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Reference Values of Somatometric and Sonographic Renal Parameters of Apparently Healthy Hausa Children in Kano metropolis, Nigeria

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Abstract

Accurate measurement of organ size is important in children to estimate adequate growth. Among various growth parameters, kidney size is an important parameter used for the clinical evaluation of renal growth and renal abnormalities. The study is aimed at evaluating the renal volume using ultrasound scan in normal Hausa primary school children in Kano aged 2 to 13 years. The study design was prospective cross sectional conducted among healthy Hausa children, aged 2 to 13 in Kano metropolis from October 2017 to October 2019. Approval to carry out the study was obtained from the State Universal Basic Education, Kano, Ministry of Health, Kano. Informed oral and written consent were obtained from the child's parents or caregiver. A simple random sampling was employed in the study and a total of 457 subjects were recruited. The instrument used was MindrayDigiprince DP4900 ultrasound machines with 3.5 – 5.0MHz curvilinear transducer. Renal ultrasound scan was performed on all the selected subjects. SPSS version 22.0 was used for the data analysis. The mean heights, weights and BMI of the subjects were 1.21±0.11m, 20.46±4.92kg and 13.93kg/m^2. The mean renal length, thickness, width and renal volume were 7.69±0.71cm, 3.31 ± 0.42cm, 4.80 ± 0.49cm and 64.79±16.13cm^3 respectively. This study provides data for normal sonographic renal volume and length in Kano metropolis, a Hausa dominated Nigerian population.

Keywords: Kano metropolis, Pediatrics, Renal volume, Sonography.

INTRODUCTION

Childhood is a critical period for the growth of many organ systems, and adequate organ growth is an important aspect of growth evaluation in children (Kim *et al*., 2021).The growth of organ is dependent on the growth of the child's body, and thus, it can be correlated with somatic parameters, such as height, weight in addition to age. Accurate measurement of organ size is important in children to estimate adequate growth. Among various growth parameters, kidney size is an important parameter used for the clinical evaluation of renal growth and renal abnormalities (Kim *et al*., 2013).

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The kidney is the main urinary organ connected to the urinary bladder by ureters and urethra and performs a variety of important functions. It eliminates waste products through excretion of urine, while water and important electrolytes as well as metabolites are conserved. Also, it regulates the osmotic pressure (osmolality) of the body fluids by excreting osmotically dilute or concentrated urine,it regulates the concentration of numerous ions in blood plasma, including Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, bicarbonate (HCO^-_3), phosphate (PO_4^{3-}), and sulphate (SO_2^{4-}) (Akor *et al*., 2010). Kidney plays an essential role in acid–base balance by excreting H+ when there is excess acid or HCO^-_3 when there is excess base and regulates the volume of the extracellular fluid (ECF) by controlling Na^+ and water excretion. It helps in regulating arterial blood pressure by adjusting Na^+ excretion and producing various substances that can affect blood pressure and eliminate the waste products of metabolism including urea, uric acid and creatinine. It removes many drugs and foreign or toxic compounds (Tanner, 2009). Kidney serve as an endocrine organ by producing kinins, 1,25 dihydroxycholecalciferols, rennin and erythropoietin (Ganong, 2001).

Ultrasound (US) however, is known to underestimate renal size by about 20-29 per cent, while magnetic resonance imaging underestimates it by about 4-5 per cent (Egberongbe *et al*., 2010). In spite of its shortcoming, US is a non-ionizing (Konus *et al*,. 1990), non-invasive method with little or no patient preparation and no medication or injection of contrast media needed. The safety of the diagnostic procedure using ultrasound is well established (Wang *et al*., 1989). It is also readily available, less expensive and easily reproducible to a large extent (Egberongbe *et al*., 2010, Okur *et al*., 2014). Renal size can be estimated by measuring renal length, thickness and volume and depends on different factors, including age, gender, body size and body mass index (Muthusami *et al*., 2014). Renal volume grows throughout fetal developmentand childhood (Leung *et al*., 2007, Chandra *et al*., 1999, Scholbach & Weitzel, 2012) and is the most accurate of these parameters is renal volume (Cheong *et al*., 2007). Kidney volume rather than kidney length has also been emphasized by several authors as a true predictor of kidney size in states of good health and disease (Emamian *et al*., 1993**.**

Several studies have assessed renal size and volume in children and have correlated to somatic parameters (Kim *et al*., 2013, Otiv *et al*., 2011, Ravikumar *et al*., 2016). There are reports of some studies on renal sizes in neonates, infants and children among Caucasians, and Asians (Lotus *et al*., 1998, Mesrobian *et al*., 1998). However, reports of similar studies are rare among Africans, especially Nigerians (Adeyekun *et al*., 2007).To the best knowledge of the researchers there is no documented work on renal volume in paediatrics in the study area. The study will provide baseline reference data for renal volume among children in Kano, Nigeria. The findings will also serve as a guide to radiographers, radiologists, paediatrician, pathologists, urologists, nephrologists and anatomists. The study is aimed at evaluating the renal volume using ultrasound scan in normal Hausa primary school children in Kano aged 2 to 13 years.

