Original Article

Reference indicators for kidney dimensions in Sudanese children using Ultrasound

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ABSTRACT

A change in renal length may be evidence of many renal diseases. This descriptive cross-sectional study aims to establish the age, height, weight, BMI, and kidney dimensions in apparently healthy Sudanese children using Ultrasound. 141 Sudanese children living in Khartoum state who had no symptoms of kidney disease were included in this study in the period from March to June 2021. Ultrasound scans were performed by an experienced sonographer, using a high-resolution real-time US scanner (CHISON 600M 2012 version) with a 3.5-5 MHz curvilinear transducer. While thickness and width were measured in the transverse section, the longitudinal measurements were obtained from the coronal section. The study revealed that the mean measurements of the right kidney were 7.29±1.17 cm, and 3.92±.85 cm, and 3.23±.64 cm for length, width, and anteroposterior diameter, respectively, and the mean measurements for the LK were 7.48±1.17 cm, and 4.07±.95 cm, and 3.23±.66 cm, for length, width, and anteroposterior diameter respectively. According to gender, there was no discernible variation in renal length, while there was a significant correlation between them (P= 0.00). The current study also found a strong relationship between age and kidney weight for both sides (P= 0.00). and other significant relations between the age, height, and weight of participants, and their kidney lengths (P=0.01). Assessing the growth pattern of the kidneys in children can help to reduce the misdiagnosis of many diseases for them and can initiate a reference value or database for Sudanese children.

Keywords: Ultrasound, Kidney, Anteroposterior diameter, Age, Children, Reference values

Introduction

Pediatric patients frequently have abdominal ultrasounds (US) to investigate a variety of illnesses as well as to gauge and track healthy organ development [1].

When assessing a child with renal disease, renal size is a crucial factor. After birth, the kidney continues to expand until it reaches an approximate adult size of 10 cm by the age of 12 [2].

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A significant indicator of renal disease is a change in kidney size. Therefore, when assessing a child who has unexpectedly worsened renal functioning for the first time, it is crucial to distinguish between an acute kidney injury, where the size may be normal or large, and an acute exacerbation of chronic kidney disease (CKD), where the size is relatively small. In certain conditions, a shrinking kidney's size might potentially be a deciding factor in deciding against a renal biopsy or immunosuppressive medication [3]. It is now well acknowledged that determining the size of the two kidneys has clinical relevance. It has made it possible to examine the natural history of several kidney disorders in a previously impossible way, among other things. In polycystic disease and several lipid storage disorders, bilateral enlargement of the kidneys was observed. One kidney will be smaller on the ipsilateral side and larger on the contralateral side in a child with unilateral illness [3].

Kidney diseases are highly prevalent globally. They have become a major public health problem and associated with considerable co-morbidity and mortality. Since abnormal renal sizes are linked to and signs of conditions affecting the kidneys, it is essential to have accurate reference values when measuring children's renal sizes using ultrasound technology [4, 5].

Most frequently, age-related nomograms are employed to Analyze the average renal length [6]. Although these are on a healthy western population, nomograms are based. Does it make sense to extrapolate these to Sudanese children?

Considering that a change in renal length could be a sign of sickness, we must have usual reference levels with regard to children's age, gender, height, weight, kidney length, and width. Renal length assessed by ultrasonography is a straightforward, useful, repeatable technique and is commonly used to track renal size and development. A child's kidneys are healthy if they are growing, as opposed to kidneys that stay the same size over time could be a precursor to CKD [3].

Kidneys are regularly examined using ultrasonography (US), which is safe for evaluating developing youngsters because there is no risk of ionizing radiation. The size of the kidneys is one of many body growth markers that is thought to be crucial in the clinical assessment of renal growth and abnormalities [7]. Several investigations [8, 9] have been conducted to determine the typical kidney size in Sudanese children. Since kidney length more closely correlates with body characteristics than kidney volume, measuring kidney volume is time-consuming and impractical [8].

The purpose of this study was to use US data to determine the age, height, weight, BMI, and kidney dimensions of Sudanese children who appeared to be in good health.

