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Original Article

Association of Body Mass Index and Renal Size among Nepalese Healthy Adults in Terai Region

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ABSTRACT

Background & Objective: The prognosis and diagnosis of renal disorders and diseases, as well as the assessment of kidney donors, both utilize ultrasound as a crucial imaging modality. Also, higher BMI is associated with the presence and development of proteinuria in individuals without kidney disease. Therefore, the purpose of this study was to determine the relationship between BMI and renal size by ultrasound imaging in healthy individuals at Janaki Medical College Teaching Hospital, Janakpurdham, Nepal.

Material and Methods: This descriptive-analytical and cross-sectional study was carried out at Janaki Medical College Teaching Hospital, Nepal. All cases that referred for ultrasound were first measured by height and weight and their BMI was calculated. The size of the kidney length and the thickness of the kidney cortex were measured in millimeters. P-value less than 0.05 were considered statistically significant.

Results: There were 110 females and 98 (47.1%) males. The range of ages was 18 to 70, with a mean age of 34.14 (SD 12.6). Both sexes have average BMIs of 23.39 (SD 4.06, range 15.5-36.1). Male subjects mean BMI is 23.705 (SD 3.5907, range 18.1-32.6), while female subjects' mean BMI is 23.108 (SD 4.44, range 15.5-36.1). The difference in BMI was not statistically significant ($p = 0.291$).Right kidney thickness and right and left cortical thickness were statistically significant ($P < 0.005$). Age and renal length and renal cortex thickness were inversely correlated, although height and weight and renal length and renal cortex thickness were positively associated ($p = 0.005$). The length of the kidney and the thickness of the renal cortex, however, did not significantly correlate with BMI ($P < 0.05$). Renal length and renal cortex thickness were negatively correlated with age, while there was a positive correlation between renal length and renal cortex thickness with positive correlation height and weight ($p = 0.005$). However, no significant correlation was found between the length of the kidney and the thickness of the kidney cortex with the BMI ($P < 0.05$).

Conclusion: A relationship between the increase in kidney length and kidney cortex with the weight and height of individuals, while this relationship was not observed in body mass index. Mean renal size is related to the side, age, gender, height and weight as well.

Keywords: Body Mass Index (BMI), Kidney, Trans Abdominal Ultra-Sonography

INTRODUCTION

The kidney is a paired retroperitoneal organ that is symmetrically positioned in the abdominal region. The size of this organ can be determined using an ultrasound by measuring its renal length, renal volume, cortical volume, or thickness [1]. Renal length has proven to be the most reliable clinical measurement in the evaluation of renal size. Renal length is measured by measuring the longitudinal plane parallel to the longest renal axis [2]. It has long been a crucial factor in determining kidney size and has been used as a diagnostic tool for a variety of diseases, including hypertension, hepatitis, renal cystic diseases, kidney stones, renal arterial stenosis, recurrent urinary tract infections, vesicoureteral reflux, chronic kidney disease, kidney tumors, etc. [3]. BMI is a characteristic that can be used to determine an individual's body size. A study by El-Rashid and Abdel-Fattah found a correlation between kidney length and BMI as well as a relationship between kidney length and height of the subjects [4]. Higher BMI is associated with the presence [5] and development of proteinuria in individuals without kidney disease [6].

Furthermore, in numerous large population-based studies, higher BMI appears associated with the presence and development of low estimated glomerular filtration rate (GFR) [7,8], with more rapid loss of estimated GFR over time [9], and with the incidence of end stage renal disease (ESRD) [10]. Moreover, higher BMI has been linked to the occurrence of ESRD and the development of low estimated glomerular filtration rate (GFR) in numerous large population-based studies [7,8]. It has also been linked to faster rate of estimated GFR loss over time [9].

