Normal Renal Dimensions in Iranian Adults Measured by Ultrasound

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ABSTRACT

Introduction: Correct interpretation of kidney images requires the knowledge of its normal size. This study aimed to establish normal values for kidney length and parenchymal thickness and identify the potential related factors in a group of Iranian adults.

Methods: Renal dimensions, including length and parenchymal thickness were measured by sonography in 103 individuals with no renal disease. Statistical analyses were done to find the effect of different variables such as side, age, and gender using 2-tailed t-test, Mann-Whitney test, paired t test, and Wilcoxon-signed rank test. The correlation of renal dimensions with anthropometric parameters, including weight, height, and body mass index (BMI) was analyzed using the Pearson correlation coefficient.

Results: Mean (SD) kidney length was 104.96(6.6) mm for the right, and 106.22(6.16) mm for the left kidney (P=0.02). Mean (SD) parenchymal thickness for the right kidney was 16.9(1.6) mm and on the left side, it was 18.2(1.7) mm (P<0.001). Gender related analysis showed significant differences between male and female renal length and parenchymal thickness (P<0.05). Age group analysis regardless of sex showed significant decrease in renal length and parenchymal thickness beyond the fifth decade of life. There was a positive correlation between bilateral renal length and body weight as well as BMI. Also, there was a weak positive correlation with body height.

Conclusion: Because of several factors affecting on kidney size, its assessment should be made individually. The important influencing factors are ethnicity, gender, age, BMI, and height.

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1. Introduction

Background knowledge of normal renal dimensions help experts in the diagnosis of kidney diseases. Many renal diseases are associated with an increase or decrease in kidney size [1-3]. Thus, it is important to establish the normal range of renal dimensions. Ultrasound is a useful, accessible, non-invasive, and inexpensive method to study renal morphology [4, 5].

Renal length and parenchymal thickness estimation by ultrasound are important parameters in clinical evaluation of adult patients with kidney disease [6]. Measurements of longitudinal renal length involve the least inter-observer variation, and therefore, are more reproducible than volumetric estimations [4, 7]. Renal parenchymal thickness also was found to be one of the ultrasonic renal parameters that can offer prognostic information on end stage kidneys [8].

Renal size shows individual variations according to the patient's height, sex, and age [9]. Ethnic differences are expected perhaps partly due to the above variables [10]. The changes in renal size can be very suggestive evidence of disease, and their interpretations require specific parameters for the population to study. In general, measurements of renal length and parenchymal thickness of any age are compared with the measurements that are predicted by standard nomograms. However, to the best of our knowledge, the current nomograms (which are widely used) were derived from studies based on Caucasian population [11, 12]. Because our currently used renal nomogram in Iran is based on the western database, it might lead to the false positive or negative diagnosis of kidney dimension. In this regard, the normal pattern of renal dimensions should be established considering its characteristics. Thus, this study aimed to evaluate the renal dimensions in Iranian population, and to verify their possible correlations with gender, body weight, age, and height.

2. Materials and Methods

This comparative cross-sectional study was conducted from July to September 2014 in the Department of Radiology, Hamedan University of Medical Sciences, Hamedan, Iran. The project was approved by our Ethics Committee. A written informed consent was obtained from all patients undergoing ultrasonography.

We prospectively measured kidney size of patients who attended sonography clinic for reasons other than renal examinations. Only patients who were older than 18 years were included in the study. Serum levels of urea nitrogen and creatinine were determined for all patients within the month preceding the examination. The anthropometric measurements, including height, weight, and body mass index (BMI) were also recorded in all subjects.

