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Normal splenic measurement in adults Sudanese using Ultrasonography: Impact of gender and Body Mass Index (BMI)

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Past Various pathological conditions, such as sickle cell disease and recurrent malaria, cause changes in spleen measurement and cause an increase or decrease in spleen length and volume, so determining spleen measurement is critical. Aim: to assess the splenic measures in healthy Sudanese participants and find a relationship between these measurements with gender, age, and BMI (body mass index). Methods and results: A cross-sectional descriptive study was conducted in Sudan from January 2021 to July 2021. Three hundred health participants were investigated using an ultrasound probe 3.5 MHz (Megahertz) following the splenic sonographic protocol. The mean splenic length, width, thickness, and volume were 9.32±1.23, 8.64±1.24, 3.86±0.79 cm, and 170.64±72.89cm^3, respectively. These measurements were higher in males than females. There was a weak positive association between height, weight, BMI (Body Mass Index), and spleen volume. Spleen length shows a weak negative relationship with age. This study concluded that splenic measurements vary with gender and age. There was a linear correlation between BMI and splenic volume.

Keywords: Spleen; Ultrasound; BMI, Gender; Age

INTRODUCTION

The spleen is the largest organ of the reticuloendothelial system. Changes in spleen size are associated with various disorders, including infectious, parasitic, invasive, immunological, and malignant conditions.(Ehimwenma and Tagbo, 2011)Typical dimensions are 5 inches long, 3 inches wide, and 1 inch thick (12.5 x 7.5 x 2.5 cm), but sizes vary greatly. (Tekle et al. 2018) Numerous diseases alter spleen size, and splenomegaly and its sequelae are the major clinical problems in developing countries caused by conditions such as malaria, typhoid fever, leishmaniasis, schistosomiasis, and lymphoma. Splenic atrophy is another collaborative problem associated with diseases such as sickle cell anemia, in which progressive atrophy develops because of repeated bouts of vascular occlusion and infarction caused by these diseases, resulting in autologous splenic atrophy. (Demissie et al. 2021) Differences in anthropometric characteristics of various populations, races, and regions influence spleen size. The literature reports normal spleen sizes across multiple age groups. Therefore, a standard normal range of spleen sizes in the population is a prerequisite for correct interpretation. Sonography showed a decrease in spleen size with age. Spleen size in adults varied by sex and age. Women's spleen size was smaller than men's across all age groups. (Chakraborti et al. 2016)

Sudan is one area with various types of tropical diseases that may affect the splenic size. Childhood spleen rates have been utilized as an epidemiologic indicator of community immunity, exposure, and transmission intensity in regions with steady malaria transmission. Few studies estimate the spleen size and its relationship with age, gender, and BMI (Body Mass Index), specifically in Sudan. Therefore, this study aims to assess the standard measurement of the spleen in Sudanese adults using ultrasonography concerning age, gender, and BMI (Body mass index).

MATERIALS AND METHODS

A cross-sectional study was conducted in two Private Centre in Khartoum state Sudan (January to July 2021) - Alzahraa Medical Centre and Almualim Medical Centre in Khartoum, Sudan, to assess the relationship between age,

gender, and BMI with the splenic measurements using ultrasonography. Three hundred participants of different ages and genders who agreed to participate in the study were included in the study sample; any patients with a medical or pathological condition that affect the spleen size, such as sickle cell anemia or recurrent malaria, were excluded.

Ultrasound scanning and measurements:

The investigations were performed using a 3.5 MHz ultrasound curvilinear probe (Esaote and Mindary DP 10 ultrasound machines). The patient was examined in both the supine and right lateral decubitus positions, with the left arm raised above the head to provide a better window for the ultrasound examination. Because it is beneath the ribcage, deep breathing makes it easier to examine. Moving the transducer via left intercostal, coronary, or oblique approaches during the examination allows for a better image of the spleen and the detection of any potential changes. The three measurements were obtained on sections through the splenic hilum. Splenic length is the maximum distance between the splenic dome and the splenic tip measured on the longitudinal section. The width of the spleen is defined as the maximum distance between the medial and lateral borders of the spleen, measured on a plane perpendicular to the length. Transverse scans were acquired with the transducer rotated through 90. Splenic depth, defined as the maximum anteroposterior dimension (thickness), is measured on a transverse section. Then the spleen volume is calculated by multiplying the three measurements length x width x thickness x 0.523. figure 1

Figure 1: A sonogram shows the width and length measurements of the spleen.

