ORIGINAL ARTICLE

ULTRASONOGRAPHY ORGANOMETERY: KIDNEY, LIVER, SPLEEN DIMENSION AND CORRELATION WITH BMI AMONG SCHOOL AGE HEALTHY CHILDREN IN SOUTHWEST, ETHIOPIA

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ABSTRACT

Background : *Childhood is an important period of growth for many organ systems. Among various growth parameters, the size of the kidney, liver and spleen useful for the clinical evaluation of abnormalities of these organs. Ultrasonographic dimensions of these organs vary with age, weight and race. However, reference standards of these parameters for healthy children for Ethiopian children are not available.*

Objective: : *To evaluate the dimensions of the kidney, liver and spleen in healthy children and its correlates with body mass index.*

Methods*: Descriptive cross-sectional study was conducted on 300 school age healthy children at Radiology Department of Jimma University Medical Center. Ultrasonographic assessment was done using a high resolution real-time scanner with a 4 MHz convex transducer by a senior radiologist. Children with abnormal ultrasonographic findings were excluded from the study and referred for further evaluation.*

Results*: A total of 300 children, 161 (53.7%) males and 139 (46.3%) females were included into the study. Body weight significantly correlated with the dimensions of the liver (r=0.584, p< 0.001), spleen (r=0.637, p< 0.001), right kidney (r=0.631, p<0.001) and left kidney (r=0.501, p< 0.001). On multiple regression analysis, body weight was significantly associated with all the organs (p <0.01).*

Conclusion*: The organ dimensions showed the highest correlation with body weight, height and age. Finding from our study assist clinician in interpretation of sonographic examinations in daily clinical practices.*

Key words: *Liver, Spleen, Kidney, Ultrasound, Jimma, Ethiopia*

INTRODUCTION

Childhood is an important period of growth for many organ systems. Among various growth parameters, liver and spleen size is an important parameter used for the clinical evaluation of disorder and abnormalities these organs. The morphological characterization of liver and spleen is one of the many parameters that go into detecting liver disorders and systemic infectious, inflammatory, and malignant pathologies (1, 2). Invariably, the complete characterization of the disease process may need morphological assessment of other anatomical structures and laboratory reports. Liver and spleen size vary widely according to age. Many diseases can affect their size, ranging from infective processes to malignant disorders (2, 3).

Abdominal ultrasound scan is one of the frequent procedures carried out using pulse-echo technique in most diagnostic ultrasound units of hospitals and diagnostic centers all over the world to determine the pathological conditions of the liver, spleen and kidneys (4). It provides real time images of the

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body organs, does not require anaesthesia and does not utilize ionizing radiation. Therefore, it is extremely safe to both the patient and the sonographer. In clinical practice, it is possible to establish the enlargement of the liver (hepatomegaly) or the spleen (splenomegaly) using ultrasound. In some situations, both the liver and the spleen could be grossly enlarged (hepato-spleenomegaly) (5).

It is therefore necessary for each country to have standard normal sonographic measurements to be used as reference values to guide sonographers for accurate diagnosis of pathologies of these organs (6). This is because significant variations in body organ sizes are seen depending on race, body structure, body weight or height from the normal universal limits. Normal ranges of liver and spleen dimensions of children and adults determined by Ultrasound have been reported previously (7-10).

Unlike in adults, visceral organs grow with age and hence we can't have a fixed standard measurement of liver and spleen in children. Hence, measured values need to be correlated with age, length/height, body weight and body surface area. As expected, in children, there is no difference in organ size between males and females. Though liver and spleen size measurements correlate best with height, some studies have shown a good correlation with weight and body surface area too (10,11). A research conducted on Indian children has shown height to be a significant correlate of the liver and spleen size across all ages and weights in both the sexes (12). There have been quite a few previous reports giving the standard sizes of the liver and spleen by ultrasound in children which have also identified their correlation with BMI (7, 9-13), but to date, none has been done in Ethiopian population. Hence, this study was done with the main objective of determining the liver and spleen dimension in relation to age, sex, height, weight, body surface area (BSA) and body mass index (BMI) among healthy school age children in Southwest Ethiopia. The provision of these data in the present study will enable a more practical and objective evaluation during a sonographic examination involving the liver and spleen of school age children.

MATERIAL AND METHODS

Study area, design and subjects

Descriptive cross-sectional study was conducted at radiology department of JUMC between March 2019 to September 2019. The sample group included school-age children between 7 to 13 years. The age of each subject was obtained from his/her hospital ID card. Some children recruited into the study attended hospital for clinical reasons unrelated to Kidney, liver and spleen and for routine medical examinations at the study center while the majority of the attended hospital just as volunteers for the study. The volunteer children were recruited from Jimma University community school. Purposive sampling technique was used to find 300 samples from both the hospital and community school.