MATERIALS AND METHODS

The study design was prospective cross sectional conducted among healthy Hausa children, aged 2 to 13years in Kano metropolis from October 2017 to October 2019. Approval to carry out the study was obtained from the State Universal Basic Education, Kano and Ministry of Health Kano state. The pupils attending the selected schools came from various parts of Kano metropolis, therefore, they are considered to represent the children aged 2 to 13 years in Kano metropolis. Informed oral and written consent were obtained from the child's parents or caregiver in the study after explaining the study protocol and giving them choice to participate or decline.

The study population included; all the apparently healthy children aged ranged from 2 to 13years from Hausa ethnic group in Special primary school, Hausawa, Model primary school, Hausawa and Iqra'a crèche, Tudun Maliki, Kano municipal without clinical history of underlining disease or apparent abnormality during the scan were included in the study. The children of Hausa ethnic group with physical deformity or non consent by parents or care givers were excluded from the study.A probability simple random sampling was employed in the study and a total of 457 subjects were recruited; involving 247 boys and 210 girls within the age range of 2 to 13 years from Hausa ethnic group in the aforementioned schools. Sample size was determined using Fisher's statistical formula as shown below. The formula is usually chosen when studying infinite population.

$n=Z^2pq/d^2$for population greater than 10,000 and was calculated to be 385 as shown below:
The formula $n=Z^2pq/d^2$(Lwanga&Lemeshow, 1991)
Where n=Desired sample size

z=standard deviation, using set at 1.96, which corresponds to 95% confidence level.

P=proportion in target population estimated to have a particular characteristic. If no reasonable estimate, 50% (0.5) is used.

q=1.0-p

d=degree of accuracy desired, usually set at 0.5

Therefore, $n=1.96^2 \text{ X } 0.5 \text{ X } (1.0-0.5)/0.5^2$

$=384.16$

The minimum sample size was calculated to be 384.16. However, to further minimize the level of error, four hundred and fifty-seven (457) subjects were used.

The instrument used for the measurement of the kidney volume was two-dimensional Mindray Digiprince DP4900 (Mindray Biomedical Electronics Co. Ltd, Shenzhen, China, 2012) ultrasound machines with 3.5 – 5.0MHz curvilinear transducer equipped with electronic callipers. In this ultrasound scanning was carried out with child in supine and prone positions after adequate abdominal exposure and the application of adequate amount of water-soluble coupling gel to the region of interest. The general architecture of the kidneys was then noted to exclude any form of kidney disorder. The maximum longitudinal length of the kidney was recorded as the length of the kidney. All the measurements were performed by one examiner using the same ultrasound machine and an average reading was taken after three different measurements to avoid intra-observer error. The renal width was obtained after the determination of long axis of the kidney, the transducer was then rotated 90 degrees to the longitudinal axis and the transverse section was obtained at the level of the renal hilum and then the renal width was measured as the maximum distance between medial and lateral borders of kidney. In the same plane of renal width measurement in Figure 2, renal thickness or depth was also measured as the distance between ventral and dorsal surfaces of the kidney (antero-posterior diameter). After the renal scan the weight and height of every selected subject was taken and recorded in a data capture sheet