It is crucial to have a set of standard sonographic measures for suitable comparison in order to identify anatomical anomalies in people with renal disorders. There is a dearth of adult statistics on renal measurements, despite the fact that extensive data on these biometric measurements in infants and children have been published in literature. One of the first such studies, carried out in 1982 on 52 patients with normal renal function, was done by Brandt et al. [11]. The scientific information that currently exists reveals diverse findings about kidney size in various groups. As reported by Arooj et al., different ethnic groups have different kidney sizes [12]. Based to research by Muthusami et al., the average kidney length in Indian populations is shorter than that described in western literature [13]. Sah et al. in a Nepalese study revealed that the average renal length, width, and thickness in Nepalese healthy individuals were 9.8 cm, 5.25 cm, and 4.23 cm, respectively. The left kidney was longer than the right kidney in length [14].

Different countries with a diverse population of ethnic backgrounds have attempted to determine the average normal renal length as measured by sonography in their localities, looking for any possible correlations with factors such as age, height, sex, and body weight [15,16]. Scientific Publications

describe the size of the kidneys in healthy persons are measured sonographically around the world [1,15,17]. However, it has been noted that there are dearth of published data on the sonographic evaluation of kidneys in Nepalese healthy people with estimation of Kidney size and its relation with BMI. Therefore, the study was designed to correlate the relationship of kidney size with BMI of Nepalese healthy adults at Janaki Medical College Teaching Hospital, Ramdaiya located in Terai region of Nepal.

MATERIAL AND METHODS

Study Site and Design

This descriptive-analytical and cross-sectional study was conducted by the Department of Human Anatomy in collaboration with Department of Radiology at Janaki Medical College Teaching Hospital, Ramdaiya during the period of April 2019 to October 2019.

Study Population

Two hundred and eight two apparently healthy volunteers aged 18 years and above were initially selected for the study.

Data Collection Procedure

A semi-structured questionnaire with questions about history, demographics, and other topics was developed. Visitors who presented with the patients served as the subjects, or volunteers from the neighborhood who were chosen at random. Their age, sex, height (meters), weight (kg), and blood pressure (left arm, sitting position) were taken after they gave their consent for the study. People with normal blood pressure were encouraged to participate in laboratory tests that included routine and microscopic urine examination, fasting or random blood glucose testing, and serum creatinine measurement. The Cockcroft-Gault formula was used to calculate creatinine clearance [18]. An expert radiologist performed an abdominal ultrasound utilizing a Toshiba MEMIOMX, Power vision 6000, Tokyo, Japan, ultrasound equipment and a 3.5MHz convex transducer after all laboratory parameters were confirmed to be normal. Measurements included renal length, breadth, and thickness. The greatest distance between the superior and inferior poles of the kidney was used to determine renal length. The maximal medio-lateral distance at the level of the renal hilum was used to calculate renal width. The maximal antero-posterior distance at the level of the renal hilum was used to quantify renal thickness.

Inclusion and exclusion Criteria

The adult healthy individuals were included. The participants who had any abnormal medical conditions and had previously undergone kidney surgical treatment or disease, high blood pressure, high blood sugar levels, abnormal urine examination findings, abnormal creatinine clearance, or acquired or congenital kidney anomalies in abdominal ultrasound (Hydronephrosis, grossly small kidney, solitary kidney, horse-shoe kidney, malrotated kidney, polycystic kidney, etc.) were all excluded from the study. 29 people with aberrant findings and 5 people who withdrew before studies were completed were excluded. Hypertensive and obese individuals were also excluded.

Ethical Statement

A letter of ethical consideration (IRC/13/2078-079) was approved by the Institutional Review Committee at Janaki medical college teaching hospital.

Statistical Analysis

The data was entered into MS word and transferred to SPSS version 21. Descriptive statistics was used for the description of the central tendencies and spread of the data. Differences of renal dimensions between the left and right kidney was analyzed using the paired t-test, and that between male and female was analyzed using the unpaired t-test. P-value less than 0.05 were considered statistically significant.