An ultrasound screening was carried out on 103 healthy volunteers who were matched with the following inclusion criteria: serum creatinine≤1.5 mg/dL, glycaemia≤110 mg/dL in patients aged over 40 years or with BMI>30 kg/m^2, arterial normotensive (systolic blood pressure<140 mmHg and diastolic blood pressure<90 mmHg), no existence of acute or chronic disease capable of causing damage to renal function, and normal appearance of the kidneys by ultrasound. Patients with the following conditions were excluded from the study: having history of hemodialysis or peritoneal dialysis, renal morphologic anomalies (such as horseshoe kidney or ectopic kidney), unilateral or partial nephrectomy, renal parenchymal diseases, polycystic kidneys, multiple bilateral cysts (4 or more), a solitary cyst larger than 1 cm, hydronephrosis, renal transplantation, renal tumors, poor ultrasound examination window (automatically elevated kidney, with interference in costal arches), pregnancy, or extreme obesity. All participants emptied their bladders prior to the examination, to avoid an increase in renal length caused by oral hydration. A single observer made the ultrasound measurements. The scanning was performed with a real-time gray scale B-mode scanner and probes of 3.5 MHz (RT-X200; GE Medical Systems, Milwaukee, WI).

Renal length was measured as the longest pole to pole distance and in 3 positions (supine, supine lateral, and prone). Three measurements were taken for each kidney, registering the longest length in absolute terms. Parenchymal thickness was defined as the combined thickness of the cortex and medulla measured at the upper and lower poles and then averaged.

The results were expressed as mean (SD). Group (gender) comparisons were made using parametric and non-parametric 2-tailed t-tests and Mann-Whitney test for independent samples. To compare right and left kidneys, paired t test and Wilcoxon-signed rank test were used.

An association test was performed between the different measured parameters and the anthropometric variables using the Pearson correlation coefficient. Finally, the total population grouped into age ranges with 10-year intervals and a comparison was done between left and right renal length and parenchymal thickness among different age groups using 1-way analysis of variance, followed by Tukey test (post hoc). A value of P<0.05 was consid-

ered statistically significant. All data were analyzed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA).

3. Results

Demographic data for the study population are shown in Table 1. Participants' ages ranged from 18 to 70 years. The data for the different anthropometric measurements in the total study population were as follows: height, 150 to 190 cm; body weight, 43 to 117 kg, and BMI, 17.85 to 40.01 kg/m^2. When the study population grouped by gender, the following data were found: the range of weight was from 56 to 117 kg for men and 43 to 95 kg for women. The range of height was 158 to 190 cm for men and 150 to 178 cm for women.

The dimensions of kidneys are summarized in Table 2. It also shows the normal values for kidney sizes, split into groups according to gender, and the right and the left kidneys. For comparison between the 2 kidneys, we used the paired t-test and for nonparametric values the Wilcoxon-singed rank test.

The total study subjects were divided according to age groups (Table 3). One-way analysis of variance between means of renal parameters with regard to age groups, showed that renal length increases to the fifth decade and the also parenchymal thickness to a slight extent. Beginning in the fifth decade, the sizes decrease (P<0.05).

Figures 1, 2, and 3 show the mean values for the renal length and parenchymal thickness with respect to gender, age, height, and weight, respectively.

Correlations among renal lengths, parenchymal thickness, body height, weight and BMI, were individually assessed using the Pearson correlation coefficient. This test showed a significant positive correlation between both renal length and parenchymal thickness with the

Table 1. General data of the studied population.

	Sex	N	Mean	Std. Deviation	P value
Age (year)	Male	34	40.147	10.4769	0.12
	Female	69	43.957	12.4066	
Weight (Kg)	Male	34	77.529	13.7140	0.02
	Female	69	68.957	11.9702	
Height (cm)	Male	34	174.441	7.4516	0.00
	Female	69	160.290	5.8513	
BMI (kg/mt^2)	Male	34	25.059	4.0522	0.13
	Female	69	26.435	4.7942	

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Table 2. Normal values for kidney length and parenchymal thickness, classified according to the side of the kidney and gender.