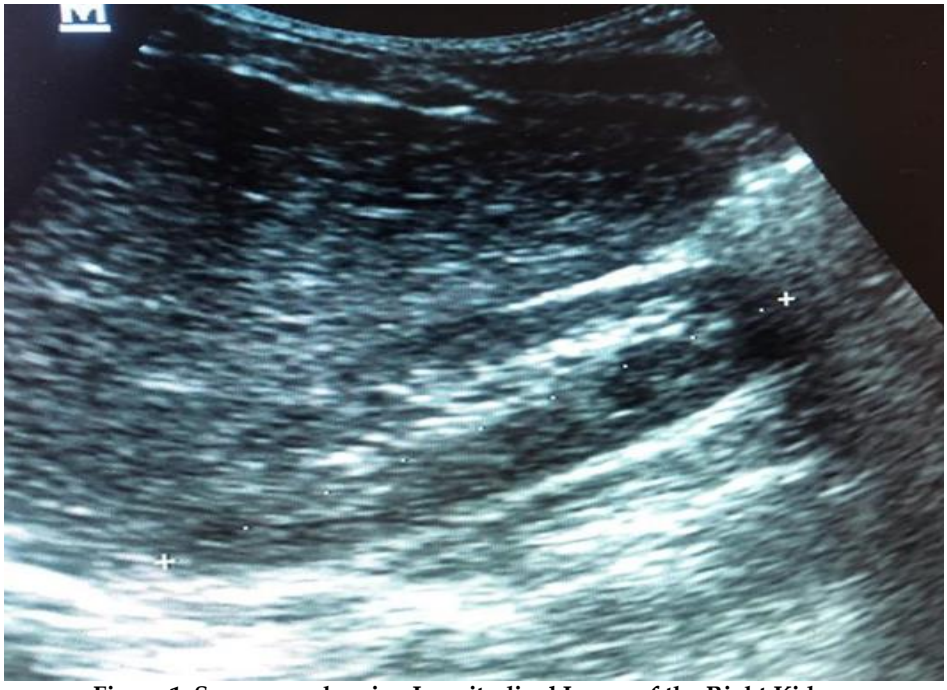

Figure 1: Sonogram showing Longitudinal Image of the Right Kidney

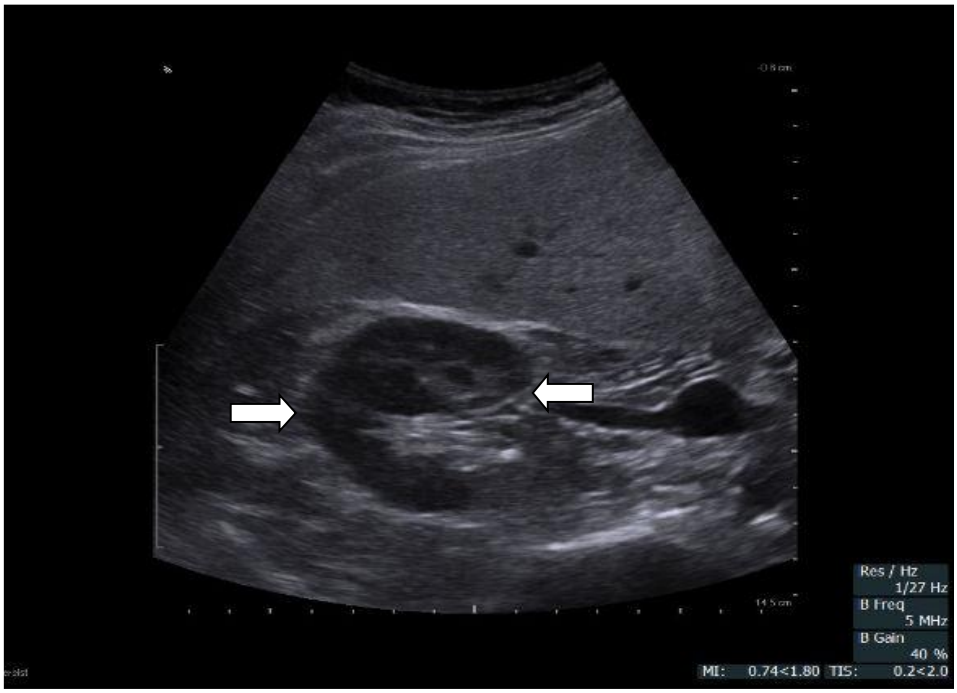

Figure 2: Sonogram showing Right Renal Width (indicated between the Heads of the two Arrows)

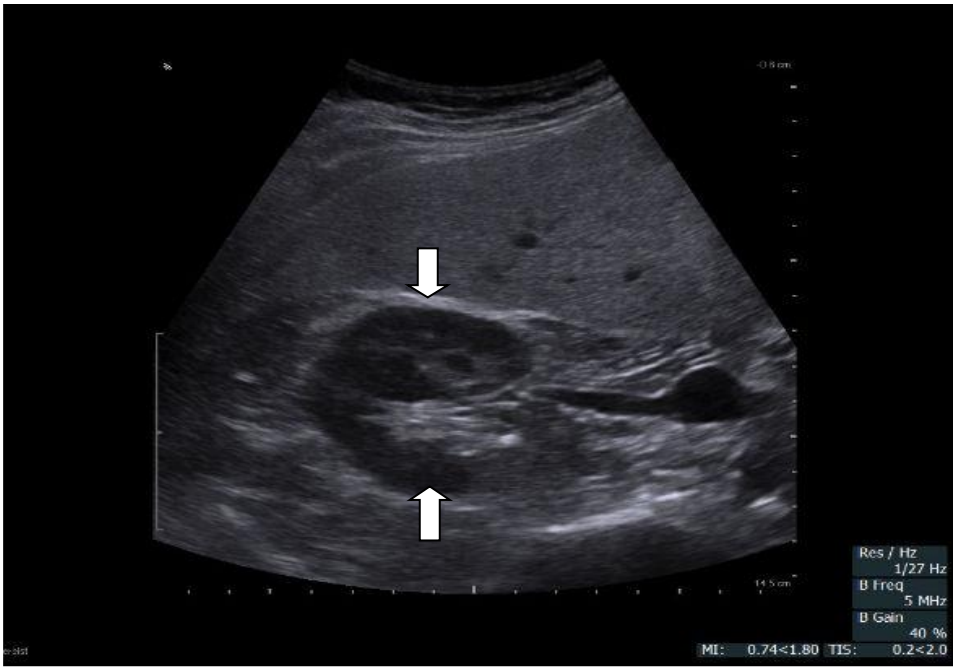

Figure 3: Sonogram of the Right Kidney showing Renal Depth (between arrows)