Participants' inclusion and exclusion criteria

Only with children with normal ultrasonographic findings and age between 7 to 13 years old were included in the study. Children with abnormal ultrasonographic findings were excluded from the study and referred for further clinical evaluation

Ultrasonic examination and somatic measurements

The sonographic examinations were performed with high resolution real time scanner (GE LOGIQ™ E9) (Fig 1) with 4 MHz convex transducer. All the children underwent an ultrasonographic assessment of the kidney, liver and spleen size by a single radiologist. Kidney dimensions were recorded in a lateral decubitus position with the renal hilum visualized to get the optimum longitudinal dimension (Fig1). The measurements of organ dimensions were made during deep inspiration. Each organ was measured 3 times and the mean value was recorded as the absolute length. The longitudinal length of the liver in the right anterior axillary (AAL) and mid-clavicular (MCL) was measured with the child in supine position, while the length (L), depth (D) and width (W) of the spleen were measured with the child in the right-recumbent position (Fig 2). Weight was measured using a calibrated electronic scale to the nearest 0.1kg and height was measured using a standiometer to the nearest 0.1cm by a trained examiner.

Data processing and analysis

Data entry was done using Epidata version 3.1 and statistical analysis was done using SPSS/PC version 22.0 (SPSS Inc., Chicago, IL). Descriptive statistics was used to describe the dimensions of organs. Multiple linear regression analysis was used to describe the relations between height, weight and age, and organ size. Multiple regression analysis using organ dimensions as the dependent variable with age, sex, weight and height as independent variables was carried separately for each organ.

Ethical consideration

Ethical approval was obtained from the Ethical review Board of Jimma University. In addition written informed consent was obtained from each parent before data collection began.

Results

In our study, a total of 300 children of which 161(53.7%) males and 139(46.3%) girls from 7 to 13years were evaluated. The mean height, weight and BMI distribution of the different age groups are shown in Table 1. Females have low mean BMI in all age groups than males, while males are higher weight than females Table 1.

Table1: Mean value of height, weight, and BMI of study participant according to sex and age group. N=300

Age	Sex	Height (m)	Weight (kg)	BMI(kg/m2)
7	M: 25	1.13	19.5	15.3
	F:20	1.14	18.5	14.2
8	M:24	1.15	20.5	15.5
	F:22	1.18	18.8	13.5
9	M 25	1.26	24.5	15.4
	F:20	1.25	22.6	14.5
10	M:18	1.32	26.8	15.4
	F:20	1.33	23.5	13.3
11	M:22	1.41	30.6	15.4
	F:17	1.40	28.4	14.5
12	M:26	1.43	32.7	15.9
	F:20	1.45	31.3	14.9
13	M:21	1.47	34.4	15.9
	F:22	1.46	33.5	15.7

The Mean Kidney, Liver and Spleen length of the study population for each age group was shown by table 2.

Table 2. Mean Kidney, Liver and Spleen length according age group

Age	Rt. Kidney		Lt. kidney		Liver (cm)		Spleen(cm)		
	L(cm)	W(cm)	L(cm)	W(cm)	MCL	AAL	Length	Width	Depth
7	7.1	2.9	7.3	3	7.9	9.7	6.8	4.9	3.5
8	7.4	3.2	8.3	3.3	8.8	10.5	7.4	4.7	3.8
9	8.4	3.1	7.9	3.4	9.6	11.9	8.6	5.6	4
10	8.1	4.8	8.5	4.2	9	11.8	8.7	5.5	4.3
11	7.9	4.6	8.6	4.4	9.3	11.9	8.8	5.4	4.6
12	8.4	4.3	8.5	4.2	9.5	11.7	8.7	5.3	4.4
13	8.7	4.4	8.8	4.3	9.7	11.8	9.2	5.2	4.3

Table 3 show Preseason correlation coefficient of organs dimension and body parameter among the study population. Body weight significantly correlated with the longitudinal dimensions of the liver ($r = 0.584$, $p < 0.001$), spleen($r = 0.637$, $p < 0.001$), right kidney ($r = 0.631$, $p < 0.001$) and left kidney ($r = 0.501$, $p < 0.001$). BMI was correlated with kidney dimensions ($r = 0.432$, $p < 0.001$ and $r = 0.353$, $p < 0.001$ right and left kidneys respectively). Age was correlated with the longitudinal dimension of the spleen ($r = 0.541$, $p < 0.001$) (Table 3)

Table 3 Correlation between organ dimensions and somatic parameters (Spearman rank correlation coefficient)

Body Parameter		**Right Kidney**	**Left Kidney**	**Liver**	**Spleen**
Weight	R	0.631	0.501	0.584	0.637
	p-value	0.001	0.001	0.001	0.001
Height	R	0.521	0.440	0.624	0.634
	p-value	0.001	0.001	0.001	0.001
BMI	R	0.432	0.353	0.420	0.422
	p-value	0.001	0.001	0.001	0.001
Age	R	0.532	0.341	0.523	0.541
	p-value	0.001	0.001	0.001	0.001

