

Role of anthropometric measurements on sonographic estimation of false hepatomegaly among healthy adult men

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Background/aim

Ultrasonography is the modality of choice in assessment of liver span and an essential part of clinical assessment of healthy and pathologic liver. Various anthropometrical measurements may influence liver span. The aim of this study is to evaluate the relationship between anthropometric variables and liver span and verify that the previously accepted cutoff value of normal liver span should be changed according to body physique.

Patients and methods

This cross-sectional study included randomly selected 106 men with normal liver function tests, visiting Hala Eisa Hospital searching for medical advice other than liver disease. Height, weight, and BMI were estimated, and ultrasound scanning for all participants was done.

Results

The mean liver span for the studied men was 16.02 ± 1.59 cm. Among the current samples, 62.3% (66) had false hepatomegaly and 37.7% (40) had normal liver span. There were insignificant differences in the anthropometric parameters between the men with false hepatomegaly and those with normal liver span; however, mean weight, height, BMI, and waist-hip ratio (WHR) were higher in men with false hepatomegaly. In addition, among men with normal liver span, there were highly significant positive correlations between liver span on one side and age, body weight, BMI, and WHR on the other side. However, among men with false hepatomegaly group, there was a highly significant negative correlation ($P < 0.01$) between liver span and height. Among men with normal liver span, WHR explained 43.2% of the changes occurred in liver span, which increased to 49.5% when age was added. Among men with false hepatomegaly, height explained 24.9% of the changes occurred in liver span, which increased to 36.7% when age was added.

Conclusion

In decision of diagnosis of hepatomegaly, body physique should be taken into consideration, particularly height and weight/height ratio. For the universe, cutoff point of 16 cm of liver span cannot be used to distinguish between those with normal liver and hepatomegaly.

Keywords:

anthropometric variables, hepatomegaly, liver, ultrasound

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Introduction

The liver is an essential organ, with numerous important functions. These include metabolism, nutrient storage, and immunity. The liver has a large capability of rejuvenating dead or injured tissues [1]. Although its span can be estimated by palpation and percussion, diagnostic imaging studies have shown that physical examination usually underestimates its span [2].

Various diagnostic techniques are used in the assessment of liver span. These include ultrasonography, computed tomography, and MRI. Ultrasonography is the initial imaging modality of choice for evaluating the liver [3].

Ultrasound is a cheap, accessible, portable, noninvasive, and radiation-free radiological modality that

necessitates little patient preparation. It has now become an essential part of the clinical assessment of healthy as well as pathologic liver [4]. Hepatomegaly was the most common findings in sonographic examinations, with bright echo patterns reflecting diffuse hepatic parenchymal disease followed by biliary system disease [5].

Although there is agreement in the clinical field about how to evaluate liver texture [6], there is a lack of consensus between sonographers on accurate measurements of liver span through two-dimensional

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ultrasound [7]. There is a wide range of liver span values reported in medical textbooks and research publications to indicate normal liver length [8]. Upper limit cutoff values for normal liver span range from 13 to 16 cm [9]. A common guideline in clinical ultrasound practice and ultrasound textbooks is that a liver measuring more than 16 cm in the midclavicular line is enlarged [10–12].

In recent years, there have been many ultrasonographic measurement studies to establish the normal range of liver span in different geographical regions and populations. These studies have often focused on sex, age, and anthropometric factors that influence liver span [13].

The aim of this study is to evaluate the relationship between anthropometric variables (height, weight, and BMI) with liver span and verify that the previously accepted cutoff value of normal liver span should be changed according to body physique.

Patients and methods

Patients and study design

This was a cross-sectional study that included 106 Egyptian men, selected randomly from tall thin patients (their height was >170.8 cm and their weight was <82.4 kg [14]), and with normal liver function tests (SGOT not above 40 U/l and SGPT not above 56 U/l) visiting Hala Eisa Hospital, Saudi Arabia, searching for medical advice from outpatient clinics. It was carried out between January 2019 and April 2019. All the participant men had normal liver parenchyma by ultrasound and normal liver function tests by laboratory investigations. Men with any prior history of liver disease or any conditions that could affect the liver structure or sonographic evidence of hepatic parenchymal lesion were excluded.

