Sonographic Evaluation of Renal Dimensions and their Correlation with Gender, Weight, and Height in Normal Young Adults of Uttar Pradesh Region

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Abstract

Background & Objectives: Renal size is an important parameter used in the diagnosis and follow up of renal diseases. However, while making decisions, clinicians must be aware of the dependence of renal length on the anthropometric indices. There is no established nomogram for renal sizes in the Indian population. Therefore, a study was under taken to help standardized a criteria to be used in clinical assessment of certain disease processes largely rely on renal dimensions.

Methods: A prospective observational study was carried on 300 individuals (207 males and 93 females) between the age group of 18 to 30 years in the department of Anatomy King George's Medical University U.P. Lucknow. Renal length, breadth, thickness and cortical thickness of both sides were measured sonographically and their correlation with sex, weight, and height of individual were determined.

Results: The mean length of left kidney vs. right kidney was 102.4+5.4mm vs. 99.9+5.7mm, respectively, $p<0.001$. the mean length of kidney in males vs. females was 101.1+5.0 vs. 97.3+6.4 for right side, 103.6+4.7 vs. 99.8+5.8 for left, $p<0.001$. The mean breadth of kidney in males differed between left vs. right (50.3+3.0 vs. 50.7+3.8, $p=0.046$). The mean thickness of kidney left vs. right was 37.2+3.5 vs. 36.2+4, $p<0.001$, the difference remained among gender. Whereas, cortical thickness was not differed between left and right side, but had difference among different gender. With increasing body weight and height, significant increase in kidney length of both the sides was observed ($p<0.05$).

Conclusion: Mean value of renal length, breadth, thickness and cortical thickness in our population were lower as compared to their western counterparts. The heights of the individual were found to be most important factors affecting the dimensions of kidney. Anthropometries did not show consistent relations i.e. on both sides of the kidney.

Key words: Renal length, Gender, Height, Weight, Ultrasonography

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Introduction

Kidneys are important regulatory organs of vertebrates. Assessment of kidney size is essential part of systemic evaluation in general clinical practice. Change in size of kidney is an indicator of a number of physiological and pathological situations including uninephrectomy, diabetes mellitus, and chronic electrolyte imbalances[1]. Renal size has been shown to be dependent on a number of factors including ethnicity, age, gender, anthropometry and health status of an individual.[2,3,4,5,6,7]

Owing to these variances, ideal normative values should be specific to a particular ethnic group and should be established separately for different age, gender and anthropometric considerations.

In the past few decades, ultrasonographic assessment has emerged as a useful technique for *in vivo* assessment of renal size with high reliability and accuracy[8,9,10].

Unfortunately, most of the data related with establishment of normative values comes from western population and as such there are limited or almost no Indian studies that take into consideration, gender, age and anthropometric differences into account[11]. Although a recent study[6] from Puducherry, India tried to provide normograms for age and anthropometric data among hospital patients, however, no such study on normal healthy individuals is available from anywhere in India. Moreover, given the vast inland ethnic differences, the applicability of this data on entire Indian population is questionable and needs further validation and confirmation.

Hence, the present study was planned to carry out a sonographic assessment of kidney size of normal young adults in a north Indian population taking into consideration the gender, anthropometry and laterality

as the covariates in order to provide a normative range of kidney sizes among healthy young adult population of India.

Material and Methods

The present prospective observational study was conducted in the Department of Anatomy, King George's Medical University, U.P. Lucknow. The study was approved by ethical committee of King George Medical University, U.P. Lucknow. This study was conducted on 300 students of 1st year M.B.B.S. and B.D.S. batches of 2012, both male and female, 16-30 years of age, apparently looking healthy, coming to the Department of Anatomy of King George's Medical University, U.P. Lucknow. Informed consent was obtained from all the participants.

Individuals with any history of frequency of micturition, burning in micturition, anasarca, trauma to abdominal region, incontinence, straining during micturition, change of colour of urine, retention of urine, renal calculus, renal tuberculosis and family history of renal diseases were excluded from the study.

Anthropometry: Anthropometric measurements (height and body weight) were made using Stadiometer (Anand Medical Exports, Delhi) and a portable weighing machine (Scure). Both the machines were standardized and calibrated and reliability of measurements was established by test-retest method.

Weight of the subject was taken by the weighing machine in kilograms.

Height of the subject was recorded by the stadiometer to the nearest centimeter which was then converted into meter.

