

Morphometric Assessment of Spleen Dimensions and Its Correlates Among Individual Living in Arba Minch Town, Southern Ethiopia

Solomon Demissie (✉ sol12162129@gmail.com)

Arba Minch University

Prasad Mergu

Arba Minch University

Teshale Fikadu

Arba Minch University

Tadios Hailu

Arba Minch University

Getachew Abebe

Arba Minch University

Mengistu Warsa



Arba Minch General Hospital

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Abstract

Introduction: The spleen is a vital lymphoid soft organ that demands constant attention from the clinical point of view. It is multi-dimensional organs that enlarge in all dimensions in disease conditions. The detection of the spleen by palpation on physical examination is not an approval of an enlarged spleen because an unenlarged spleen may palpable. Therefore, this study aimed to assess the Morphometry of spleen dimensions and its correlates among individuals living in Arba Minch Town by sonographic examinations.

Methods and Materials: Community-based cross-sectional study was conducted in Arba Minch town from February 1 to March 30, 2020. A multi-stage systematic and simple random sampling technique was applied to select study participants. Data was entered into Epi-Data version 3.1 software and exported to SPSS version 20 software for analysis.

Result: A total of 708 individuals, 390 (55.1%) males and 318 (44.9 %) females were included in the current study. The mean splenic length, width, thickness and volume were 10.24 cm, 4.79 cm, 3.93 cm, and 109.34 cm³, respectively. The mean spleen length, width, thickness and volumes among males were 10.64 cm, 4.92 cm, 4.05 cm and 119.81 cm³ and among females were 9.75 cm, 4.63 cm, 3.78 cm and 96.50 cm³ respectively. Significant negative correlations were found between age and spleen dimensions. Significant positive correlations were observed between spleen dimensions and height, weight, Body Mass Index, and Body Surface area. But, the correlation between width and body mass index was non-significant (p-value > 0.05).

Conclusion and Recommendations: The spleen dimensions were higher in males than females and have a significant positive correlation with height, weight, Body Mass Index and Body Surface Area except for the width. Further studies in different parts of the country have to be done to have normative data on the dimension of Spleen in Ethiopia.

Introduction

The spleen is the largest lymphoid soft organ that lies in the left hypochondrium between the fundus of the stomach and the diaphragm where it is entirely covered by the inferior thoracic rib cage (1). It extends from the 9th – 11th ribs on the left side with its long axis runs parallel to the 10th rib (2). Its shape is ovoid with a convex outer diaphragmatic surface and an indented inner visceral surface related to the stomach, left kidney, pancreatic tail, left suprarenal gland and left colic flexure (3, 4). The apex lies in line with the spine of the 10th thoracic vertebra about 4 cm from the midline and the base does not descend beyond the midaxillary line (5).

The spleen is an encapsulated intraperitoneal organ entirely covered with peritoneum except for its hilum where the splenic branches of the splenic artery and vein enter and leave (5, 6). It is supported by a phrenico-colic ligament that originates from the colon from the bottom and anchored to the stomach by gastro-splenic ligament and to the left kidney by a lien renal ligament (7).

In diseases condition spleen enlarges at different rates in its dimensions and most easily vulnerable organs (8–10). A variety of diseases condition alters spleen dimensions, where splenomegaly and its consequence becomes a primary clinical concern in any part of the world (11, 12). Splenomegaly is commonly seen in about 63% of patients with PAH (13), IM (14, 15), malaria (16, 17), lymphoma (18), kala-azar (19), typhoid fever (20), and others. The altered splenic dimensions and structure during these diseases result in asymptomatic enlargement and complications such as hematoma formation, rupture, hypersplenism, ectopic spleen, and torsion that affect other adjacent organs (21, 22). The splenic atrophy is also another common problem seen in diseases like sickle cell anemia (23) and celiac disease

(24). The progressive atrophy as a result of repeated attacks of vaso-occlusion and infarction caused by these diseases leads to auto splenectomy (23, 25, 26).