Data analysis:

The data were analyzed using SPSS version 23; frequency and percentage were used for categorical variables, then descriptive statistics were used for continuous variables. Furthermore, an independent sample t-test, A nova test, and Pearson's correlation were used to determine the relationship between the study variables; a P-value ≤ 0.01 or 0.05 was considered significant.

RESULTS

In the study's sampling, more than 3/4th were females (78.7%), and more than 2/3rd (73.3%) were in the age group 18-38 years table 1.

Table 1: Demographic characteristic

Gender	Frequency	Percent	Cumulative Percent
Female	236	78.7	78.7
Male	64	21.3	100.0
Age group / years			
18-38	220	73.3	73.3
39-59	54	18.0	91.3
60-80	26	8.7	100.0
Total	300	100	

No significant difference was found in splenic width and length in both genders, but there was a significant difference in the measurement of thickness and volume in both gender $p< 0.05$, all measurement was more in males than females (measurement of spleen length, width, thickness and volume in males were 9.52±1.30, 8.83±1.24, 4.08±0.94 cm and 189.69±91.28cm^3, and for females 9.27±1.21, 8.59±1.24, 3.80±0.74 cm and 156.90±66.31cm^3), table 2, fig 2.

Spleen length decreased significantly as the age of participants increased, $p <0.05$; in the participant with ages ranged 18-38 years, the spleen length was 9.41±1.17 cm, while in 39-59 years and 60-80 years was 9.26± 1.33 cm and 8.70±1.39 cm respectively. The width, thickness, and volume of the spleen insignificantly vary in various age groups, $p > 0.05$, table 3.

Table 2: Compares mean splenic measurements in both genders.

Variables	t-test for equality of mean						
	Gender	N	Mean	Median	SD	SE	P value
Length	Female	236	9.27	9.30	1.212	0.0789	0.161
	Male	64	9.52	9.40	1.308	0.164	
Width	Female	236	8.59	8.60	1.245	0.0810	0.171
	Male	64	8.83	8.85	1.247	0.156	
Thickness	Female	235	3.81	3.80	0.740	0.0483	0.015[a]
	Male	64	4.08	3.95	0.941	0.118	
Volume	Female	235	165.46	156.90	66.317	4.3260	0.018[a]
	Male	64	189.69	168.88	91.282	11.410	

[a] Levene's test is significant ($p < .05$), suggesting a violation of the assumption of equal variances