The BMI of every selected subject was calculated using the formula as follows: BMI = Weight (kg)/Height^2 (m^2), Bouguerra*et al*., (2007).The renal volume was calculated using the ellipsoid formula as follows = L (cm) x W (cm) x {(D1 +D2 (cm)/2} x 0.523 (Kim et al., 2013) L= length, W= width, D1 + D2 = Average of depth. The obtained data was categorized into boys and girls; each category was further categorized into 3 group; 2-5 years, 6-9 years and 10-13 years. The mean, standard deviation and range of the age, height, BMI, weight and kidney volume was obtained using descriptive statistics. The mean difference in kidney volume between boys and girls was obtained using student t-test. The correlation between the kidney volume and the weight, height and BMI was obtained using Pearson's bivariate correlation method. Multivariate analysis was performed between the right and left renal volumes and the age, gender and right and left renal length. SPSS version 22.0 was used for the data analysis.

RESULTS

Table 1 shows that,the total number of the children was 457 with aged ranged 2 to 13 years;247 (54.0%) were males while, 210 (46.0%) were females. Majority were in the age group 6 to 9 years.

Table 1: Descriptive Statistics of Age and Sex Distribution in School Children Aged from 2 to 13 Years in Kano Metropolis, Nigeria

Age group (years)	Male	Female	Total	Percentage /Frequenc
2 – 5	42	39	81	17.7
6 – 9	123	125	248	54.3
10 – 13	82	46	128	28.0
TOTAL	247	210	457	100

Table 2 shows the mean±SD of the heights and weights were 1.21±0.11m and 20.46±4.92kg with minimum and maximum values of 0.8m and 1.5m and 10.0 kg and 41.0 kg respectively. The mean±SD of the BMI was 13.93 ± 1.91 kg/m^{2}with a minimum and maximum value of 8.57kg/m^{2}and 19.5kg/m^2 respectively. The mean±SD of the renal length, thickness, width and volume were 7.69±0.71cm, 3.31 ± 0.42 cm, 4.80 ± 0.49cm and 64.79±16.13cm^3 respectively.

Table 2: Descriptive Statistics of Age, Body Height, Body Weight, BMI, Renal Length, Renal Width, Renal Thickness and Renal Volume in School Children Aged from 2 to 13 Years in Kano Metropolis, Nigeria.

Variables	N	Min	Max	Mean	Std. Deviation
Age (years)	457	3.00	13.00	7.98	2.29
Body Height (m)	457	0.8	1.50	1.26	1.14
Body Weight (kg)	457	10.00	41.00	20.46	4.92
Body Mass Index	457	8.57	19.50	13.93	1.94
Renal Length (cm)	457	5.56	10.34	7.69	0.71
Renal Thickness (cm)	457	2.04	7.23	3.31	0.42
Renal Width (cm)	457	3.10	6.55	4.80	0.49
Renal Volume (cm^3)	457	26.90	123.30	64.79	16.13

Table 3 shows the mean±SD values of heights and weights of 2 to 5 years were 1.05±0.08m and 15.74±2.66kg with minimum and maximum values of 0.8m and 1.2m and 10.0kg and 24.0kg respectively. The mean±SD BMI of 2 to 5 years were 14.38 ± 2.14 kg/m^2 a minimum and maximum value of 8.57$kg/m^2$and 19.32kg/m^2 respectively. The mean renal length, thickness, width and volume were 7.10±0.64cm, 3.17± 0.37cm, 4.42± 0.47cm and 52.73±12.90cm^3 respectively. The mean±SD value of heights and weights under the age of 6 to 9 years were 1.20±0.78m and 19.64 ± 3.88kg respectively. The mean value of renal length, thickness, width and volume were 7.71 ± 0.66cm, 3.27 ± 0.43cm, 4.81 ± 0.45cm and 64.04 ± 14.72cm^3respectively. The mean±SD value of heights and weights aged ranged 10 to 13 years were 1.31±0.07m and 25.04 ± 4.06kg respectively while the mean value of renal length, thickness, width and volume were 8.05 ± 0.61cm, 3.46 ± 0.39cm, 5.03 ± 0.44cm and 73.88 ± 15.14cm^3respectively