Materials and Methods

Type, place, and duration of the study

This was a descriptive cross-sectional study of both kidneys for a sample of children from Khartoum state, they were selected randomly from those who agree to participate in the study after verbal consent was taken from their parents, in the period from March to June 2021.

Study population

141 healthy Sudanese children, who had no symptoms of kidney disease their ages ranged from one month to 15 years old were selected to participate in this study.

Machine and protocol used

A sonographer with experience in abdominal US (MA- 10+ years) did the US scans. The spleen was scanned while subjects were suspended from breathing using a commercially available high-resolution real-time US scanner (CHISON 600M 2012 version) with a 3.5–5 MHz curvilinear transducer. Participants were lying supine or slightly right and left lateral decubitus, and the scan was done through an oblique intercostal approach.

The following measurements were taken of both kidneys: thickness, breadth, and length: The kidney thickness was defined as the distance between the inner and outer surfaces (measured at the level of the kidney hilum on a transverse section) (ST), the kidney width as the maximum distance between the medial and lateral borders of the kidney (measured in a plane perpendicular to the length) (SW), and the kidney length as the maximum distance between the dome of the spleen and the tip of the spleen on a longitudinal section in the sagittal plane (SL).

Data analyses

Microsoft Excel and the Statistical Package for the Social Sciences (SPSS), IBM version 16, were used to analyze the data.

The normality of the distribution of continuous variables in one sample was examined using the Kolmogorov-Smirnov test. To show continuous variables, the mean and standard deviation (SD) were employed. The t-test was used to compare data between groups when they had a normal distribution. The degree to which the two continuous variables were correlated was assessed using Pearson's correlation coefficient (r). Statistical significance was defined as $P < 0.05$ for probability values.

Results and Discussion

In this study, 141 healthy Sudanese children from Khartoum state were examined; 113 of the boys and 28 of the girls were included, and none of them displayed any signs of renal illness. All participants undergo for US scans for both kidneys' and measurements were obtained for them. The characteristics of all variables in the study sample were described as frequencies, means, and correlations with p-value (0.005).

Table 1. Shows max, min, and means of children's age, weight, height, and kidney parameters.

Variables	N	Min	Max	Mean ± Std. Deviation
Age (years)	141	0.1	15.0	5.992±3.61
Height (cm)	141	50	163	103.79±24.45
Weight (kg)	141	5.0	58.0	17.75±9.94
Body mass index-BMI (kg/cm^2)	141	9.52	22.66	15.50±2.55
RK length (cm)	141	4	11	7.29±1.17
Right kidney width (cm)	141	2.0	8.0	3.92±.85

Right kidney anteroposterior diameter (cm)	141	1.8	6.4	3.23±.64
Left kidney length (cm)	141	4.0	10.0	7.48±1.17
Left kidney width (cm)	141	2.0	8.0	4.07±.95
Left kidney anteroposterior diameter (cm)	141	1.8	5.9	3.23±.66

The sample's ages ranged from one month to 15 years, with a mean of 5.992 ± 3.61 years; their height ranged from 50 cm to 163 cm, with a mean of 103.79 ± 24.45 cm; their weight ranged from 5 kg to 58 kg, with a mean of 17.75 ± 9.94 kg; and their BMI ranged from 9.5 kg/m2 to 22.66 kg/m2, with a mean of 15.50 ± 2.55 kg/cm2 (1).

The study discovered that the RK had mean measurements of 7.29±1.17 cm, 3.92±.85 cm, and 3.23±.64 cm for length, width, and anteroposterior diameter, respectively, and the LK had mean measurements of 7.48±1.17 cm, 4.07±.95 cm, and 3.23±.66 cm for length, width, and anteroposterior diameter, respectively; the LK was longer and wider than the RK, which corresponded to a previous study [9].