Ethical approval

This study complied with the Declaration of Helsinki. Local ethical approval was obtained from Hala Eisa Hospital medical advisor/administrator in 2019, and patients agreed and signed a well-informed consent before joining the study.

Inclusion and exclusion criteria

This was a cross-sectional study. All the participant men had normal liver function tests by laboratory investigations and normal liver parenchyma by ultrasound. The normal range for AST (SGOT) is 5–40 U/l of serum. The normal range for ALT (SGPT) is ~ 7 –56 U/l of serum. Men with any prior history of

liver disease or any conditions that could affect the liver structure or sonographic evidence of hepatic parenchymal lesion were excluded. Moreover, all patients with abnormal liver functions were not included in the study from the start.

Methods

Anthropometric measurements, laboratory tests, and ultrasound scanning for all participant men were collected.

Anthropometric measurements were performed for every participant following the recommendations of the International Biological Program [15]. Body height was measured to the nearest 0.1 cm using a Holtain Limited, UK, portable anthropometer. Body weight was determined to the nearest 0.01 kg using a Seca Scale Balance, with the patient wearing minimal clothing and with no shoes. Then, BMI was calculated using the following formula:

$$\text{BMI} = [\text{weight}(\text{kg}) / \text{height}(\text{m}^2)].$$

Ultrasound scanning

The participants were taken to the Radiology Department for the scanning after fasting overnight to reduce food residue and gas that may reduce image quality. All the sonographic examinations were done by a single trained radiologist to avoid interobserver error.

Ultrasound scanning of the patients was carried out using the craniocaudal liver diameter at midclavicular line for each participant. All measurements were taken in supine position during deep inspiration with the right hand under the head to raise the lower costal margin. Measurements were made by Logic 9 (GE machine; General Electric Company GE, Chicago, USA), ultrasound machine using 3.5/5 MHz curvilinear transducers. All measurements were recorded to the nearest millimeter.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS/Windows, Version 18, SPSS Inc., Chicago, Illinois, USA). Normality of data was tested using the Kolmogorov–Smirnov test, and they were normally distributed. The 106 participating men had normal liver function tests (by laboratory investigation of SGPT and SGOT) and normal liver parenchyma (by ultrasound examination). They were classified into two groups according to their liver span, that is, 40 men with normal liver span (<16 cm) and 66 men with false hepatomegaly (≥ 16 cm) according to Curry and

Tempkin [9]. Descriptive statistics were expressed as mean $\pm$ SD. Comparisons between the two groups in the anthropometric variables were investigated using independent sample *t* test. The Pearson's correlation was used to examine the significance of linear association between liver span and anthropometric variables. Stepwise linear regression analysis was used to develop model for the prediction of liver span. The graphs were drawn using Microsoft Excel program. Outcomes were considered statistically significant if the *P* value was less than 0.05.

Results

Descriptive statistics of the study sample are illustrated in Table 1. The mean liver span for the studied men was 16.02 $\pm$ 1.59 cm (ranged between 12 and 18.8 cm). The age range for them was 23–50 years, with the mean ages of 34.94 $\pm$ 6.98 years. Their height was ranged between 156 and 195 cm, with the mean of 177.28 $\pm$ 8.34 cm, and their weight range was 50–117 kg, with the mean of 81.43 $\pm$ 14.08 kg.

Among the current sample, 62.3% (66 men) had false hepatomegaly and 37.7% (40 men) had normal liver span. There were insignificant differences in the anthropometric parameters between the two groups (Table 2); however, mean weight, height, BMI, and waist–hip ratio (WHR) were higher in men with false hepatomegaly than those with normal liver span (*P*>0.05).