USG Evaluation: All the subjects were asked to do overnight fasting. Oral intake was restricted for a minimum of 6 hours. Before examination students were asked to empty their bladder. Procedure of ultrasound scanning was explained to them by the operator.

Ultrasound gel was applied on the subject's skin and moved over the area being studied. Initially the scanning was done in supine position to exclude the presence of any renal pathology like stone, cyst, dilatation of calyces and horseshoe shaped kidney. If any of the pathological features were found to be present, then subject was excluded from the study. After this subject was asked to lie in left lateral position to examine right kidney and right lateral to examine left kidney as the image is best seen in this posture. After locating the kidney subject was asked to hold his breath for a while to measure various parameters.

Once the kidney was located, the maximal longitudinal axis was evaluated from ventral side and **renal length** (Fig. 1) was measured as the maximum bipolar dimension in longitudinal plane. **Width and thickness** (Fig. 2, 3) were measured in a section perpendicular to the longitudinal axis of kidney as assessed from the longitudinal image. The probe was thus not necessarily perpendicular to the skin. The level of this transverse section was intended to be placed quite close to the hilum of kidney but at the same time free of the pelvis. Width and thickness were then measured in two orthogonal directions. **Cortical thickness** is the distance between the renal capsule and the external margin of the hypoechoic medulla was measured in four points-the upper pole, lower pole, and two points of the lateral cortex—for each kidney.

All the measurements were performed by a single consultant.

Calculated Parameters

- Body mass index (in kg/meter^2) of the subject was calculated by using following formula:

BMI= Weight (kg)/height^2 (in meter)

Statistical Analysis: The data was analyzed using Statistical Package for Social Sciences, version 15.0. Paired 't'-test, Independent samples 't'-test and ANOVA was used to compare the data. The confidence level of the study was kept at 95%, hence a "p" value less than 0.05 indicated a statistically significant association.

Results

Age of study group ranged from 18 to 30 years. Majority of them were males (69%) **(Table 1)**.

Body weight of study group ranged from 37.8 to 95 kg with a mean value of 59.5±9.0 kg. On dividing the distribution in quartile ranges, the first quartile value was <53 kg and had 81 (27.0%) subjects, second quartile range was 53-58.9 kg and had 56 (18.7%) subjects, third quartile range was 59-64.9 kg and had 78 (26.0%) subjects. Finally, the fourth quartile had 85 (28.3%) subjects with body weight ≥65 kg **(Table 1)**.

Height of subjects ranged from 148 to 185 cm with a mean value of 167.5±7.6 cm. The first quartile range for height was <162 cm and had 74 (24.7%) subjects, second quartile had 76 (25.3%) subjects with height ranging from 162 to 168.4 cm. The third quartile for height was 168.5-172.9 cm and had 67 (22.3%) subjects. Height for the fourth quartile was ≥173 cm and was observed in 83 (27.7%) subjects **(Table 1)**.

For BMI, WPRO (2000) criteria was used for categorization. As per these criteria, 43 (14.3%) subjects were underweight (BMI <18.5 kg/m^2). Majority of subjects were in normal weight category (BMI 18.5-22.9 kg/m^2) (n=195; 65.3%). There were 49 (16.3%) overweight and 12 (4%) subjects with risk of obesity. Mean BMI of subjects was 21.1±2.3 kg/m^2 (range 16.2-29.4 kg/m^2) **(Table 1)**.

Kidney Length: Mean length of left kidney was significantly higher as compared to right kidney for overall as well as both the genders independently ($p<0.001$) **(Table 2).** Mean length of both the kidneys was significantly higher in males as compared to that of

females (p<0.001) **(Table 2).** With increasing body height, weight, and BMI a significant increase in kidney length of both the sides was observed (p<0.05) (**Table 2).**

Kidney Breadth: Overall as well as in females, mean kidney breadth of two sides did not vary significantly (p>0.05), however in males, mean breadth of right kidney was statistically greater as compared to that of left kidney (p=0.046). Mean breadth of kidney, in males, was significantly higher as compared to that of females (p<0.001) on both side (**Table 3)**. With increasing body weight, and height, a significant increase in kidney breadth was also observed for both the sides (p<0.001). However, with respect to BMI, a significant incremental trend in kidney breadth was observed for right side only (p<0.001) **(Table 3)**.

