159	190	174.57	7.884
	Weight	46	46	95	65.41	10.284
	RT-K Length	46	8.1	12.0	9.793	.8015
	RT-K Width	46	3.40	6.00	4.5524	.66443
	RT-K Parenchymal Thickness	46	11.0	18.0	14.554	1.7723
	RT-K Cortex Thickness	46	4.10	9.50	6.2674	1.16009
	LT-K Length	46	7.8	11.3	9.685	.7754
	LT-K Width	46	3.0	10.0	4.693	1.1002
	LT-K Parenchymal Thickness	46	10.0	18.0	14.967	1.9666
	LT-K Cortex Thickness	46	4.5	9.0	6.672	1.1680
	BMI	46	16.49	31.38	21.4164	2.70130
	Smoking duration Years	46	3	36	8.52	6.174
	Valid N (listwise)	46				

3.3. Comparison of Renal Dimensions

The Mann-Whitney U test revealed a statistically significant difference in the width of the left kidney between the groups, with smokers showing a greater mean width than non-smokers (p = 0.048). No significant differences were observed for any other renal dimensions, including the length, parenchymal thickness, and cortical thickness of either kidney (p > 0.05 for all). The results are summarized in Table 3.

Table 3. Comparison of Renal Dimensions

Test Statistics	RT-K Length	RT-K Width	RT-K Parenchymal Thickness	RT-K Cortex Thickness	LT-K Length	LT-K Width	LT-K Parenchymal Thickness	LT-K Cortex Thickness
Mann-Whitney U	1200.0	1153.50	1321.00	1184.0	1355.0	1070.5	1231.0	1302.50
Wilcoxon W	2281.0	2983.50	2402.0	2265.0	2436.00	2900.50	2312.0	3132.50
Z	-1.150	-1.446	-.377	-1.250	-.160	-1.978	-.951	-.494
Asymp. Sig. (2-tailed)	.250	.148	.706	.211	.873	.048	.342	.621
a. Grouping Variable: smoker /non smoker								

3.4. Correlation Between demographic and Smoking Duration with Renal Dimensions

Pearson correlation analysis in the smoker group revealed a statistically significant, weak negative correlation between the duration of smoking and the length of both the right kidney (r = -0.303, p = 0.041)(Figure 1& table 4) and the left kidney (r = -0.368, p = 0.012)(Figure 2 Table 4). This indicates that as the duration of smoking increased, the kidney length tended to decrease. No significant correlations were found between smoking duration and renal width, parenchymal thickness, or cortical thickness for either kidney. Table 4.Cigarette consumption per day did not demonstrate any statistically significant correlations with renal parameters, although weak negative trends were noted for several variables. In terms of age, a significant inverse correlation was found between age and LT-K length in smokers (r = –0.306, p = 0.039), suggesting a possible age-related reduction in kidney size among this group. Table 4.

Among non-smokers, BMI showed a statistically significant positive correlation with RT-K parenchymal thickness (r = 0.262, p = 0.043), suggesting a potential influence of body mass on renal parenchymal dimensions. No other significant correlations were observed between age or BMI and kidney parameters in the non-smoking group. Overall, these findings suggest that smoking duration and age may be associated with reduced renal size in smokers, while BMI may influence parenchymal thickness in non-smokers.

		RT-K Length	RT-K Width	RT-K Parenchymal Thickness	RT-K Cortex Thickness	LT-K Length	LT-K Width	LT-K Parenchymal Thickness	LT-K Cortex Thickness
Smoking duration	Pearson Correlation	-.303*	-.285	-.002	-.047	-.368*	-.217	.129	.045
	Sig. (2-tailed)	.041	.055	.987	.757	.012	.148	.394	.765
Cigarettes /Day	Pearson Correlation	-.203	-.110	.074	-.219	-.122	-.205	.072	-.159
	Sig. (2-tailed)	.177	.467	.625	.143	.419	.173	.635	.292
BMI	Pearson Correlation	-.196	.033	.039	-.148	-.040	.098	.040	.089
	Sig. (2-tailed)	.191	.829	.797	.325	.793	.518	.792	.557
Age	Pearson Correlation	-.217	-.130	-.160	-.024	-.306*	-.271	.229	.027
	Sig. (2-tailed)	.147	.388	.289	.875	.039	.069	.125	.861
Non smokers									
BMI	Pearson Correlation	-.007	.073	.262*	-.039	-.051	.053	-.133	-.006
	Sig. (2-tailed)	.959	.577	.043	.765	.697	.688	.311	.964
Age	Pearson Correlation	-.080	.052	.149	.032	-.088	-.114	.222	.046
	Sig. (2-tailed)	.546	.694	.257	.806	.502	.384	.089	.726
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).									