Table 3: Descriptive Statistics of Body Height, Body Weight, BMI, Renal Length, Renal Width, Renal Thickness and Renal Volume in School Children Aged from 2 to 5,6 to 9 and 10 to 13 Years in Kano Metropolis, Nigeria

	2-5 years (n=81)		6-9 years (n=248)		10-13 years (n=128)	
Variables	Min – Max	Mean ± SD	Min - Max	Mean ± SD	Min – Max	Mean ± SD
Body Height (m)	0.80-1.26	1.05 ± 0.08	1.02 – 1.46	1.20 ± 0.78	1.18 - 1.50	1.3 1± 0.071
Body Weight (kg)	10.00 - 24.00	15.74 ± 2.66	11.00 - 35.00	19.64 ± 3.88	17.00 - 41.00	25.04 ± 4.06
BMI (kg/m^2)	8.57 - 19.32	14.38 ± 2.14	8.93 - 19.32	13.48 ± 1.83	9.61 - 19.50	14.52 ± 1.77
RL (cm)	5.56 - 8.73	7.10 ± 0.64	5.98 - 9.61	7.71 ± 0.66	6.45 - 10.34	8.05 ± 0.61
RT (cm)	2.31 - 4.56	3.17 ± 0.37	2.04 - 7.23	3.27 ± 0.43	2.57 - 4.59	3.46 ± 0.37
RW (cm)	3.10 - 5.79	4.42 ± 0.47	3.15 - 6.24	4.81 ± 0.45	3.70 - 6.55	5.03 ± 0.44
RV (cm^3)	26.97 - 95.68	52.73 ± 12.90	30.41 - 114.16	64.04 ± 14.72	39.03 - 123.30	73.88 ± 15.14

RL = Renal Length RT = Renal Thickness RW = Renal Width RV = Renal Volume

Table 4 shows that, the mean±SD values of heights, weights and BMI of 2 to 5 years for males were 1.02 ±0.08 m, 15.65 ± 2.69 kg and 14.49 ± 2.18kg/m^{2}respectively.The heights, weight and BMI for females were 1.55 ± 0.08m, 15.83 ± 2.68kg, and 14.25 ± 2.13kg/m^{2}respectively. The mean±SD values of right renal length, right thickness, right width and volume of 2 to 5 years formales were 6.97 ± 0.61cm, 3.08± 0.31cm, 4.32 ± 0.42cm and 49.04 ± 11.97cm^{3}respectively while in females were 6.96 ± 0.63cm, 2.97 ± 0.39 cm, 4.27 ± 0.48cm and 46.58 ± 11.10cm^{3}respectively. The mean±SD value of heights, weights and BMI of the aged ranged 6 to 9 years for males were 1.21 ± 0.08 m, 20.03 ± 3.85kg and 13.61 ± 1.62kg/m^{2}while for females were 1.20 ± 0.08m, 19.25 ± 3.90kg and 11.00-35.00kg/m^2.The mean±SD value of right renal length, right renal thickness, right renal width and volume for males were 7.66 ± 0.67cm, 3.12 ± 0.32 cm, 4.68 ± 0.4cm and 58.95 ± 12.00cm^{3}respectively while for females were 7.54 ± 0.61 cm, 3.15 ± 0.47 cm, 4.67 ± 0.43 cm and 58.54 ± 13.32cm^{3}respectively. The mean±SD value of heights, weights and BMI of the aged range 10 to 13 years was slightly higher in males than the females The mean±SD right renal volume 10 to 13 years in males and females were 58.98 ± 12.00cm^{3}and 58.84 ± 13.32cm^{3}respectively. The mean±SD value of right renal length, thickness and right renal volume were also slightly higher in males than the females.

Table 4: Descriptive Statistics of Body Height, Body Weight, BMI, Right Renal Length, Renal Width, Renal Thickness and Right Renal Volume in School Children Aged from 2 to 5, 6 to 9 and 10 to 13 Years in Males and Females in Kano Metropolis, Nigeria