Table 2. Shows the relation between children's gender and their renal measurements

Measurement	Gender	N	Mean ± Std. Deviation	Std. Error Mean	P value
Right kidney length (RKL)	Boys	113	7.32 ±1.02	.096	0.558
	Girls	28	7.13±1.66	.315	
Right kidney width (RKW)	Boys	113	3.89±.74	.0701	0.526
	Girls	28	4.04±1.21	.2287	
Right kidney thickness (RKT)	Boys	113	3.26±.63	.0596	0.250
	Girls	28	3.10±.67	.1269	
Left kidney length (LKL)	Boys	113	7.50±1.05	.099	0.737
	Girls	28	7.40±1.5	.301	
Left kidney width (LKW)	Boys	113	4.04±.84	.0793	0.541
	Girls	28	4.20±1.31	.2488	
Left kidney thickness (LKT)	Boys	113	3.20±.58	.0553	0.534
	Girls	28	3.32±.92	.1746	

This study revealed that there is no significant correlation between children's gender and their renal measurements, as in **Table 2**, most of the previous studies supported this finding [10-14].

Table 3. Presents correlations measurements of both kidneys by the three age groups of children

Age groups		RKL	RKW	RKT	LKL	LKW	LKT
1month-2 years	Mean	6.02	3.161	2.578	5.94	3.200	2.522
	N	18	18	18	18	18	18
	Std. Deviation	1.243	.7500	.4095	.885	.6886	.3750
3-9 years	Mean	7.21	3.865	3.210	7.47	4.062	3.167
	N	99	99	99	99	99	99
	Std. Deviation	.877	.6706	.5009	.851	.8311	.4716
10-15 years	Mean	8.53	4.737	3.808	8.69	4.804	4.017
	N	24	24	24	24	24	24
	Std. Deviation	1.046	.9762	.7950	1.151	1.0344	.7676
Total	Mean	7.29	3.923	3.231	7.48	4.078	3.229
	N	141	141	141	141	141	141
	Std. Deviation	1.175	.8546	.6420	1.172	.9521	.6655
		P value 0.00					

According to the table, the children were divided into three age groups (3). In groups 1, 2, and 3, the mean RKL progressively grew with age from 6.02 cm to 7.21 cm to 8.53 cm and showed that for groups 1, 2, and 3, the respective means of LKL were

5.94 cm, 7.47 cm, and 8.69 cm. Therefore, both the R and LKL rose with age, and there was a very substantial link between them at (P = 0.00).

The study also found a strong relationship between the age and the KW of both sides (P= 0.00), where the means of RKW were 3.161, 3.865, and 4.737 cm for groups 1,2, and 3 respectively. And the means for LKW were 3.200, 4.062, and 4.804 cm for groups 1,2, and 3 respectively. KL was estimated with the following equations: LTKL= 0.2439× age (years)+ 6.0209 cm (R^2=0.566), RTKL= 0.2352× age (years)+5.876 (R^2=0.5235) **Figure 2**. Since there was a considerable correlation between them, age is a crucial influencing factor in evaluating KL. These findings are in line with one study by Salome *et al*. [15].

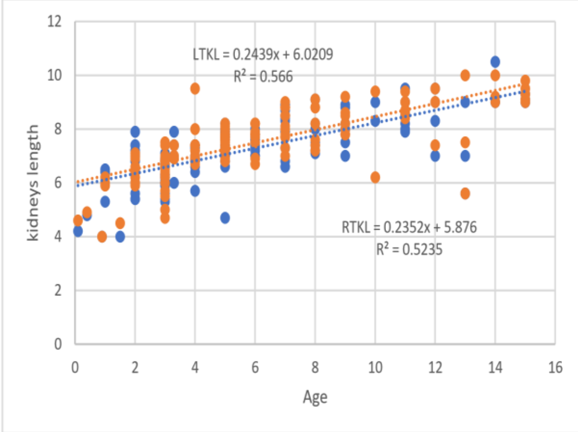

Figure 1. Linear relationship between the length of right and left kidneys and age.

Table 4. Presents the correlation between the age, height, and weight of participants, and their kidneys length

Correlation		Age	Hight	Weight
	Pearson Correlation	.724**	.800**	.737**
RKL	Sig. (2-tailed)	.000	.000	.000
	N	141	141	141
	Pearson Correlation	.752**	.818**	.768**
LKL	Sig. (2-tailed)	.000	.000	.000
	N	141	141	141

*There is a correlation between the variables represented in the p-value (0.01).