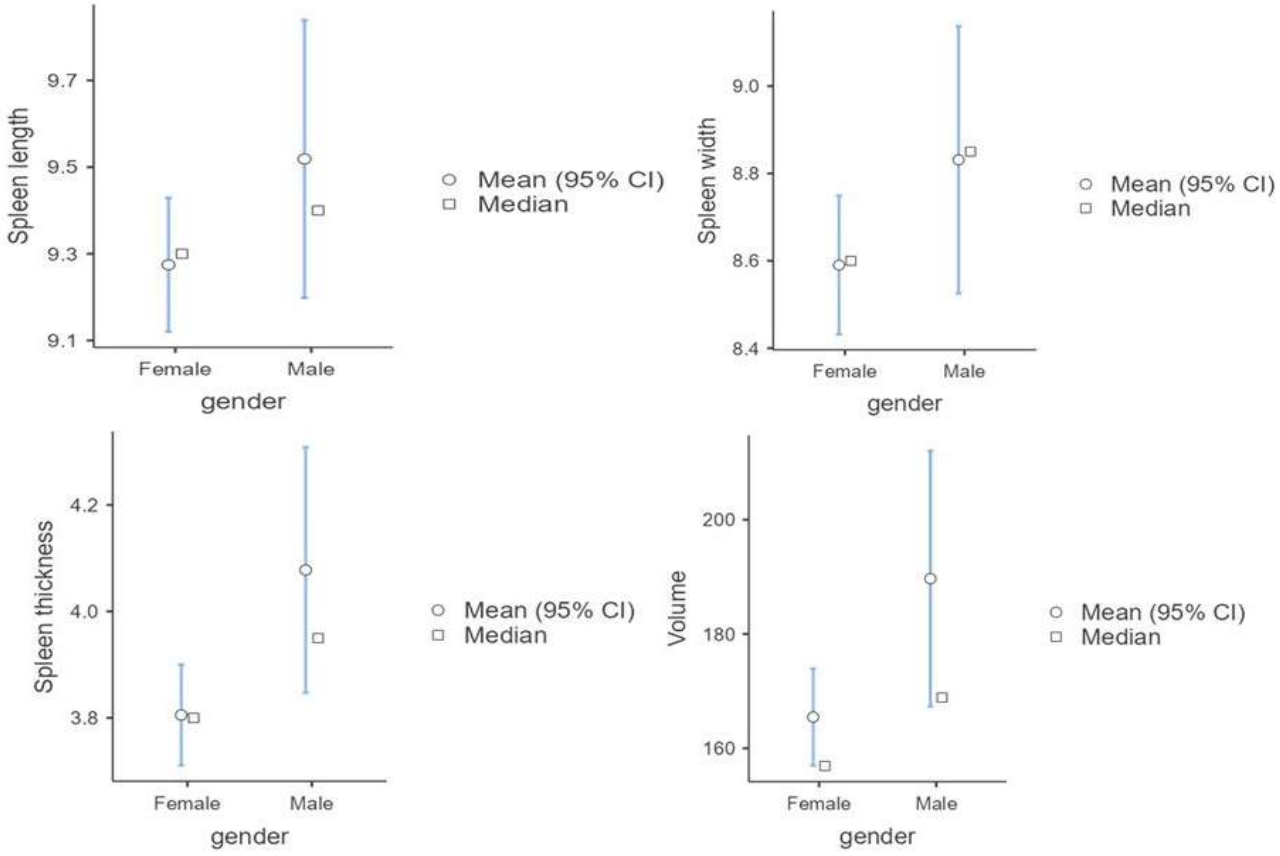

Figure 2: Plot box shows mean and median measurements in both gender

Table 3: Compares mean splenic measurements in different age groups

Age group		Length	Width	Thickness	Volume
18-38	Mean	9.416	8.704	3.840	171.8189
	SD	1.1741	1.1779	.7322	69.59055
39-59	Mean	9.263	8.643	4.024	177.4389
	SD	1.3302	1.4123	.9248	84.22631
60-80	Mean	8.704	8.112	3.731	146.6708
	SD	1.3915	1.3736	.9703	73.24368
Total	Mean	9.327	8.642	3.864	170.6471
	SD	1.2351	1.2469	.7936	72.89737
P values		0.019[a]	0.072	0.210	0.189

There is a weak negative correlation between age and splenic length and a weak significant positive correlation between height, weight, BMI, and splenic length and volume. A weak positive linear relationship between BMI (Body mass index), length, and spleen volume Table 4, figure 3.

Table 4: Correlation between splenic measurements with age, weight, height, and BMI

Spleen measurements	Correlation	age	height	weight	BMI
Spleen length	Pearson's r	-0.125	0.178	0.247	0.195
	p-value	0.031	0.002	< .001	< .001
Spleen width	Pearson's r	-0.097	0.141	0.202	0.160
	p-value	0.093	0.015	< .001	0.005
Spleen thickness	Pearson's r	0.034	0.090	0.258	0.246
	p-value	0.561	0.121	< .001	< .001
Volume	Pearson's r	-0.043	0.139	0.261	0.226
	p-value	0.459	0.016	< .001	< .001