RESULTS

In the present study, total number of study population was 208. There were 98 (47.1%) males 110 (52.9%) females. The mean age was 34.14 (SD 12.6, range 18-70) years. The mean age of male subjects was 36.71 (SD 14.97, range 18-70) years and female subjects was 31.85 (SD 9.53, range 18-66) years. The difference between sexes was statistically significant (p = 0.005).The mean height of male subjects was 1.6 (SD 0.07, range 1.45 - 1.73) and female was 1.5 (SD 0.04, range 1.42 - 1.64) m. The difference in height of both sexes was statistically significant (p = 0.001). The mean weight of male subjects was 60.68 (SD 10.176, range 41 – 81.5) kg and female was 51.25 (SD 10.086, range 34 - 79) kg. The difference in weight of both sexes was statistically significant (p = 0.001).

The mean BMI of male subjects was 23.705 (SD 3.5907, range 18.1 – 32.6) and female was 23.108 (SD 4.44, range 15.5 – 36.1). The

Table1: Demographic profile and parameters of body habitus

	Overall (n=208)	Male (n=98)	Female (n=110)	p-value
Mean age (years) Range SD	34.14 18 - 70 12.6	36.71 18 - 70 14.97	31.85 18 - 66 9.53	0.005
Mean height (meter) Range SD	1.53 1.42 - 1.73 0.08	1.6 1.45 - 1.73 0.07	1.5 1.42 - 1.64 0.04	0.001
Mean weight (Kg) Range SD	55.7 34 - 81.5 11.15	60.68 41 – 8.5 10.176	51.25 34 - 79 10.086	0.001
Mean body mass index Range SD	23.39 15.5-36.1 4.06	23.705 18.1 – 32.6 3.5907	23.108 15.5 – 36.1 4.44	0.291

Table 2: Association of body habitus parameters with renal parameters

		Right kidney			Left kidney		
		Length	Breadth	Thickness	Length	Breadth	Thickness
Age	Pearson Correlation	-0.282	-0.168	-0.244	-0.309	-0.279	-0.352
	p-value	0.001	0.015	0.001	0.001	0.001	0.001
Height	Pearson Correlation	0.166	0.264	0.143	0.248	0.373	0.131
	p-value	0.016	0.001	0.039	0.001	0.001	0.059
Weight	Pearson Correlation	0.150	0.383	0.383	0.257	0.322	0.423
	p-value	0.031	0.001	0.001	0.001	0.001	0.001
BMI	Pearson Correlation	0.074	0.285	0.223	0.231	0.283	0.239
	p-value	0.287	0.001	0.001	0.001	0.001	0.001

difference in BMI statistically was not significant (p = 0.291). The height and body mass index of these individuals were significantly higher in males (p-0.001). Table 2 highlights the mean right renal length was 9.8 (SD 0.898, range 7.8 – 12.17) cm. The mean length of right kidney wass 9.65 (SD 0.87, range 8 - 11.8) cm. and that of left kidney was 9.98 (SD 0.89, range 7.8 - 12.17) cm.

The difference between right and left renal length was statistically significant (p = 0.001). The mean right renal breadth was 5.25 (SD 0.903, range 3.5 – 7.6) cm. The mean breadth of right kidney was 5.18 (SD 0.79, range 3.5 - 7.4) cm. and that of left kidney was 5.32 (SD 0.99, range 3.38 - 7.6) cm.

The difference between right and left renal breadth was statistically not significant (p = 0.120). The mean right renal thickness was 4.227 (SD 0.702, range 2.75 – 6.2) cm. The mean thickness of right kidney was 4.05 (SD 0.63, range 2.75 - 5.5) cm. and that of left kidney was 4.4 (SD 0.72, range 3.1 - 6.2) cm. The difference between right and left renal thickness was statistically significant (p = 0.001).

Table 3a shows that out of five independent variables sex, age, height, weight and BMI, the most important variables that correlated most with the right renal length were age. Here, the age correlated negatively and BMI correlated positively.

Table3b shows that, out of five independent variables sex, age, height, weight and BMI the three most important variables that correlated most with the left renal length are age, height and BMI. Here, the age correlated negatively and height and BMI correlated positively.