The study has represented a significant relationship between the age, height, and weight of participants, and their kidney lengths (P=0.01), as in **Figure 1** and **Table 4**. KL and children's height was estimated with the following equations: LTKL= 0.0392×(height)+ 3.4138 cm (R^2=0.6692), RTKL= 0.0384×(height)+3.2953 (R^2=0.6403) presented in **Figure 2**. While KL and children's weight was estimated with the following equations: LTKL= 0.0904×(weight)+ 5.8763 cm (R^2=0.5893), RTKL= 0.0871× (weight)+6.7386 (R^2=0.5438), as in **Figure 3**, which agrees with C. Ayad *et al*. results [16].

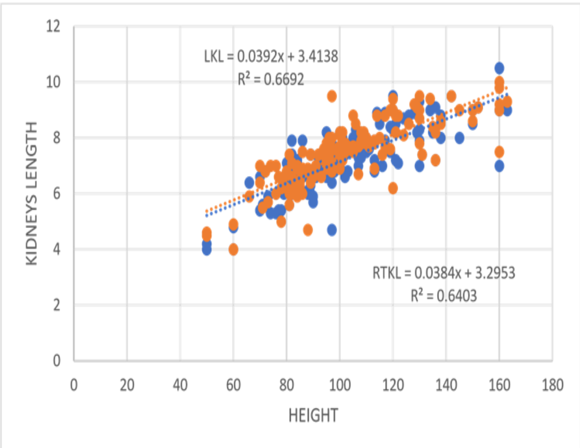

Figure 2. Correlation between the height of participants, and their kidneys length

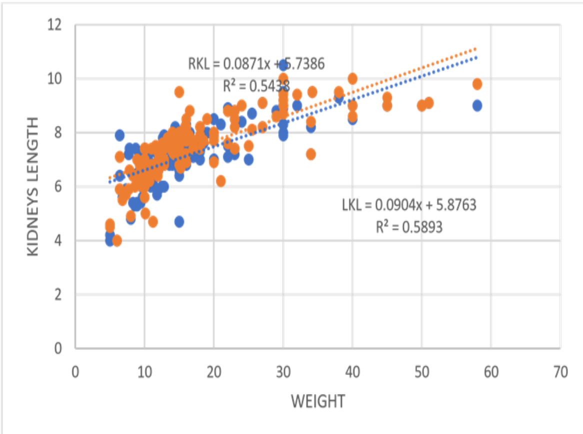

Figure 3. Correlation between the weight of participants, and their kidney length.

Reference values are obtained by comparing measured normal organ diameters with derived organ volumes and body measurements of physical growth in children, such as height and weight.

A reliable indicator of kidney assessment may not be BMI. This is in contrast to another study, which found a substantial relationship between BMI and renal length [17].

In keeping with a recent study by Younus *et al*., the current investigation showed that age and all body size indicators, with the exception of BMI, were strongly associated (p <0.01) with all kidney dimensions [18]. This finding approved by the study results of Aldosh *et al*. [19], who stated that US scan was used to characterize renal upnormality, including its morphology, kind, kidney size, parenchymal echogenicity, corticomedullary differentiation, and other hints it picked up, inorder to learn new information that might be useful for enhancing public health and to support researchers in the field of medicine [20].

Conclusion

In order to lower the likelihood that children will receive a false diagnosis of kidney illness, it is crucial to understand the average kidney measurements. The study established age-, weight-, and height-specific normative values for kidney function in Sudanese children who appeared to be in good health and created regression equations for an accurate assessment and monitoring of renal illnesses in clinical radiography and general medicine. The study highlighted that assessing the growth pattern of the kidneys in children can help to reduce the misdiagnosis of many diseases for them, and can initiate a reference value or database for Sudanese children.

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Conflict of interest: None

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Ethics statement: All participants were emailed a copy of the consent form prior to the examinations, and verbal consent was obtained from their parents.

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