Scatter plot of both kidney length and smoking duration years

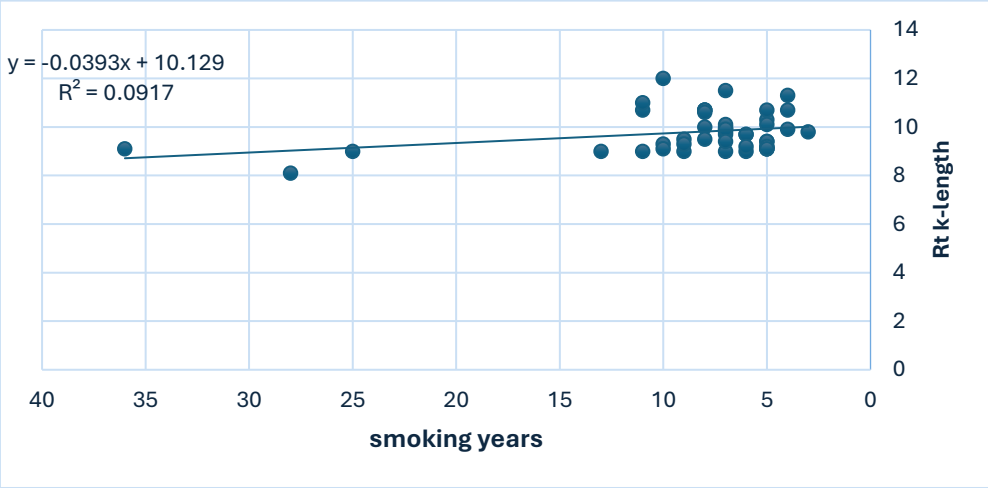

Figure 1: Scatter plot of Rt kidney length and smoking duration years

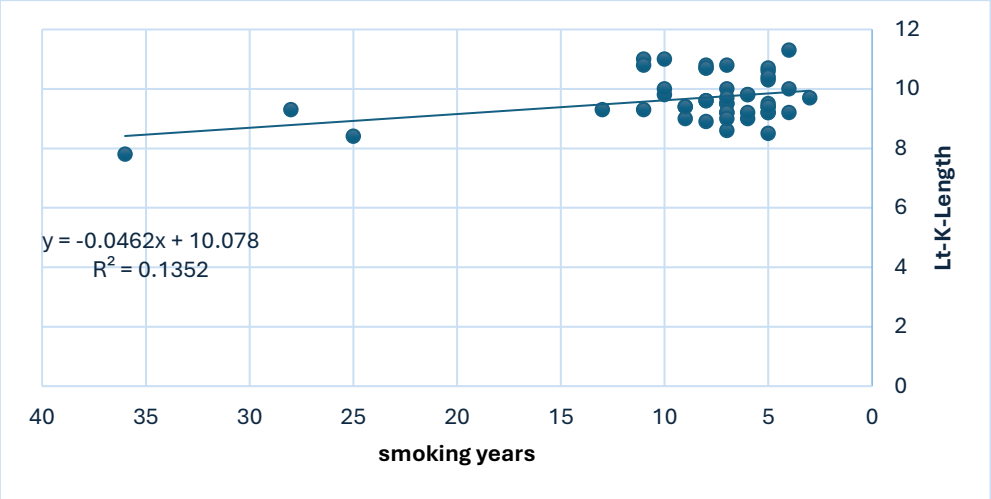

Figure 2: Scatter plot of Lt kidney length and smoking duration years

4. DISCUSSION

This study provides important insights into the relationship between cigarette smoking and renal morphology in a Sudanese population. The primary finding is that a longer duration of smoking was significantly associated with a reduction in both right and left kidney length. This inverse relationship supports the hypothesis that chronic exposure to tobacco smoke contributes to a gradual and subclinical loss of renal mass.

Our results are consistent with the growing body of literature linking smoking to detrimental renal effects. Two cross-sectional studies conducted in Pakistan also found that individuals with a longer smoking history had smaller kidney dimensions [4,6] Similarly, a study by [5] in Indonesia reported a significant association between higher pack-years of smoking and reduced kidney dimensions. The consensus from these studies, including our own, points towards a dose-dependent toxic effect of smoking on the renal parenchyma. The underlying pathophysiology is likely multifactorial, involving chronic renal ischemia, oxidative stress, and endothelial injury caused by the thousands of toxins in cigarette smoke. These insults are known to promote glomerulosclerosis and tubulointerstitial fibrosis, leading to a progressive reduction in functional renal tissue and, consequently, overall kidney size [3].

An interesting and unexpected finding in our study was that smokers exhibited a significantly greater left kidney width compared to non-smokers, despite the trend towards smaller kidney length with longer smoking duration. This finding contrasts with the expected long-term outcome of global renal atrophy. The lack of a significant difference in overall kidney length between the groups could be attributed to the relatively young age and moderate smoking duration (mean 8.5 years) of our smoker cohort. It is plausible that significant atrophy becomes sonographically apparent only after a more extended period of exposure. The increased kidney width

could represent an early-stage compensatory or inflammatory response to smoking-induced renal injury before the onset of irreversible fibrotic changes. However, this finding could also be an anomaly given the study's sample size and cross-sectional design, and it warrants further investigation in larger, longitudinal studies.

The strengths of this study include its focus on a specific, under-researched population and the use of standardized, blinded sonographic measurements. However, several limitations must be acknowledged. First, the cross-sectional design prevents the inference of causality. Second, the sample size was relatively small, which may have limited our power to detect other potential associations. Third, there was a gender imbalance, with all participants in the smoker group being male, which limits the generalizability of the findings to female smokers. Finally, smoking data were self-reported, which introduces potential recall bias.

5. CONCLUSION

In conclusion, this study demonstrates a significant association between the duration of cigarette smoking and reduced kidney length among Sudanese adults. This finding supports the concept that long-term smoking has a detrimental structural impact on the kidneys, likely reflecting a gradual loss of renal parenchyma. These results underscore the importance of public health initiatives aimed at smoking cessation to mitigate the risk of chronic kidney disease.

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