Table 3a: Multiple linear regression analysis for right renal length

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	8.877	7.783		1.140	00.255
Age	-0.022	0.005	-0.318	-4.663	0.001
Gender	0.053	0.163	0.031	0.326	0.745
Height	-3.333	7.274	-0.302	-0.458	0.647
Weight	-0.084	0.123	-1.077	-0.686	0.493
BMI	-0.033	0.158	-0.152	-0.206	0.837
(Constant)	7.315	1.771		4.131	0.001
Age	-0.022	0.005	-0.318	-4.670	0.001
Gender	0.053	0.163	0.030	0.324	0.746
Height	-2.132	4.337	-0.193	-0.492	0.624
Weight	-0.093	0.114	-1.191	-0.812	0.418
(Constant)	7.742	1.185		6.535	0.001
Age	-0.022	0.005	-0.321	-4.782	0.001
Height	-2.209	4.320	-0.200	-0.511	0.610
Weight	-0.089	0.114	-1.146	-0.787	0.432
(Constant)	7.536	1.112		6.775	0.001
Age	-0.022	0.005	-0.315	-4.773	0.001
Weight	-0.033	0.026	-0.420	-1.272	0.205
(Constant)	8.799	0.502		17.523	0.001
Age	-0.022	0.005	-0.311	-4.714	0.001

Table 3b: Multiple linear regression analysis for left renal length

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-1.108	7.456		-0.149	0.882
Age	-0.024	0.005	-0.343	-5.402	0.001
Gender	0.067	0.156	0.037	0.429	0.669
Height	11.150	6.968	0.981	1.600	0.111
Weight	0.075	0.117	0.934	0.639	0.524
BMI	0.161	0.151	0.729	1.062	0.290
(Constant)	-0.608	7.349		-0.083	0.934
Age	-0.025	0.004	-0.347	-5.538	0.001
Height	11.083	6.952	0.976	1.594	0.112
Weight	0.079	0.117	0.987	0.679	0.498
BMI	0.162	0.151	0.733	1.070	0.286
(Constant)	-2.254	6.929		-0.325	0.745
Age	-0.025	0.004	-0.354	-5.716	0.001
Height	9.858	6.705	0.868	1.470	0.143
BMI	0.198	0.141	0.898	1.403	0.162
(Constant)	4.572	1.113		4.110	0.001
Age	-0.026	0.004	-0.360	-5.856	0.001
Height	3.201	0.696	0.282	4.600	0.001
BMI	0.058	0.013	0.262	4.278	0.001

Table 4: Comparison of renal parameters between Individuals with BMI less than 25 and above

Mean SD	BMI < 25 (n=136)	BMI ≥ 25 (n=72)	p-value
Rt. Kidney length(cm) SD	9.61 0.913	9.7 0.785	0.445
Rt. Kidney breadth (cm) SD	5.036 0.813	5.47 0.67	0.001
Rt. Kidney thickness (cm) SD	3.99 0.637	4.15 0.615	0.083
Lt. Kidney length (cm) SD	9.83 0.912	10.26 0.797	0.001
Lt. Kidney breadth (cm) SD	5.23 1.09	5.49 0.768	0.070
Lt. Kidney thickness(cm) SD	4.36 0.677	4.5 0.798	0.145

Table 4 depicted that there was a negative correlation between renal length and renal cortex thickness with age, which was also statistically significant (Right renal length: 9.65 and p=0.001 / Thickness of the right renal cortex: 4.05 and p=0.001/left kidney length: 9.98 and p=0.001 / Thickness of the left renal cortex: 4.4 and p=0.001). However, there was a significant correlation between renal length and renal cortex thickness with positive correlation with height and weight (p = 0.001).

DISCUSSION

Knowledge of the kidney size previously relied on cadaveric studies mainly from western world. The introduction of imaging procedures like ultrasound, CT scan, and MRI has made it possible to assess kidney size in living bodies with accuracy and without invasiveness. Ultra-sonography has been routinely used for abdomen examination for decades and provides accurate information about the anatomy and size of the kidneys. The length of the kidney is the characteristic that is most frequently assessed in order to determine the size of the kidney in clinical practice, among other kidney measurements such as breadth, thickness, cortical thickness, and volume. Renal size, which varies with age, gender, ethnic origin, height, and weight, is a crucial and easily verifiable measurement as a predictor of renal function [14].