Sex	Variables	2-5 years (n= 81)		6-9 years (n=248)		10-13 years (n=128)	
		Min-Max	Mean ± SD	Min-Max	Mean ± SD	Min-Max	Mean ± SD
Male	Body Height (m)	0.80-1.16	1.04 ± 0.08	1.03-1.40.	1.21 ± 0.08	1.18-1.50	1.32 ± 0.06
	Body Weight (kg)	10.00-24.00	15.65 ± 2.69	11.00-35.00	20.03 ± 3.85	19.00-41.00	25.56 ± 3.98
	BMI (kg/m^2)	8.57-18.52	14.49 ± 2.18	9.09-18.92	13.61 ± 1.62	10.74-19.50	14.63 ± 1.74
	RL (cm)	5.56-8.34	6.97 ± 0.61	5.98-9.31	7.66 ± 6.67	6.45-10.34	7.93 ± 0.55
	RT (cm)	2.51-4.15	3.08 ± 0.31	2.35-4.22	3.12 ± 0.32	2.57-4.57	3.38 ± 0.37
	RW (cm)	3.10-5.52	4.32 ± 0.42	3.50-5.77	4.68 ± 0.41	3.70-5.78	4.81 ± 0.39
	RV (cm^3)	30.36-89.81	49.04 ± 11.97	33.84-89.82	58.95 ± 12.00	40.33-102.03	68.16 ± 13.76
Female	Body Height (cm)	0.91-1.26	1.55 ± 0.08	1.20-1.46	1.20 ± 0.08	1.20-1.45	1.30 ± 0.06
	Body Weight (kg)	10.00-24.00	15.83 ± 2.68	11.00-35.00	19.25 ± 3.90	17.00-39.00	24.11 ± 4.10
	BMI (kg/m^2)	9.92-19.32	14.25 ± 2.13	8.93-19.32	13.35 ± 2.02	9.61-19.48	14.32 ± 1.82
	RL (cm)	5.71-7.96	6.96 ± 0.63	6.02-9.04	7.54 ± 0.61	6.65-9.17	7.91 ± 0.56
	RT (cm)	2.31-4.60	2.97 ± 0.39	2.04-7.06	3.15 ± 0.47	2.66-3.81	3.30 ± 0.28
	RW (cm)	3.18-5.70	4.27 ±0. 48	3.47-6.05	4.67 ± 0.43	3.99-5.79	4.91 ±0. 41
	RV (cm^3)	26.97-70.50	46.58 ± 11.10	30.41-114.16	58.54 ± 13.32	39.03-98.59	67.34 ± 11.03

RL = Renal Length RT = Renal Thickness RW = Renal Width RV = Renal Volume

Table 5 shows the mean±SD value of heights, weights and BMI of aged ranged 2 to 5 years for males were 1.04± 0.08m, 15.66 ± 2.69kg and 14.49 ± 2.18kg/m^{2}respectively while for females were 1.05 ± 0.08m, 15.83 ± 2.68kg, and 14.25 ± 2.13kg/m^{2}respectively. The mean value of right renal length, right thickness, right width and volume of 2 to 5 years in males were 7.28 ± 0.61cm, 3.3.35± 0.28cm, 4.61± 0.42cm and 59.46 ± 13.27cm^{3}while in females were 7.21 ± 0.59cm, 3.27 ± 0.37cm, 4.49 ± 0.43cm and 55.63 ± 11.16cm^{3}respectively. The mean±SD value of heights and weights under the age of 6 to 9 years in males were 1.21 ± 0.08m and 20.03 ± 3.85kg and that of females were 1.20 ±

0.08m, 19.25 ± 3.90kg while the mean value of left renal length, right renal thickness and right renal width in males were 7.28 ± 0.61cm, 3.46 ± 0.49 cm and 4.98 ± 0.49cm and in females were 7.76 ± 0.67cm, 3.35 ± 0.33 and 4.91 ± 0.42respectively. The mean left renal volume 6 to 9 years in males and females were 71.36 ± 14.00cm^{3}and 67.34 ± 14.40cm^{3}respectively. The mean value of heights, weights and BMI under the age of 10 to 13 years was slightly higher in males than the females while the mean value of left renal length, thickness and left renal volume were also slightly higher in males than the females.

Table 5: Descriptive Statistics of Body Height, Body Weight, BMI, Left Renal Length, Renal Width, Renal Thickness and Left Renal Volume in School Children Aged from 2 to 5, 6 to 9 and 10 to 13 Years in Males and Females in Kano Metropolis, Nigeria