Kidney Thickness: Mean value of thickness of left kidney was significantly greater as compared to that of right side for overall as well as both the genders independently (p<0.001) **(Table 4)**. With increasing body weight, and height, the thickness showed a significant increasing trend. However, this association was not significant statistically for BMI **(Table 4)**.

Cortical Thickness: On overall evaluation, mean cortical thickness of left kidney was higher as compared to that of right kidney but the difference was not significant statistically (p=0.135) **(Table 5)**. However, in both the genders independently, no significant difference between two sides was observed. But, mean cortical thickness of males was higher as compared to that of females for both the sides (p<0.001) **(Table 5)**. An increasing trend of body weight, and height was associated with increasing cortical thickness. A significant similar association was also observed between BMI and cortical thickness of left kidney but not for right kidney (**Table 5).**

Discussion

In present study, normograms of renal measurements were established for young healthy adult north Indian population. Unfortunately most of the normative values for kidney size are from western literature and as such there is a complete lack of normative data on this issue with respect to Indian population despite established ethnic differences[11]. Although, attempts to establish a normative range for Indian population was also done in past by Muthusami *et al.* (2014)[6], however, these attempts were marred by the fact that they included hospital attending patients and not healthy individuals. Moreover, this previous attempt was also limited by the high diversity in age and thus limited availability of cases in different age groups (total 280 cases spanned in five different age groups ranging from 18 to 72 years. In another attempt, Otiv *et al.* (2012)[12] established normative range of kidney size for 1000 normal Indian children aged 1 month to 12 years and established an association between age, changing anthropometry and renal length and volume. However, no such study in normal adult population on a reasonable sample size is available in literature.

In present study, we completed this assessment in 300 young adults aged 18 to 30 years and found a significant association between anthropometric parameters and renal dimensions, thus showing that renal size is dependent on a great extent to the anthropometric parameters. A relationship between anthropometric parameters and renal size is well established and is also stated to be the basis of ethnic differences[13].

In present study, the renal dimensions show a difference in laterality with left side being significantly larger as compared to right side. This is another finding which has been reported in previous studies too[7,8,14,15,16,17,18,19]. In present study, BMI showed a weaker correlation with renal measurements as compared to other anthropometric parameters, one of the reasons for this could be the higher prevalence of normal healthy adults with normal BMI, this might be owing to the fact that we included only on the healthy individuals. Subnormal and above normal values are often associated with health related abnormalities.

In present study, gender wise differences were also observed in renal size with male showing significantly larger renal measurements as compared to females. Similar observations were made in the study of Muthusami *et al.* (2014)[6] too. These differences could once again be attributed to the differences in body structure and composition of two genders.

The findings of present study, for the first time attempted to serve the long felt need of providing a normative range of renal measurements with respect to different anthropometric and body stature groups for the normal healthy individuals. Subsequent studies to evaluate utility of these normative values are recommended to by studying variation in normative ranges in different health compromised groups.

Table 1: Profile of Subjects enrolled in the study

SN	Characteristic	Statistic
1.	Age Range (in years)	18-30
2.	Gender	
	Male	207 (69.0%)
	Female	93 (31.0%)
3.	Body weight (in kg)	
	Q1 (<53 kg)	81 (27.0%)
	Q2 (53-58.9 kg)	56 (18.7%)
	Q3 (59-64.9 kg)	78 (26.0%)
	Q4 (≥65 kg)	85 (28.3%)
	Mean Weight ± SD (Range)	59.5±9.0 (37.8-95.0)
4.	Height (in cm)	
	Q1 (<162 cm)	74 (24.7%)
	Q2 (162-168.4 cm)	76 (25.3%)
	Q3 (168.5-172.9 cm)	67 (22.3%)
	Q4 (≥173 cm)	83 (27.7%)
	Mean Height ± SD (Range)	167.5±7.6 (148-185)
5.	BMI (kg/m^2)	
	Underweight (<18.5 kg/m^2)	43 (14.3%)
	Normal weight (18.5-22.9 kg/m^2)	196 (65.3%)
	Overweight (23.0-24.9 kg/m^2)	49 (16.3%)
	Obesity risk (25.0-29.9 kg/m^2)	12 (4.0%)