		n	Range (mm)	Mean (mm)	SD	P value
Male	RRL	34	95.0-118.0	106.353	5.9385	0.56
	LRL	34	96.0-120.0	106.912	6.0721	
	RPT	34	14.0-21.0	17.088	1.7121	0.24
	LPT	34	14.0-21.0	18.118	1.7883	
Female	RRL	69	85.0-12.0	104.275	6.8037	0.02
	LRL	69	90.0-12.0	105.884	6.2250	
	RPT	69	13.0-21.0	16.870	1.5138	0.00
	LPT	69	15.0-23.0	18.275	1.6705	
Total	RRL	103	85.0-120.0	104.961	6.5752	0.02
	LRL	103	90.0-120.0	106.223	6.1643	
	RPT	103	13.0-21.0	16.942	1.5769	0.00
	LPT	103	14.0-23.0	18.223	1.7031	

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RRL=Right Renal Length, LRL=Left Renal Length, RPT=Right Parenchymal Thickness, LPT=Left Parenchymal Thickness

Table 3. Distribution of renal length and parenchymal thickness according to age group (years).

(mm)	18-29 N=13	30-49 N=32	40-49 N=30	50-59 N=16	60-69 N=12	P value
RRL (Mean±SD)	102.23±6.78	104.87±6.58	108.03±5.89	102.75±6.77	103.42±5.53	0.007
LRL (Mean±SD)	105.38±5.59	105.50±6.99	108.37±5.44	104.81±5.56	105.58±6.49	0. 14
RPT (Mean±SD)	16.23±1.30	16.63±1.49	17.77±1.36	16.75±1.61	16.75±1.91	0.003
LPT (Mean±SD)	17.62±1.61	18.59±1.41	18.57±1.89	18.13±1.71	17.17±1.64	0.09

RRL=Right Renal Length, LRL=Left Renal Length, RPT=Right Parenchymal Thickness, LPT=Left Parenchymal Thickness

different anthropometric measurements, such as weight, height, and BMI (Table 4).

An association test was performed between left and right renal lengths and also renal length and parenchymal thickness using the Pearson correlation coefficient. This test showed a significant positive correlation between right with left renal length (r=0.616, P<0.001). For the left and right kidney length, the corresponding parenchy-

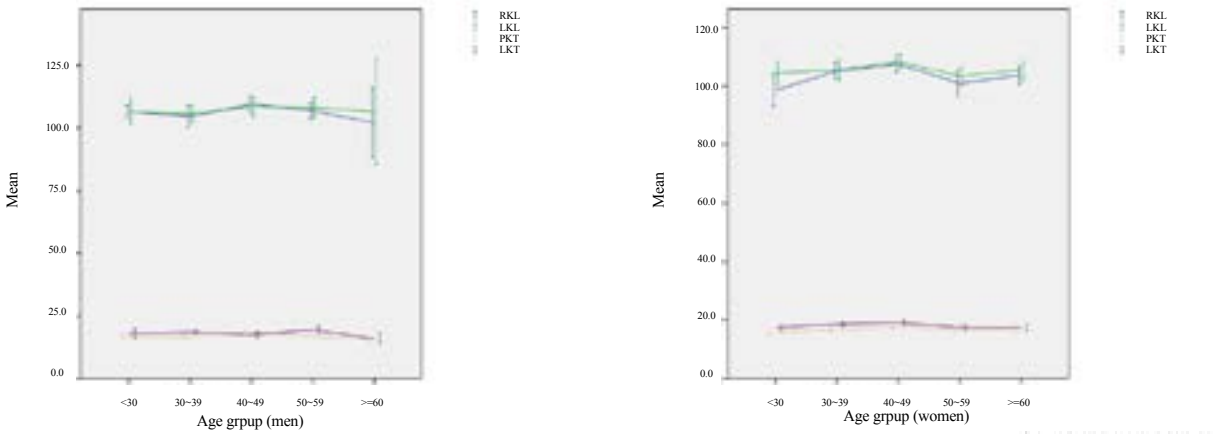

Figure 1. The mean values for the Kidney length and parenchymal thickness in relation to age and the side of the kidney in men and women.