		2-5 years (n=81)		6-9 years (n=248)		10-13 years (n=128)	
Sex	Variables	Min-Max	Mean ±SD	Min-Max	Mean ±SD	Min- Max	Mean ±SD
Male	Body Height (m)	0.80-1.16	1.04 ± 0.08	1.03-1.40	1.21 ± 0.08	1.18-1.50	1.32 ± 0.06
	Body Weight (kg)	10.00-24.00	15.66 ± 2.69	11.00-35.00	20.03 ± 3.85	19.00-41.00	25.56 ± 3.98
	BMI (kg/m^2)	8.57-18.52	14.49 ± 2.18	9.09-18.92	13.60 ±1.62	10.74-19.50	14.63 ± 1.74
	RL (cm)	5.67-8.73	7.28 ± 0.69	6.25-9.61	7.88 ± 0.66	6.79-9.90	8.24 ± 0.64
	RT (cm)	2.85-3.92	3.35 ± 0.28	2.69-7.23	3.46 ± 0.49	2.74-4.59	3.58 ± 0.38
	RW (cm)	3.71-5.79	4.61 ± 0.47	3.15-6.24	4.98 ± 0.49	4.28-6.55	5.17 ± 0.37
	RV (cm^3)	37.36-95.68	59.46 ± 13.27	35.15-106.85	71.36 ±14.90	53.54-123.30	80.40 ±15.67
Female	Body Height (m)	0.91-1.26	1.05 ± 0.08	1.02-1.46	1.20 ± 0.08	1.20-1.45	1.30 ± 0.06
	Body Weight (kg)	10.00-24.00	15.83 ± 2.68	11.00-35.00	19.25 ± 3.90	17.00-39.00	24.11 ± 4.10
	BMI (kg/m^2)	9.92-19.32	14.25 ± 2.13	9.09-18.92	13.35 ± 2.02	9.61-19.48	14.32 ± 1.82
	RL (cm)	6.10-8.51	7.21 ± 0.59	6.55-9.38	7.76 ± 0.67	6.91-9.99	8.04 ± 0.64
	RT (cm)	2.52-4.65	3.27 ± 0.37	2.60-4.22	3.35 ± 0.33	2.71-4.03	3.54 ± 0.32
	RW (cm)	3.76-5.51	4.49 ± 0.43	3.86-5.91	4.91 ± 0.42	4.17-6.32	5.28 ± 0.47
	RV (cm^3)	34.31-85.41	55.63 ±11.16	39.92-99.16	67.34 ± 14.40	47.39-101.73	78.98 ± 13.69

RL = Renal Length RT = Renal Thickness RW = Renal Width RV = Renal Volume

Table 6 shows statistically significant difference in renal volumes between males and females only in the 6 to 9 years age group (p=0.03). There was no statistically significant difference between males and females in the other age groups (p>0.05).

Table 6: Independent t- Test on Renal Volume in School Children Aged 2 to 5, 6 to 9 and 10 to 13 years in Kano Metropolis, Nigeria.

		Male	Female		
Variable	Age Group	Mean ± SD	Mean ± SD	t	P-value
Right Renal Volume	2-5 years (n=81)	49.04 ± 11.97	46.58 ±11.09	0.96	0.34
	6-9 years (n=150)	58.95 ± 12.00	58.54 ± 13.32	0.25	0.80
	10-13 years (n=128)	68.16 ± 13.76	67.34 ± 11.03	0.35	0.28
Left Renal Volume	2-5 years (n=81)	59.46 ± 13.27	55.63 ± 11.16	1.40	0.17
	6-9 years (n=150)	71.36 ± 14.90	67.34 ± 14.40	2.17	0.03
	10-13 years (n=128)	80.40 ± 15.67	78.98 ± 13.69	0.51	0.61

Table 7 shows that there was strong positive correlation between BMI, renal length and renal volume in age groups (r>0.7; p=0.000). This means that as the renal volume increases so as also the BMI and renal length increases.

Table 7: Correlation between Renal Volume with BMI and Renal Length in School Children Aged 2 to 5, 6 to 9 and 10 to 13 Years in Kano Metropolis, Nigeria.

Age Group	Correlation Coefficient 'r'	P-value
2 – 5 Years	0.757	0.000
6 – 9 Years	0.752	0.000
10 – 13Years	0.730	0.000

Table 8 shows there was a moderate positive correlation between renal volume and age in males 2-5 years age group and males and females in 6-9 years age group (p>0.3; p=0.000). However, a weak positive correlation was observed between renal volume and age in females 2 to 5 yearsage group and in males and females 10-13 years age group (p<0.3; p>0.05).

Table 8: :Pearson's Correlation Co-efficients between Renal Volumes and Age in School Children Aged 2 to 5, 6 to 9 and 10 to 13 Years in Males and Females in Kano Metropolis, Nigeria.

Age Group	Sex	Variable	Correlation Coefficient 'r'	P-value
			Age (Years)	
2 -5 Years	Male	Renal Volume (cm^3)	0.402	0.000
	Female	Renal Volume (cm^3)	0.129	0.259
6 – 9 Years	Male	Renal Volume (cm^3)	0.390	0.000
	Female	Renal Volume (cm^3)	0.351	0.000
10 – 13 Years	Male	Renal Volume (cm^3)	0.119	0.128
	Female	Renal Volume (cm^3)	0.207	0.048