Table 2: Normative range for renal length for different covariates

SN	Body weight	Right side					Left side				Significance of difference (paired "t"-test)	
		n	Mean (mm)	SD	95% CL (Normative range)		Mean (mm)	SD	95% CL (Normative range)			
					Lower	Upper			Lower	Upper	"t"	"p"
1.	**Overall**	300	99.9	5.7	99.3	100.6	102.4	5.4	101.8	103.0	12.048	<0.001
2.	**Gender**											
	Male	207	101.1	5.0	100.4	101.8	103.6	4.7	103.0	104.3	-11.047	<0.001
	Female	93	97.3	6.4	96.0	98.6	99.8	5.8	98.6	100.9	-5.619	<0.001
	Sig. (Male vs Female)	t=5.619; p<0.001					t=6.110; p<0.001					
3.	**Body weight**											
	Q1	81	96.4	6.3	95.0	97.8	99.1	6.5	97.7	100.5	-6.453	<0.001
	Q2	56	100.0	5.3	98.7	101.4	102.9	5.1	101.5	104.2	-5.721	<0.001
	Q3	78	100.9	5.5	99.6	102.1	103.0	4.3	102.0	103.9	-4.981	<0.001
	Q4	85	102.4	3.7	101.6	103.1	104.8	3.3	104.1	105.5	-6.982	<0.001
	Sig. (Inter-quartile)	F=18.934; p<0.001					F=19.534; p<0.001					
4.	**Body height**											
	Q1	74	95.2	6.1	93.8	96.6	98.0	6.4	96.5	99.4	-6.349	<0.001
	Q2	76	99.5	5.2	98.4	100.7	102.1	4.6	101.0	103.1	-6.534	<0.001
	Q3	67	101.0	4.3	100.0	102.1	103.5	3.2	102.7	104.3	-4.901	<0.001
	Q4	83	103.6	3.4	102.9	104.3	105.8	3.0	105.2	106.5	-6.417	<0.001
	Sig. (Inter-quartile)	F=40.486; p<0.001					F=41.455; p<0.001					
5.	**BMI category**											
	Underweight	43	100.1	5.3	98.6	101.7	102.9	4.8	101.5	104.4	-5.200	<0.001
	Normal	196	99.9	5.8	99.1	100.7	102.4	5.5	101.6	103.2	-9.464	<0.001
	Overweight	49	99.7	5.6	98.1	101.3	101.9	5.4	100.4	103.5	-4.166	<0.001
	Obesity risk	12	100.3	6.3	96.8	103.9	103.1	5.6	99.9	106.3	-7.272	<0.001
	Sig. (Inter-category)	F=40.486; p<0.001					F=41.455; p<0.001					

Table 3: Normative range for renal breadth for different covariates

SN	Body weight	Right side					Left side				Significance of difference (paired "t"-test)	
		n	Mean (mm)	SD	95% CL (Normative range)		Mean (mm)	SD	95% CL (Normative range)			
					Lower	Upper			Lower	Upper	"t"	"p"
1.	**Overall**	300	50.0	4.0	49.6	50.5	49.8	3.1	49.5	50.2	1.243	0.215
2.	**Gender**											
	Male	207	50.7	3.8	50.2	51.2	50.3	3.0	49.9	50.7	2.011	0.046
	Female	93	48.6	4.1	47.8	49.4	48.8	3.2	48.2	49.4	-0.768	0.444
	Sig. (Male vs Female)	t=4.267; p<0.001 (S)					t=4.001; p<0.001 (S)					
3.	**Body weight**											
	Q1	81	48.2	4.4	47.2	49.1	48.2	3.2	47.5	48.9	-0.036	0.971
	Q2	56	50.2	3.6	49.3	51.2	49.4	2.8	48.6	50.1	3.054	0.003
	Q3	78	50.2	3.4	49.4	51.0	49.9	2.7	49.3	50.5	1.369	0.175
	Q4	85	51.5	3.7	50.7	52.3	51.7	2.5	51.1	52.2	-0.503	0.616
	Sig. (Inter-quartile)	F=10.679; p<0.001 (S)					F=21.277; p<0.001 (S)					
4.	**Body height**											
	Q1	74	47.5	3.9	46.6	48.4	48.1	3.3	47.4	48.9	-2.029	0.046
	Q2	76	49.4	3.8	48.5	50.2	49.4	2.9	48.8	50.1	-0.328	0.744
	Q3	67	50.6	3.3	49.8	51.4	50.0	2.6	49.4	50.6	2.498	0.015
	Q4	83	52.4	3.2	51.7	53.1	51.6	2.6	51.0	52.2	2.749	0.007
	Sig. (Inter-quartile)	F=26.034; p<0.001 (S)					F=19.852; p<0.001 (S)					