Table 1 Descriptive statistics of the study sample

	Mean $\pm$ SD	Minimum	Maximum
Age (years)	34.94 $\pm$ 6.98	23.00	50.00
Weight (kg)	81.43 $\pm$ 14.08	50.00	117.00
Height (cm)	177.28 $\pm$ 8.34	156.00	195.00
BMI (kg/cm ²)	25.89 $\pm$ 4.04	17.62	36.72
WHR	0.46 $\pm$ 0.07	0.32	0.62
Liver span (cm)	16.02 $\pm$ 1.59	12.00	18.80

WHR, waist–hip ratio.

Pearson's correlation between liver span and the anthropometric parameters is presented in Table 3. There were highly significant positive correlations (*P*<0.01) between liver span and age in the two groups. In addition, among men with normal liver span, there were highly significant positive correlations between liver span on one side and body weight, BMI, and WHR on the other side. However, among men with false hepatomegaly group, there was a highly significant negative correlation (*P*<0.01) between liver span and height.

The stepwise regression analysis (Table 4) revealed that among men with normal liver span, WHR explained 43.2% of the changes occurred in liver span. When age was added to WHR, this model increased the percentage to 49.5% of the changes occurred in liver span. Among men with false hepatomegaly, height explained 24.9% of the changes occurred in liver span. When age was added to height, this model increased the percentage to 36.7% of the changes occurred in liver span.

Discussion

Liver is a large, solid organ situated in the upper part of the right side of abdominal cavity and extends from the fifth intercostal space in the midclavicular line to right costal margin. Its weights is ~1400–1600 g in

Table 3 Pearson's correlation between liver span and the anthropometric parameters of the participant men according to their liver span

	Normal liver span <16 cm (N=40)		False hepatomegaly ≥16 cm (N=66)	
	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>
Age (years)	0.527	0.000**	0.418	0.000**
Weight (kg)	0.618	0.000**	−0.144	0.250
Height (cm)	0.006	0.969	−0.499	0.000**
BMI (kg/cm ²)	0.627	0.000**	0.165	0.185
WHR	0.657	0.000**	−0.001	0.993

WHR, waist–hip ratio. *Significant differences at *P* value less than 0.05. **Highly significant differences at *P* value less than 0.01.

Table 2 Comparisons between the anthropometric parameters of the participants according to their liver span

	Normal liver span <16 cm (N=40)		False hepatomegaly ≥16 cm (N=66)		<i>t</i> value	<i>P</i>
	Mean	SD	Mean	SD		
Age (years)	36.15	7.41	34.21	6.77	0.975	0.334
Weight (kg)	81.10	9.73	81.64	16.40	−0.149	0.882
Height (cm)	177.15	6.66	177.36	9.37	−0.089	0.929
BMI (kg/cm ²)	25.86	3.05	25.91	4.61	−0.043	0.966
WHR (kg/cm)	0.46	0.05	0.46	0.08	−0.086	0.932
Liver span (cm)	14.25	1.06	17.09	0.58	−11.012	0.000**

WHR, waist–hip ratio. **Highly significant differences at *P* value less than 0.01.

Table 4 Stepwise regression analysis between different anthropometric parameters that can affect the liver span according to their liver span group

Groups	Model	Unstandardized coefficients		Standardized coefficients Beta	R^2	t	Significance
		B	SE				
Normal liver span ^a	1	Constant	8.053	1.160		6.944	0.000
		Weight/height ratio	13.528	2.519	0.657	5.371	0.000
	2	Constant	7.820	1.113		7.023	0.000
		Weight/height ratio	10.816	2.717	0.525	3.981	0.000
Hepatomegaly $\geq 16^a$	1	Age	0.041	0.019	0.284	2.151	0.038
		Constant	22.541	1.184		19.043	0.000
		Height	-0.031	0.007	0.499	-4.610	0.000
	2	Constant	20.928	1.193		17.544	0.000
		Age	0.030	0.009	0.347	3.420	0.001
		Height	-0.027	0.006	-0.444	-4.376	0.000

^aDependent variable: Liver span.

males and ~1200–1400 g in females, which comprises ~1/40th of the adult body weight [16].