The average dimensions of the spleen are 12.5 cm, 7.5 cm and 2.5 cm in length, width and thickness respectively and 150–200 grams in weight, but its dimensions vary considerably (2, 27). The literature revealed that spleen dimensions are affected by geographical differences, races, nutritional status and anthropometric measurements (28–30). Due to these variations, a normal range of spleen dimensions varies from country to country where some accept less than 12 cm spleen length (31) and others accept less than 13 cm spleen length in their clinical practice (32), etc. The study conducted in Northern Ethiopia revealed also these variations where normal spleen length ranges vary from 7- 13.6 cm (33).

In clinical practice, palpation is commonly used to detect spleen dimensions. However, detection of the spleen by palpation is not reliable because the normal spleen is palpable and a non-palpable spleen is not normal sized at all (34–37). Similarly, diagnoses of diseases associated with the spleen by physical examination and laboratory findings do not determine parasite load, the extent of diseases and complications caused in case of severe cases (38).

Although, Literatures indicates radiological imaging modalities like ultrasound can detect the extent, complications, and classify the severity of cases, yet enough attention is not given in clinical practice (39). On sonographic examinations, the spleen is crescent-shaped with the outer margin is smooth and convex and the inner margin is irregularly indented. Its echotexture is homogeneous and more echogenic than healthy liver tissue and markedly hyperechoic compared to kidney tissue (13).

Even though there are several studies in which the spleen dimensions have been analyzed in many countries, there is still a lack of adequate information in African populations including Ethiopia. Therefore, the study is aimed to assess the morphometry of spleen dimensions and to determine its variations with sex, age, height, weight, BMI, and BSA among individuals living in Arba Minch town.

Methodology And Material

The community-based cross-sectional study was conducted from February 1 to March 30, 2020, in Arba Minch town, SNNP region which is located at an altitude of 1285 m above sea level and about 437 km far from Addis Ababa. 708 individuals (390 males and 318 females) fulfilling inclusion criteria were included in the current study of spleen dimensions. The data collection checklist was developed after reviewing different literature (33, 40, 41). The checklist was developed in English and the face validity was assessed by a public health specialist and Anatomist. The checklist was composed of socio-demographic factors (age and sex); anthropometric measurements (height, weight, BSA and BMI) and spleen dimensions (length, width, thickness and volume). A multi-stage sampling technique was used to select study participants. Individuals selected at household levels were sent to the nearest health center or selected private clinics for sonographic examination. History and physical examination of individuals were taken before sonographic examination by clinicians. Then the individuals were sent for sonographic examinations which were performed by two radiology technologists using portable and stationary ultrasound machines equipped with 3.5 MHz curvilinear probes. The subjects were examined in the supine or right oblique positions for overall abdominal examinations to exclude cases associated with the spleen. Then spleen dimensions measurements were performed for apparently healthy individuals. The spleen was scanned during suspended respiration. The splenic length was measured in a longitudinal plane between the dome of the spleen and the splenic tip. The splenic width was also measured in a longitudinal plane perpendicular to the length between the medial and lateral borders of the spleen. The splenic thickness was measured on the transverse plane from the posterior margin to the anterior margin. The volume

was calculated using the ellipsoid formula during the analysis (41, 52). The spleen dimensions were measured three times and recorded on the checklist then the average value was taken during analysis (42-45).

Finally, the baseline data including age and sex were recorded for all participants. The height and weight were measured with the stadiometer and weighing machine for all participants respectively. BSA and BMI were calculated during the analysis.