RRL=Right Renal Length, LRL=Left Renal Length, RKT=Right Parenchymal Thickness, LKT=Left Parenchymal Thickness.

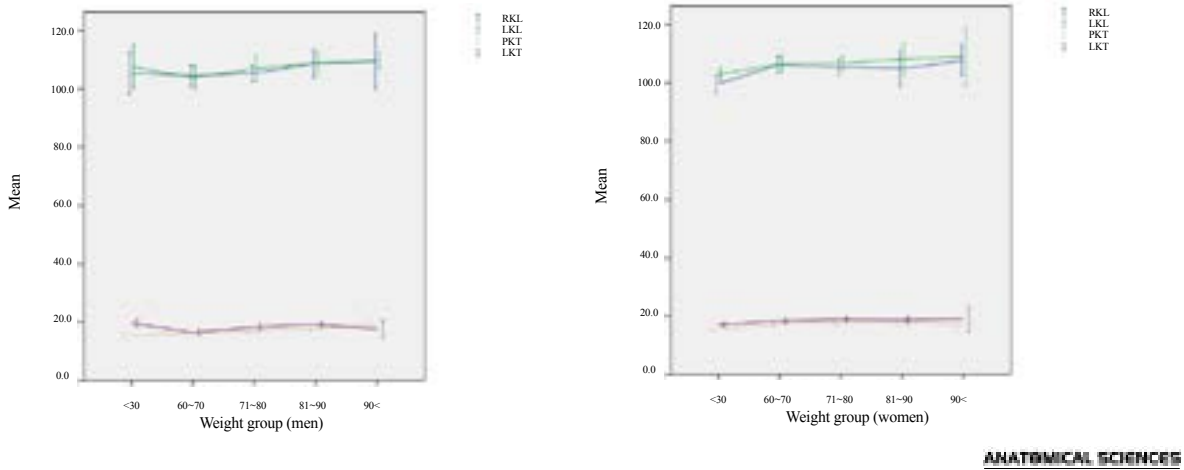

Figure 2. The mean values for the Kidney length and parenchymal thickness in relation to weight and the side of the kidney in men and women.

RRL=Right Renal Length, LRL=Left Renal Length, RKT= Right Parenchymal Thickness, LKT=Left Parenchymal Thickness.

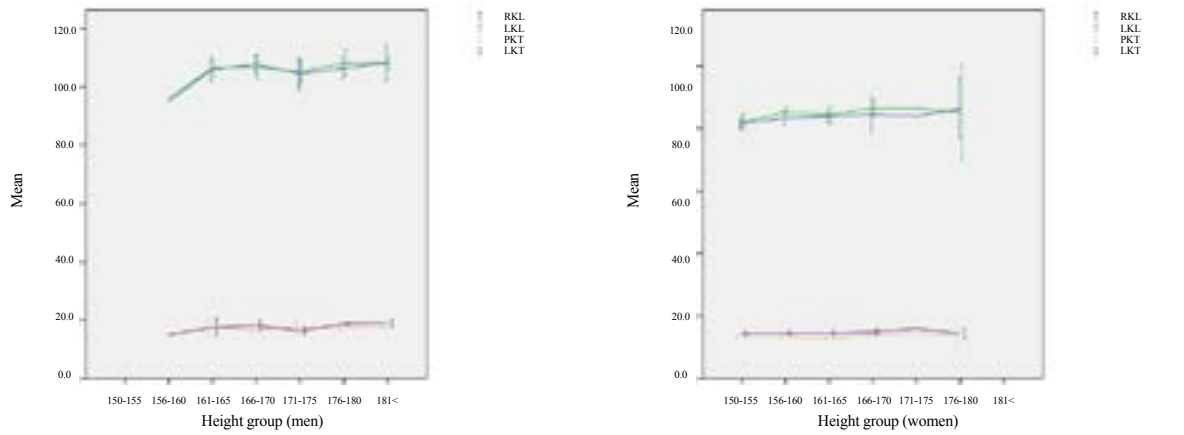

Figure 3. The mean values for the Kidney length and parenchymal thickness in relation to height and the side of the kidney in men and women.