DISCUSSION

The findings of this study as shown in Table 1 children ranging 2 to 13 years of age were recruited with the mean age of 7.98years. The findings of this study are in agreement with the findings of the studies conducted by Min-su Oh *et al.*, (2016); AbdulHamid et al., (2015); Scholbach and Weitzel, (2012) and Bo Shi *et al,* (2015) that all recruited children were under 13 years in their studies. However, the findings of this study are contrary to the findings of the studies conducted by Kim *et al*., (2013) Eze *et al., (2014)* and Adeyekun *et al*., (2014) that recruited children 0-18 years of age.The possible reason of the disagreement might be due to different age group used. Previous documented studies have demonstrated that renal sizes in children aged more than 13 years show little differences over subsequent years (Park et al., 2017). At 13 years of age, the renal size in children is approximately 90% of that of adults (Park *et al*., 2017). However, a recent study by Kecler-Pietrzyk, (2007) had demonstrated that the renal sizes approximates to that of an adult at 15 years of age. In the present study, heights are higher in male children than their female counterparts in 6 – 9 and 10- 13 years' age as shown in Table 2. This is in contrast to the finding by Eze *et al.,* (2014) in Nsukka in which there were gender variations in height in different age groups; the younger males (6–9 years

old) were generally taller than their female counterparts but at older age 10 years and above the trend changed with females being taller and heavier than the males. This could be attributed to ethnic differences as noted by Arooj *et al*., (2011) and Okoye *et al*., 2005). There is also difference in weight between boys and girls with boys being heavier than girls in the 6 – 9 and 10 – 13 years age groups with females heavier than males in 2 – 5year age group. Similarly, Akor *et al*., (2014) noted among the children studied that males were heavier and taller than their female counterparts till the age of 9–10 years after which the trend reversed with females being heavier and taller than males. This may be linked to the prepubertal growth spurt which occurs earlier in females than males. Under hormonal influence, females experience earlier and more rapid increase in body size and shape than boys just before puberty. The mean BMI of the subjects in the present study was 13.93kg/m^2 and there is an increase the mean BMI from age 6 to 13 years in both males and females as shown in Table 2. The findings of this study are similar to the findings of the studies conducted by (Kim *et al*., 2013; Otiv *et al*., 2011 and Ravikumar *et al.,* 2016)

In this study the overall mean renal length was 7.69±0.71cm and there was steady increase in renal length from 2 – 5 year to 9 - 13-year age groups as shown in Table 3. The findings of this study are similar to the findings of the studies conducted by Otiv *et al.,* (2011); Ravikumar *et al*., (2016); Kecler-Pietrzyk, (2007) and Rosenbaum *et al*., (1984) that all reported steady increase in renal length from 2 – 5 year to 9 - 13-year. The findings of this study as shown in Table 4 also shows that all renal dimensions were larger on the left than on the right side in both males and females. The findings are similar to the findings of the studies conducted by Wang *et al*., (1989) and Emamian *et al*., (1993) that reported similar findings. In the present study also, the mean right and left kidney lengths in all age groups in both males and females as shown in Table 5 were found to be lower than the values obtained in a study by (Ayad *et al*., (2014).

The mean renal volumes were found to increase from 2 – 5 year to 10 – 13-year age groups in both males and females as shown in Table 5. These values are however found to be higher in males compared to females. In the present study renal volume increased steadily from 52.7 cm^3 at 2 years of age to 73.9 cm^3 at 13 years of age as similar observation was noted in a study by Ravikumar et al., that mean renal volume (SD) increased from 9.9 (5.0) ml at 1 month of age to 62.8 (13.9) ml at 12 years of age. In the study done by Otivet al. the mean renal volume increased form 9.7ml to at 1 month to 61 (17) ml at 12 years of age. Kidneys become relatively wider and thicker with age. One possible explanation for this could be the relaxation of the abdominal wall with age, so that the kidneys are squeezed less in older persons. This would also explain the broadening that becomes most pronounced for the right kidney, which has been squeezed more because of the liver.

As indicated in Table 6, there was statistical significant difference in renal volumes between males and females only in the 6 to 9 years age group. However, there was no statistical significant difference between males and females in the other age groups. This study as shown in Table 7, there was strong positive correlation between BMI, renal length and renal volume in age groups ($r>0.7$; $p=0.000$). This means that as the renal volume increases so as also the BMI and renal length increases. As also shown in Table 8, there was a moderate positive correlation between renal volume and age in males 2-5 years age group and males and females in 6-9 years age group ($p>0.3$; $p=0.000$). However, a weak positive correlation was observed between renal volume and age in females 2 to 5 years age group and in males and females 10-13 years age group ($p<0.3$; $p>0.05$). This is similar to the findings of the studies conducted by Otiv *et al.,* 2011; Kim *et al*., (2012) &

Ravikumar *et al.,* 2016) that reported renal volume in children correlated to somatic parameters like age, sex and BMI.

CONCLUSION

This study provides data for normal sonographic renal volume and length in Kano metropolis, a Hausa dominated Nigerian population. This could serve as guide for making reference while performing renal ultrasound examination for kidney diseases in this study location.

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