Table 4 shows multiple regression analysis of organ dimension. On multiple regression analysis, weight and age were significant predictors of the longitudinal length of the liver after controlling for height. Weight and height were significant predictors of spleen length after controlling for age. In the case of the kidneys, only weight was a significant predictor of length after controlling for height and age, when each kidney was considered separately and when both kidneys were considered together (Table 4)

Table 4 multiple regression analysis with organ dimensions as the dependent variable

Organ Dimension		**Regression coefficient**	**SE**	**P-value**	**95%cl**	**R_2**
Rt kidney	Constant	5.181	0.604			0.396
	Weight	0.052	0.008	0.001	0.031–0.065	
	Age	0.053	0.032	0.080	−0.008-0.089	
	Height	0.021	0.007	0.062	0.001–0.012	
Lt kidney	Constant	5.422	0.562			0.376
	Weight	0.049	0.009	0.001	0.044–0.075	
	Age	0.036	0.025	0.147	−0.013-0.086	
	Height	0.008	0.004	0.100	−0.005-0.027	
Liver	Constant	6.532	0.906			0.458
	Weight	0.087	0.024	0.001	0.072–0.223	
	Age	0.151	0.044	0.001	0.062–0.326	
	Height	−0.014	0.009	0.136	−0.032-0.004	
Spleen	Constant	4.023	0.815			0.366
	Weight	0.071	0.022	0.001	0.052–0.094	
	Age	−0.070	0.041	0.061	−0.155-0.007	
	Height	0.021	0.007	0.004	0.004–0.025	

Discussion

Sonography is a common imaging method used in routine practice. The inability to interpret the results due to lack of population norms was a major knowledge gap. Our objective was to define the normal limits of liver, spleen and kidney dimensions in a large group of school aged children. There have been quite a few previous reports giving the standard sizes of kidney, liver and spleen by ultrasound in children (9, 10, 11, 13, 15, 16), but none has been done in Ethiopia population. To our knowledge this is the only study of this kind done on Ethiopian school aged children.

Longitudinal measurements of the liver, spleen and kidneys have been reported to best correlate with body parameters (10, 13, 17, 18). In obtaining measurements of the liver, the longitudinal length at the MCL plane has shown the best correlation with body parameters (10, 13, 17) and this was the measurement that we used in this study. Of the different methods for evaluating the kidney by sonography, lateral decubitus position was used preferentially by many previous investigators (17, 19).

Previous studies showed that the longitudinal measurements of the liver, spleen, and kidneys were best correlated with body parameters (7, 10, 17 –24). The results of our study were in accordance with the findings of those studies. In many studies, the lengths of the liver in the MCL and midsagittal planes were both measured, but they found better correlation between the measurement of the MCL plane and the body parameters (8, 9, 10, 16, 25).

In our study, only MCL measurements of the liver were used, and strong correlations were found with the body parameters. This result indicates that MCL measurement of the liver is practical and yields reliable information.

There are different methods for evaluating the kidneys by sonography, such as lateral decubitus, supine, and prone positions. A lateral decubitus position was mostly preferred in previous studies (19, 20, 22, 26). Accordingly, we used a lateral decubitus position for the measurements. Kidney dimensions in pediatric age groups have been studied relatively more frequently by many authors than liver and spleen dimensions. In this study, the longitudinal length of the left kidney was greater than that of the right kidney, as shown in previous studies (17, 19, 21, 22, 23). However, Christophe et al found a slight difference between kidney lengths and considered it negligible(24).

Previous studies described normal percentiles of the liver and spleen according to age. However, our study showed that liver and spleen dimensions showed weak correlations with age. Spleen dimensions showed the best correlation with body weight, as did liver dimensions. Soyupak et al and Dinkel et al also reported that liver, spleen, and kidney dimensions showed the best correlation with body weight (21, 25). In our study, longitudinal lengths of the

right kidney showed the best correlation with height. This finding was consistent with those of many previous studies (17, 21, 23, 24).

In our study, we found that the longitudinal parameters of all the organs measured, were highly correlated with body weight, similar to findings of previous studies (13, 21, 25). Age and height were also correlated with organ dimensions but not to the extent of body weight. This is clearly seen in weight being a predictor of the dimensions of all organs, unlike height and age, in the multiple regression analyses which controlled for all the variables.

Conclusion

The normal limits of the liver, spleen, and kidneys are important parameters during a sonographic examination. This study revealed that organ dimensions showed the best correlation with body weight. Longitudinal parameters of liver, spleen and kidneys correlated with body weight, height and age. The results of this study may be used as a guide to interpret the normal sizes of the liver, the spleen and the kidneys of school aged south west Ethiopian children based on body weight categories. As the study population comprised only south west Ethiopian children wide survey including all ethnicities all regions needs to be conducted to generate percentile graphs for generalized clinical use.

COMPETING INTERESTS

The authors declare that they have no competing interests.

Acknowledgments

We thank all the staff of Jimma University Medical Center for assistance and cooperation during physical measurements and data collection processes. Financial support for this study was provided by Jimma University, Institute of Health is also gratefully acknowledged.

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