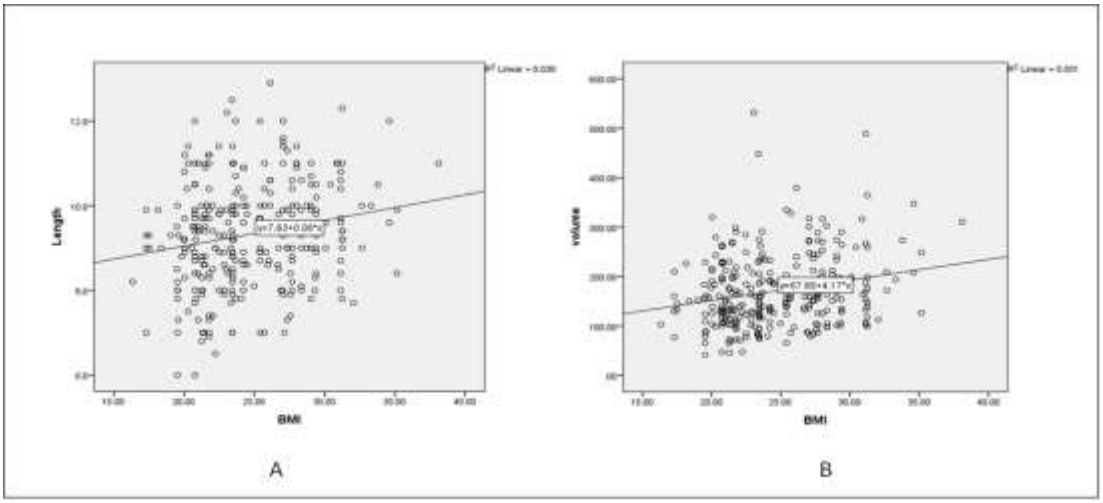

Figure 3 (A-B): Scatter plot shows a weak linear relationship between BMI and length and volume.

DISCUSSION

Splenomegaly is an important clinical finding and may be present in various diseases, including liver disease, portal hypertension, splenic vein thrombosis, lymphoma, other primary and metastatic neoplastic processes, and hematologic entities. Assessment of spleen size by physical examination is notoriously subjective and inaccurate, so radiographic evaluation is expected. Ultrasound is a quick, easy, and inexpensive method that poses no hazard to ionizing radiation. (Yetter et al. 2012)

The splenic measurements differ more in the literature, which could be attributed to differences in height, weight, and BMI. This study determined the normal measurements: length, width, thickness, and volume. Several studies in the literature evaluate the standard splenic length and volume(Chakraborti et al. 2016; Demissie et al. 2021; Ehimwenma and Tagbo, 2011; Frank et al. 1984; Loftus and Metreweli, 1997; Okoye et al. 2006; Tekle et al. 2018; Yetter et al. 2012)

The present found that the mean splenic measurements were 9.32±1.23, 8.64±1.24, 3.86±0.79 cm, and 170.64±72.89cm^3 for length, width, thickness, and volume, respectively. There is little variability in these measurements among different studies due to varying methods of measurement, particularly splenic width, as well as the variation in spleen measurements due to ethnic differences. It was found that the splenic measurements were higher in males than in females, with significant differences in thickness and volume. There was no significant difference in length and width in both genders. Ehimwenma O et al. (Ehimwenma and Tagbo, 2011) found that splenic measurements were higher in males, with significant differences in length, width, depth, and volume. Badran DH et al. found that splenic measurements were also higher in males, with significant differences in length, depth, and volume. (Badran et al. 2015) Additionally, Arora et and Çeliktas et al found that splenic length, width, and thickness increased in males. (Arora et al. 2010; Çeliktas et al. 2015)

The present study revealed that splenic length decreased as age increased, particularly in the age group of 18-38 years compared to the age groups of 39-59 and 60-80 years. A weak negative correlation was found between

splenic length and age; this result is consistent with other studies. (Arora et al. 2010; Asghar et al. 2011) A weak positive relationship was found between splenic measurement weight, height, and BMI. This result is consistent with other studies. (Badran et al. 2015; Ehimwenma and Tagbo, 2011) A study conducted in Turkey found no significant association between splenic volume and body parameters in males. (PABUÇCU et al. 2010)

This study contradicts other Sudanese studies in which the mean splenic volume is lesser than those in our findings, with no significant difference in splenic volume with age. The difference in spleen volume could be attributed to different methods of measuring splenic width. (Yousef, 2018)

This study's results can be utilized as a reference value for assessing pathologic alterations in the spleen and offer surgeons and radiologists essential information concerning splenic abnormalities.

CONCLUSION

The study found significant differences in the thickness and volume of the spleen in the different sexes. The splenic measurements were larger in males than in females. A weak positive association was found between splenic length, width, volume and height, weight, and BMI. The splenic length and volume reduced with age.

CONFLICT OF INTEREST

The authors declared that the present study was performed in the absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

AG designed the study, analyzed the data, and wrote, edited, and reviewed the manuscript before approving the final version.

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