Inclusion and Exclusion Criteria

Inclusion criteria

All apparently healthy individuals and age greater than 13 years (46, 47)

Exclusion criteria

- Individuals with a recurrent clinical history of malaria
- Recurrent history of typhoid fever
- Individuals with a history of infections (infectious mononucleosis, kala-azar, endocarditis, sarcoidosis, toxoplasmosis).
- Recent history of upper abdominal surgery
- Individuals with any case finding on sonographic examinations (cirrhosis, melanoma, lymphoma, metastasis, any cystic or solid massive lesions)
- Individuals with Diabetic Mellitus (DM) cases.
- Hypertensive individuals
- Individuals with a history of heart disease
- Individuals with a recent abdominal traumatic condition (within the previous 6 months)
- Pregnant women

Study variables

Dependent variables

Spleen dimensions (length, width, thickness and volume)

Independent variables

- Age
- Sex
- Height
- Weight
- BSA and
- BMI

Operational definitions

Apparently healthy individuals: - defined as the absence of disease based on clinical signs and symptoms of individuals normally assessed by history, physical evaluation and sonographic examinations (48, 49).

Data Analysis and Processing

Data was entered into Epi-Data version 3.1 software and exported to SPSS version 20 software for analysis. A descriptive summary was used to present the result. Independent- Samples t-test was conducted to compare the mean spleen dimensions among sex and one-way ANOVA was conducted to compare the mean spleen dimensions among age groups. T and F statistics were calculated and $P < 0.05$ was taken as statistically significant. To determine the relationships between the studied parameters, Pearson correlation coefficients were calculated

Result

Socio-demography

A total of 708 (55.1% male and 44.9% female) participants were included in the study with a 100% response rate. The mean age of the study participant was 32.28 ± 13.17 years with a majority of 278 (39.3 %) were between the age group of 21 – 30 years (Table 1).

Table 1: Age and sex distribution of the study participants living in Arba Minch town, 2020

Age category in years	Sex		Total
	Male	Female	
11-20	72	58	130
21-30	154	124	278
31-40	88	66	154
41-50	28	38	66
Above 50	48	32	80
Total	390	318	708
%	55.1%	44.9%	100.0%

Anthropometric measurements

The mean height, weight, BMI, and BSA of the study participants were 167.56 ± 6.69 cm, 61.75 ± 8.23 kg, 21.98 ± 2.53 , and 1.67 ± 0.13 respectively (Table 2).

Table 2: Anthropometric measurement of the study participants living in Arba Minch town, 2020

	N	Minimum	Maximum	Mean	Std. Deviation
Height (cm)	708	150.00	188.00	167.5607	6.68908
Weight (kg)	708	44.00	89.00	61.7446	8.22522
BMI	708	14.81	30.67	21.9785	2.53226
BSA	708	1.38	2.10	1.6924	.13246
Total	708				

Overall spleen dimensions

The mean splenic length, width, thickness, and volume were 10.24 ± 1.458 cm, 4.79 ± 0.99 cm, 3.93 ± 1.05 cm, and 109.34 ± 61.68 cm³, respectively. The dimensions lie with the range of (7.07-13.91) cm in length, (2.32-7.20) cm in width, (2.10-7.09) cm in thickness, and (20.83-349.03) cm³ in volume (Table 3).

Table 3: Average spleen dimensions of study participants living in Arba Minch town, 2020

	Minimum	Maximum			Std. Deviation	95% Confidence Interval	
			Mean	Std. Error	Statistic	Lower bound.	Upper bound.
Length	7.07	13.91	10.2421	.05441	1.44771	10.14	10.35
Width	2.32	7.20	4.7889	.03751	.99811	4.72	4.86
Thickness	2.10	7.09	3.9311	.03960	1.05367	3.85	4.00
Volume	20.83	349.03	109.3381	2.31811	61.68084	104.79	113.89

Comparison of spleen dimensions by sex

The mean spleen length, width, thickness and volume among males were 10.64 ± 1.38 cm, 4.92 ± 1.03 cm, and 4.05 ± 1.09 cm and among females were 119.81 ± 65.32 cm³ and 9.75 ± 1.38 cm, 4.63 ± 0.93 cm, 3.78 ± 0.98 cm and 96.50 ± 54.31 cm³ respectively. A significant difference in splenic dimensions was observed in which the dimensions were higher among males than females (Table 4).