Our study depicted that the mean height, weight and BMI of male subjects were 1.6 (SD 0.07, range 1.45 - 1.73), 60.68 (SD 10.176, range 41 – 81.5) kg, 23.705 (SD 3.5907, range 18.1 – 32.6) whereas for females it was 1.5 (SD 0.04, range 1.42 - 1.64), 51.25 (SD 10.086, range 34 - 79) kg, 23.108 (SD 4.44, range 15.5 – 36.1) respectively. In a similar type of study conducted by Mujahid et al., in Pakistan measured renal dimensions with height and weight under USG in 4035 subjects.

They revealed that height of the subjects ranged from 120–192 cm with a mean of 172.6±6.9 cm for men and 155.2±5.9 cm for women. Similarly, weights ranged from 36–137 Kg with a mean of 76.3±14.4 Kg for men and 67.1±13.9 Kg for women. Statistically significant difference was found between dimensions of RT and LT kidneys, with LT being slightly larger than RT [19]. The dimensions are concurrent with our study. But, a significant increase in RL and renal volume was seen with increase in subject's BMI which do not match our findings. A significantly positive but weak linear relationship was found when RL and BMI were correlated for both kidneys. However, our results were not significant. This might be due to the strong environmental component in the development of kidney size, including the effect of associated nutritional factors in different geographical distribution.

Rasmussen et al., has reported the total renal volume to be the most accurate when correlated with the body weight; and normal values of total renal volume per Kg of body weight were 4.3–8.0 ml/Kg. In normal subjects, the smallest kidney's volume should not be less than 37% of the total renal volume [20]. In previous studies by Emamian et al., [21] and Fernandes et al., [22] a significant correlation was seen between renal length and height bilaterally; while some authors concluded that renal length is not associated with body's height, but with subject's weight, while others believed that lengths and widths of kidneys were not associated with height in either genders [16].

However, some believed that lengths and widths of kidneys were not associated with height in either gender [23]. Our findings are consistent with above findings in previous studies. The Brenner's concept of appropriate renal dosing, which claims that higher body size requires a larger nephron dose to meet its metabolic demands, may be the basis for the close relationship between renal length and body weight [24]. Previous studies weight and BMI had a significant positive correlation with kidney size, regarding gender; weight was also related to all renal measurements [25, 26].

Elsayed NM performed a study on 100 adults in Saudi volunteers revealed that the significance increase of right and left lengths were associated with increased BMI [27]. However, Cheong et al., revealed that there was no correlation between kidney dimensions and BMI [28]. Lavanya and Sukumar that there was no relationship between renal size and body habitus and that renal size was independent of BMI are consistent with other research [29]. Increased BMI was found to be closely related to an increased risk of developing both chronic renal disease and ESRD (end stage renal disease), reported to several studies [7,30,31].

Previous studies from different geographical areas demonstrate a strong relationship between renal function and patient's BMI [16,32]. It might be due to the possible explanations hypothesized that the presence of liver on right side with less spatial growth of the corresponding kidney and greater blood flow to the left kidney on account of a shorter left renal artery [21]. Due to the circumstance that it was conducted in a single centre only with a small population, our study has limitations. Future research should examine the significance of these moderating factors in relation to race in larger populations using a long-term follow-up methodology. It is suggested that physicians, researchers, and radiologists should establish a normal kidney size for each individual by considering variables like sex, age, underlying diseases, anthropometric features, and diet.

CONCLUSION

The study concludes with a relationship between an increase in kidney length and renal cortex and an individual's weight and height; however, this relationship was not shown with body mass index. The side, age, gender, height, and weight are all associated to mean renal size

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Conflict of interest

None declared

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*manuscript-**NBS,RKP,NS**. All the authors read and approved final draft of manuscript.*

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