Sonography is a real-time, rapid, and inexpensive radiological modality used in the assessment of the adult liver span. With increasing its availability as smaller, more portable and affordable units, it becomes an attractive office and bedside diagnostic technique. This improved the diagnostic ability of liver pathology and subsequently determination of the most effective treatment approach to disease [11].

Sonographic measurement of the liver at the right midclavicular line plane is a reliable indicator of the liver span. Kratzer *et al.* [10] and Verma *et al.* [17] suggested that liver span greater than 16 cm indicates hepatomegaly.

A study conducted by Awad *et al.* [18] reported that the average liver span was 15.00 cm in the study conducted in Saudi Arabia compared with 10.5 cm in Niederau *et al.* [19] in a prospective study conducted in Germany, and 12.3 cm. in a study done in Jordan by Tarawneh *et al.* [20].

The mean liver span in the current study was 16.02 $\pm$ 1.59 cm. Cutoff value of 16 cm for the liver span was used to consider that a liver measuring over 16 cm in the midclavicular line is enlarged as documented in the aforementioned text. Among the current sample, 62.3% (66 men) had false hepatomegaly and 37.7% (40 men) had normal liver span.

The evident effect of anthropometric variables and anthropometric indices on liver size should be taken into cognizance during ultrasound examination to avoid the possibility of false-negative and false-positive diagnosis [21].

Weight was correlated significantly with the liver span in the studies by Kratzer *et al.* [10], Tarawneh *et al.* [20], and Bhavna *et al.* [22]. Altunkaynak and Altunkaynak [23] also concluded that excessive weight is a determining factor for hepatomegaly, especially in females.

The results of the current study are in line with the studies by Tarawneh *et al.* [20], Mabrouk *et al.* [21], and Bhavna *et al.* [22]. They have concluded that height was the best determinant of liver span. This proximity in results raised the possibility that liver span among Middle East population may be within a close range.

Current results are concurrent with Mabrouk *et al.* [21], who concluded that estimation of liver span on the basis of a single parameter such as midclavicular line may be limited by some of these variables, especially the height, because the liver is oriented longitudinally in slender individuals and transversely in heavily built individuals. Moreover, Awad *et al.* [18] had postulated that factors such as body weight and body height may exert an influence on liver span and should be considered at the time of the sonographic examination.

Kangasa *et al.* [24] have demonstrated that BMI of 25 kg/m² or more is associated with large liver size. This finding is similar to what was found in the studies by Ekpo *et al.* [25] and Rajpaty *et al.* [26]. The increase in the liver size in those with higher BMI may be owing to higher fat [25]. In addition, high BMI could be associated with increased activity of the liver with subsequent increase in liver size [26]. In current study, there were insignificant differences in the anthropometric parameters between the two groups; however, mean BMI was higher in men with false hepatomegaly than those with normal liver span.

The discrepancies in the liver span could be explained by the influence of genetics, nutrition, and environmental factors on the different populations [27].

The present study revealed that anthropometry of individuals had its effect on liver span, where, among men with normal liver span, WHR explained 43.2% of the changes occurred in liver span. When age was added to WHR, this model increased the percentage to 49.5% of the changes occurred in liver span. Among men with false hepatomegaly, height explained 24.9% of the changes occurred in liver span. When age was added to height, this model increased the percentage to 36.7% of the changes occurred in liver span.

The differences seen in the anthropometric parameters of different populations should be taken into considerations by all ultrasound communities. A larger sample size might enhance the precision of the estimates and also the general reliability of the data. There is a need for each country to set up their own specific normograms of liver span in adults with reference to the body parameters that shows the best correlation with liver span dimensions [27].

Conclusion

The cutoff point of 16 cm of liver span cannot be used to distinguish between those with normal liver and hepatomegaly for the universe. Anthropometric parameters should be taken into consideration in decision of diagnosis of hepatomegaly, particularly height and weight/height ratio. Further studies on a larger scale should be done to investigate the relation between anthropometry and liver span. Establishment of average liver sizes in different regions and subregions will provide baseline data for diagnosis of any liver-related disease that may alter its size in that particular region.

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Conflicts of interest

There are no conflicts of interest.

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