Table 4: Independent sample t-test analysis in comparison of spleen dimensions by sex among individuals living in Arba Minch town, 2020

	Sex	N	Mean	Std. Deviation	95% CI for Mean		T-test	P-value
					Lower Bound	Upper Bound		
Length	Male	390	10.6433	1.37963	10.5098	10.78569	8.575	0.000
	Female	318	9.7500	1.37759	9.6067	9.9044		
Width	Male	390	4.9155	1.03225	4.8118	5.0181	3.812	0.000
	Female	318	4.6336	.93295	4.5366	4.7385		
Thickness	Male	390	4.0537	1.09359	3.9444	4.1768	3.49	0.001
	Female	318	3.7809	.98357	3.6774	3.8898		
Volume	Male	390	119.8054	65.31931	113.4938	126.7284	5.183	0.000
	Female	318	96.5009	54.30818	90.9121	102.8142		

Comparisons of spleen dimensions with different age groups

Significant variations were observed in all spleen dimensions among age categories of study participants. The lowest value was recorded in age groups of above 50 years (9.36cm, 4.35cm, 3.56cm and 86.33 cm³ for length, width, thickness, and volume respectively) and the highest in age groups of 31-40 years (10.76cm, 4.91cm, 4.2 and 126.02 cm³ for length, width, thickness, and volume respectively). As the age increases all spleen dimensions were found to decrease above the age of 40 years (Table 5).

Table 5: One-way ANOVA analysis of different age groups in comparison of spleen dimensions among the study participants living in Arba Minch town, 2020

	Age (in a year)	N	Mean	SD	95% CI		F	P-value
					Lower B.	Upper B.		
Length	11-20	130	10.14	1.21	9.93	10.35	16.53	0.000
	21-30	278	10.37	1.31	10.23	10.53		
	31-40	154	10.76	1.49	10.52	10.99		
	41-50	66	9.72	1.57	9.34	10.11		
	>50	80	9.36	1.56	9.02	9.71		
	Total	708	10.24	1.45	10.14	10.35		
Width	11-20	130	4.90	0.90	4.75	5.06	6.43	0.000
	21-30	278	4.85	0.92	4.75	4.96		
	31-40	154	4.91	1.08	4.74	5.08		
	41-50	66	4.54	1.04	4.28	4.80		
	>50	80	4.35	1.08	4.11	4.59		
	Total	708	4.79	0.99	4.72	4.86		
Thickness	11-20	130	3.99	0.87	3.85	4.15	5.94	0.000
	21-30	278	3.91	0.99	3.79	4.02		
	31-40	154	4.20	1.21	4.01	4.39		
	41-50	66	3.73	1.08	3.47	3.99		
	>50	80	3.56	1.05	3.32	3.79		
	Total	708	3.93	1.05	3.85	4.01		
Volume	11-20	130	109.59	51.77	100.61	118.58	6.55	0.000
	21-30	278	109.70	54.92	103.22	116.19		
	31-40	154	126.02	71.26	114.68	137.37		
	41-50	66	96.26	69.01	79.29	113.22		
	>50	80	86.33	64.20	72.04	100.61		
	Total	708	109.34	61.68	104.79	113.89		

Correlation analysis of spleen dimensions

Pearson's correlation analysis showed that a significant correlation was observed among all evaluated spleen dimensions and height, weight, BSA, and BMI except the width which showed non-significant correlations with BMI ($p>0.05$). The highest positive correlation was observed between spleen length and height of participants ($r = 0.518$) while the lowest was between spleen thickness and BMI of participants ($r = 0.111$). Spleen length, width, thickness and volume were negatively correlate with age ($r = -0.183, -0.165, -0.107$ and -0.100 respectively) (Table 6).