Table 4. Correlations between renal lengths, parenchymal thickness and body height, weight and BMI.

	Weight	Height	BMI
Right renal length (r) Sig. (2- tailed)	0.306 0.002	0.222 0.024	0.185 0.062
Left renal length (r) Sig. (2- tailed)	0.325 0.001	0.211 0.032	0.210 0.033
Right parenchymal thickness (r) Sig. (2- tailed)	0.498 0.000	0.113 0.257	0.459 0.000
Left parenchymal thickness (r) Sig. (2- tailed)	0.235 0.017	0.089 0.372	0.195 0.048

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mal thickness correlations were r=0.413(P<0.001) and r=0.404 (P<0.001), respectively.

4. Discussion

Renal disease can change renal size, and may be accompanied by changes in the normal organ structure. Renal measurements by sonography is important in studying renal function and its disorders, which offers the advantage of a non-invasive method [7]. The obtained inter-observer and intra-observer variations in renal length and parenchymal thickness measurements showed that the degree of variation is similar whether the left or right kidney is measured or the measurements are made by one or multiple sonographers. This suggests that determining renal length and parenchymal thickness by sonography of normal adult kidneys are reasonably reliable [4, 7]. Assessment of kidney size should also be made individually because many factors like BMI, height, gender, and age affect the measurements [6].

There are metric and non-metric differences in body components among populations and these variations relate to genetic and environmental factors [10, 13]. The anthropometric profile, such as body weight and height of the samples showed a significant difference between genders, and it has shown that these data are typical of the Iranian population [14].

In the present study, we analyzed renal size in terms of length and parenchymal thickness, in Iranian population by using ultrasound. The evaluations of these parameters are simple, reproducible, reliable, and objective.

In our study, the mean right kidney length was shorter than the left kidney length and the difference was significant (P=0.02). A finding that corresponds with the results of Glodny [9], Fernandes [15], and Akpinar [11]. However, regarding the gender, this difference is not significant in men (P=0.56), probably owning to the sample size and power of the study (Table 5).

Table 5. Comparison of renal lengths reported from different populations.

Author	Population		Renal length			parenchymal thickness		
			Men	Female	All	Men	Female	All
Muthusami P	India (south)[12]	Right	90.68	90.52	90.6	-	-	10.99
		Left	90.75	90.67	90.71	-	-	20.09
Oyuela-Carrasco J	Mexico [16]	Right	100.57	100.29	100.43	-	-	-
		Left	10.72	10.46	100.58	-	-	-
Raza M	Pakistan [22]	Right	100.32	100.00	100.17	9.00	13.8	-
		Left	100.46	100.00	100.23	15.8	14.5	-
Okoye IJ	Nigeria, [18]	Right	-	-	100.33	-	-	-
		Left	-	-	100.45	-	-	-
Okoye IJ	Nigeria[23]	Right	-	-	-	-	-	1.85
		Left	-	-	-	-	-	1.95
Arooj A	Malaysia [17]	Right	90.67	90.7	90.7	-	-	-
		Left	100.04	90.8	90.9	-	-	-
Kang KY	South korea[24]	Right	-	-	100.2	-	-	-
		Left	-	-	100.5	-	-	-
Akpinar IN	Turkey [11]	Right	100.7	100.5	-	-	-	-
		Left	100.9	100.7	-	-	-	-
Fernandes MM	Brazil [15]	Right	120.03	120.01	-	-	-	-
		Left	120.67	120.59	-	-	-	-
Glodny B	Austria [9]	Right	110.2	100.38	100.85	16.3	14.5	15.4
		Left	110.49	100.63	110.13	16.5	15	15.8
Barton EN	Jamaica [19]	-	-	-	-	-	-	9.7
		-	-	-	-	-	-	10.0
Currentstudy	Iranian	right	106.35	104. 27	104.96	17.08	16.87	16.94
		left	106.9	105.88	106.22	18.11	18.27	18.22