Table 4: Normative range for renal thickness for different covariates

SN	Body weight	Right side					Left side				Significance of difference (paired "t"-test)	
		n	Mean (mm)	SD	95% CL (Normative range)		Mean (mm)	SD	95% CL (Normative range)			
					Lower	Upper			Lower	Upper	"t"	"p"
1.	**Overall**	300	36.2	4.0	35.8	36.7	37.2	3.5	36.8	37.6	6.791	<0.001
2.	**Gender**											
	Male	207	36.4	4.1	35.8	36.9	37.3	3.6	36.8	37.8	-5.760	<0.001
	Female	93	36.0	3.7	35.2	36.7	36.9	3.1	36.3	37.6	-3.589	0.001
	Sig. (Male vs Female)	t=0.725; p=0.569 (NS)					t=0.947; p=0.344 (NS)					
3.	**Body weight**											
	Q1	81	34.9	3.2	34.2	35.6	35.8	2.6	35.2	36.4	-3.536	0.001
	Q2	56	36.7	4.4	35.6	37.9	37.2	4.2	36.1	38.3	-1.904	0.062
	Q3	78	36.7	3.5	35.9	37.5	37.8	3.1	37.1	38.5	-3.663	<0.001
	Q4	85	36.7	4.6	35.7	37.7	38.0	3.6	37.2	38.7	-4.116	<0.001
	Sig. (Inter-quartile)	F=4.161; p=0.007 (S)					F=7.110; p<0.001					
4.	**Body height**											
	Q1	74	34.9	2.8	34.3	35.6	35.8	2.4	35.2	36.3	-3.599	0.001
	Q2	76	36.3	3.7	35.5	37.1	36.9	3.6	36.1	37.7	-2.229	0.029
	Q3	67	36.9	4.3	35.8	37.9	38.0	3.7	37.1	38.9	-3.687	<0.001
	Q4	83	36.9	4.6	35.9	37.8	38.1	3.6	37.4	38.9	-4.041	<0.001
	Sig. (Inter-quartile)	F=4.104; p=0.007 (S)					F=8.014; p<0.001 (S)					

Table 5: Normative range for cortical thickness for different covariates

SN	Body weight	Right side					Left side				Significance of difference (paired "t"-test)	
		n	Mean (mm)	SD	95% CL (Normative range)		Mean (mm)	SD	95% CL (Normative range)			
					Lower	Upper			Lower	Upper	"t"	"p"
1.	**Overall**	300	15.5	2.3	15.2	15.7	15.6	2.0	15.3	15.8	1.498	0.135
2.	**Gender**											
	Male	207	15.8	2.4	15.5	16.1	16.0	2.1	15.7	16.3	-1.936	0.054
	Female	93	14.7	1.7	14.3	15.0	14.6	1.5	14.3	14.9	0.474	0.637
	Sig. (Male vs Female)	t=4.059; p<0.001 (S)					t=5.773; p<0.001 (S)					
3.	**Body weight**											
	Q1	81	14.5	1.7	14.1	14.9	14.4	1.5	14.1	14.7	0.721	0.473
	Q2	56	15.4	2.3	14.8	16.0	15.5	1.8	15.1	16.0	-0.939	0.352
	Q3	78	15.9	2.2	15.4	16.4	15.9	1.9	15.5	16.3	0.145	0.885
	Q4	85	16.0	2.5	15.5	16.5	16.4	2.2	16.0	16.9	-2.650	0.010
	Sig. (Inter-quartile)	F=7.793; p<0.001 (S)					F=16.966; p<0.001 (S)					
4.	**Body height**											
	Q1	74	14.1	1.2	13.8	14.4	14.3	1.3	14.0	14.6	-1.656	0.102
	Q2	76	14.8	1.8	14.4	15.2	15.1	1.4	14.7	15.4	-1.450	0.151
	Q3	67	16.0	2.2	15.5	16.6	16.2	2.1	15.7	16.7	-1.128	0.263
	Q4	83	16.7	2.7	16.2	17.3	16.6	2.2	16.2	17.1	0.778	0.439
	Sig. (Inter-quartile)	F=25.997; p<0.001 (S)					F=26.265; p<0.001 (S)					

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