Table 6: *Pearson's correlation analysis of spleen dimensions with age, height, weight, BMI and BSA among individuals living in Arba Minch town, 2020*

		Height	Weight	BMI	BSA	Length	Width	Thickness	Volume	Age
Height	R	1	.516**	-.112**	.693**	.518**	.411**	.354**	.437**	.002
	Sig. (2-tailed)		.000	.003	.000	.000	.000	.000	.000	.960
Weight	R	.516**	1	.790**	.975**	.442**	.307**	.312**	.374**	.309**
	Sig. (2-tailed)	.000		.000	0.000	.000	.000	.000	.000	.000
BMI	R	-.112**	.790**	1	.636**	.143**	.066	.111**	.120**	.363**
	Sig. (2-tailed)	.003	.000		.000	.000	.080	.003	.001	.000
BSA	R	.693**	.975**	.636**	1	.506**	.364**	.354**	.427**	.262**
	Sig. (2-tailed)	.000	0.000	.000		.000	.000	.000	.000	.000
Length	R	.518**	.442**	.143**	.506**	1	.707**	.621**	.803**	-.183**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000	.000	.000
Width	R	.411**	.307**	.066	.364**	.707**	1	.690**	.864**	-.165**
	Sig. (2-tailed)	.000	.000	.080	.000	.000		.000	.000	.000
Thickness	R	.354**	.312**	.111**	.354**	.621**	.690**	1	.900**	-.107**
	Sig. (2-tailed)	.000	.000	.003	.000	.000	.000		.000	.004
Volume	R	.437**	.374**	.120**	.427**	.803**	.864**	.900**	1	-.100**
	Sig. (2-tailed)	.000	.000	.001	.000	.000	.000	.000		.008
Age	R	.002	.309**	.363**	.262**	-.183**	-.165**	-.107**	-.100**	1
	Sig. (2-tailed)	.960	.000	.000	.000	.000	.000	.004	.008	

Discussion

This study describes the morphometry of spleen dimensions; compare the presence of a significant difference between sex and age as well as dimensional correlations with anthropometric measurements. The mean of spleen dimensions was also compared with other studies and consistency and the difference was noted in the current study.

The sonography assessment of spleen dimensions provides essential inputs for clinicians in daily clinical practice for proper diagnosis of splenomegaly (32, 44, 53–55). The result of this study gives reference values which helps radiologist for appropriate diagnosis of diseases associated to splenomegaly and splenic atrophy, for the surgeons to appropriately design surgical cases associated to spleen, for hematologist and immunologist for proper diagnosis of various gastrointestinal and hematological diseases and forensic studies (56–59).

The mean of spleen length at 95% CI with SD was 10.24 ± 1.45 cm which is consistent with studies conducted in Russia and Kashmir (60, 61). But, less than from study conducted in Turkey(42), Bangladesh, Jordan and North India (8, 41, 62, 63) and greater than from study conducted in Nepal, Nigeria, Sudan and Northern Ethiopia (29, 33, 42, 64).

The mean of spleen width was 4.79 ± 0.998 cm which is less than from study conducted in Bangladesh, Nepal, Kashmir, North India and Nigeria (8, 42, 44, 61, 63, 64) and greater than from study conducted in Sudan and Northern Ethiopia (29, 33).

The mean of spleen thickness in the current study was 3.93 ± 1.054 cm which is consistent with the study conducted in Ethiopia (33). But less than from studies conducted in Russia, Bangladesh, Jordan, Nepal, north India, and Nigeria (8, 41, 42, 44, 60, 63, 64) and is greater than from a study conducted in Sudan (29).

The mean spleen volume was 109.34 ± 61.68 cm³ which is less than from studies conducted in Saud Arabia, Russia, Jordan and Nepal (41, 53, 60, 64, 65) but greater than from the study conducted in Sudan and Ethiopia (33, 40).

The overall dimensional difference of the current study from studies conducted in other areas may be due to age group difference, sample size difference, anthropometric measurements, geographical differences, nutritional status, physical exercise, and race difference which were stated in different literature (32, 44, 59, 66–69).