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Renal length in our population were smaller than those in the Caucasian population [11, 12] and also those reported for Brazilian [15] and Austrian populations [9], but were similar to the values reported from Mexico [16], Pakistan [6], Malaysia [17], Nigeria [18] and Jamaica [19]. These studies also show the necessity of investigating renal length for each population (Table 5).

The age-related changes of the renal length are well known. In our study, an increase in renal length was found from 18-29 years old up to the fourth decade of life (P=0.007). The increase in the renal length in men up to their fifties has already been documented [9, 12]. Both right and left kidneys length decrease significantly after 50(P=0.008). Previous study reported that kidney's length decreases after age 60 [9].

The normal ranges of kidney lengths are wide. Within the standard deviation of renal length, there are values less than 100 mm in slim youngest and oldest women and up to 120 mm for both men and women in their thirties and forties. The influencing factors for renal length such as height and BMI must be viewed individually to arrive at relevant conclusions.

Renal parenchymal thickness was found to be one of the renal parameters that can offer prognostic information on end stage kidneys [8]. In our study, the mean right kidney parenchymal thickness was shorter than the left kidney thickness and the difference was significant (P<0.001). A finding that corresponds with the results of other authors. Regarding the gender, this difference is not significant in men (P=0.24).

The mean (SD) parenchymal thickness was found to be 1.76(0.16) cm (range=1.30-2.30 cm) as against 1.89(0.36) cm (range=1.10–2.90 cm) reported for a Caucasian population. This implies that the lower normal limit for parenchymal thickness in our study group is 1.30 cm. Values less than 1.30 cm indicate reduced parenchymal thickness as against less than 1.10 cm reported for Caucasians.

Renal parenchymal thickness in our population was smaller than those in the Nigerian [20] and Indian [12], and similar to the values reported from Pakistan [21] and Austria [9]. These studies also show the necessity of investigating renal parenchymal thickness for each population. The noted racial differences in different studies could be due to genetic and environmental variations as well as the different sample sizes.

According to our study, 2 renal lengths significantly and positively correlate with regard to weight, and to the lesser degree with height and BMI. The same results were found in another report from Mexico [16]. Based on the study of Carrasco et al. on Mexican, the renal lengths correlate with body height. The study of Muthusami on Indian also showed a moderate positive correlation of renal length with body weight while there was a weak positive correlation with body height [12]. The results of Glondy et al. study showed linear correlations between height and renal lengths and parenchymal thickness, which are statistically significant in both men and women [9]. All these studies showed significant positive correlation with BMI that was inconsistent with our results.

In our study, an association test was performed between the renal length and parenchymal thickness. There was a strong linear relationship between these 2 renal parameters. Okoye et al. [18] also reported a good linear relationship between renal length and corresponding parenchymal thickness. Renal length and parenchymal thickness are reproducible parameters and indicators of renal function and show variations with age, gender, ethnic background, height, weight, and BMI.

We acknowledge a few limitations of the study. The present study shows the need for (but cannot serve as a nomogram for the Iranian population) a large number of healthy individuals in each age group and across various Iranian ethnicities. Moreover, the patient group was not a randomly selected sample.

In conclusion, the presence of close relationship between kidney size and different factors such as age, weight, and so on encouraged the researchers to study renal sizes for different ethnic groups and body sizes. The results of this study would be helpful in the diagnosis of kidney diseases.

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Conflict of Interest

The authors of this study declared no conflict of interests.

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