The fact that fewer average total red cell mass among females and due to genetic factor splenic dimensions was lower in females (31, 70). This is supported by our findings where all dimensions were significantly larger in males than females. This is consistent with the study conducted in Turkey, Saudi, Nigeria and Sudan (40, 53, 59, 71, 72). But, a non-significant difference in spleen volume was observed in a study conducted in Nepal (64) which is due to the small sample size and age range difference where 1–90 years were included in the study of Nepal. Also, the length was higher among females than males in the study conducted in Egypt (73) which is maybe due to nutritional status where Egyptian culture accepts excess weight gain among women than men due to fertility considerations (74, 75).

The spleen dimensions decrease in older age due to a decrease in the number and size of B cell follicles of the white pulp of the spleen which decreases with a decrease of germinal center in older age groups (76–78). This is supported by our finding where the lengths, width, thickness, and volumes were significantly increased up to the age of 40 years then decrease in older ages. This is consistent with the study conducted in Iraq, western Nepal, and India (32, 45, 54, 55, 79, 80). But, this different from the study conducted in Pakistan, Jordan, and Nigeria (41, 42, 68, 72). The difference is maybe due to nutritional status where larger anthropometric measurements and obesity were observed in the study of Pakistan (68), Jordan (41) and Nigeria (42, 72).

From a physiological perspective as individuals' body parameters (height, weight, BMI, and BSA) increase, the blood volume increase and requiring larger spleens for filtration (41). This is supported by our finding where all dimensions were positively correlated with height, weight, BMI, and BSA ($p < 0.05$). This is consistent with the study conducted in Jordan, USA, India, Sudan (29, 31, 37, 41, 61, 63, 79). But, different from the study conducted in Turkey, Nigeria and Egypt (42, 62, 68, 73). This may be due to nutritional status where the study participants in the study of Turkey, Nigeria and Egypt were overweight than ours. The non-significant correlations observed between spleen width and BMI in the current study ($P = 0.080$) is consistent with the study conducted in Sudan (40).

Limitation Of The Study

- The current study does not include the history of the physical exercise of the participants. A laboratory finding of study participants is not known.

Conclusion

The mean value of spleen dimensions of the Arba Minch town community was 10.24 cm, 4.79 cm, 3.93 cm, and 109.34 cm³, in length, width, thickness, and volume respectively. The study indicated that there is a significant morphometric difference in splenic dimensions between males and females. Only the width shows a non-significant correlation with BMI and significant negative correlations was seen between age and spleen dimensions. This study gives baseline information for clinicians as well as for academicians about the morphometric variation of spleen dimensions which helps in diagnosing pathological cases associated with spleen both splenomegaly as well as splenic atrophy.

Abbreviations And Acronym

AP: - Antero-Posterior

BMI: -Body Mass Index

BSA: -Body-Surface Area

CI: - Confidence Interval

CSA: - Central statistical agency

CT Scans: - Computed Tomography Scans

IM: - Infectious Mononucleosis

MHz: -Megahertz.

MRI: - Magnetic resonance imaging

P: - P-value

PAH: - Pulmonary arterial hypertension

R: - Pearson correlation coefficient

RT: - Radiologic Technologists

SD: - Standard Deviation

SNNP: Southern Nations, Nationalities and peoples

SPSS: - Statistical Package for the Social Sciences.

US: - Ultrasonography

Declarations

The ethical approval letter was obtained from Arba Minch University's ethical review board. The letter of cooperation was obtained from the town administration and written informed consent was obtained from the study participants. For participants less than 18 years parental written consent was obtained after informing the purpose of the study. All methods were carried out following relevant guidelines and regulations.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing of interest.

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Availability of data and materials

All relevant data are included in the article. The dataset of this study are available from the corresponding authors upon reasonable request.

Authors' contributions

SD conceptualize and designed the study, conducted the analysis, interpret and write the first draft of the paper for publication. GA and MW were involved in the data analysis and interpret the data, and reviewed the manuscript for publication. TF, PM and TH supervise the data collection process. All authors read and approve the final manuscript before submission.

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