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An evaluation of gallbladder fasting volume, residual volume and contractility index in a normal cohort in Saudi Arabia utilizing ultrasonography

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This study was conducted to evaluate the diameters of the gall bladders (GB) of healthy adults in Jeddah city in the Kingdom of Saudi Arabia. Only 50 male adult volunteers were assessed via ultrasound following overnight fasting. The participants were the students and staff of a college of applied medical sciences and a college of medicine at university of Jeddah. The volume and ejection fracture of the GBs was calculated before and after fatty meals. Their ages varied from 18 to 50 years. The average GB length and width were 8.6 cm and 4 cm, respectively. There was a decrease in the length and width after fatty meals. Their maximum volume was 36.4, and the ejection fracture was 83.7 in the fasting condition. A reduction was observed in both volume and contraction after fatty meals. No significant correlations were detected between age and volume, between age and contractility index, or between body mass index and volume. A significant correlation was observed between weight and the volume of the GB, but no association was identified between volunteers' weight and the contractility of the GB. The study is relevant for medical advice and reference purposes.

Keywords: gallbladder, ultrasound, fasting volume, cholecystokinin

INTRODUCTION

The gallbladder serves as a vital auxiliary organ to the liver in the digestive system. Its primary function revolves around the storage, concentration, and subsequent release of bile, a hepatically produced fluid that is crucial for fat emulsification and absorption. A healthy adult gallbladder can distend to accommodate 30 to 50 mL of bile (Wangzhem et al. 2023). However, in cases of obstruction, this capacity can significantly increase, reaching up to 300 mL (Wangzhem et al. 2023). The mechanism by which bile is concentrated involves the active transport of sodium and chloride ions (2). This process effectively removes water from the stored bile, leading to a tenfold increase in the bile's salt concentration. This concentrated bile serves as a more potent agent for fat digestion. The release of this concentrated bile is strategically regulated. The presence of dietary fat triggers a neurohormonal pathway, culminating in gallbladder contraction and the expulsion of bile into the small intestine, where it facilitates fat digestion (Ibukuro, et al. 2016). Cholecystokinin (CCK) is a key hormone involved in stimulating gallbladder contractions. Conversely, several substances can inhibit gallbladder contractions. These include somatostatin, L-arginine, nifedipine, progesterone, trimebutine maleate, loperamide, and ondansetron. Understanding the interplay between these stimulatory and inhibitory influences is crucial for maintaining optimal gallbladder function (Welling, 2022).

A functioning gallbladder plays a critical role in preventing biliary complications. Regular contractions act as a self-cleaning mechanism, expelling bile and preventing stagnation. During digestion, neurohumoral signals trigger coordinated gallbladder contractions and the relaxation of the sphincter of Oddi, thereby allowing bile to flow into the lumen of the gallbladder. However, structural abnormalities or inflammation can compromise the gallbladder's motility, leading to impaired emptying and bile accumulation within the organ (Portincasa, et al 2008). This prolonged exposure to concentrated bile acids is suspected to contribute to the development of various gallbladder diseases, including mucoceles (mucus-filled sacs), cholecystitis (inflammation), and cholelithiasis (gallstones). To investigate the potential link between impaired emptying and these pathologies, establishing accurate and reliable methods for assessing gallbladder motility is crucial (Welling, 2022).

Several imaging procedures are available to measure GB contractility after fatty meals, such as computed tomography and hepatobiliary scintigraphy. However, most of them use ionizing radiation and are not reproducible. Among the methods that have been used to measure gallbladder volume, real-time ultrasonography is an accurate, reproducible, noninvasive, cheap, relatively easy, and widely available method of studying gallbladder volume variations. Sonography has long played a role in screening patients with gall bladder disorders, facilitating examinations focusing mainly on length and contractility (Mehra et al. 2015).

To the best of our knowledge, thus far there have been no reports about gall bladder contractility among healthy populations living in Saudi Arabia. Therefore, the aim of this study is to assess the effects of fatty meals on the gall bladder's volume and contractility index in relation to the age, weight, and body mass index of the participants using ultrasonography. Moreover, the study will help to establish a reference value for the contractility index among healthy populations.

MATERIALS AND METHODS

The study was cross sectional and included healthy volunteers participating in the radiology department at the University of Jeddah in Jeddah city. Any participants with co-existing liver disease, gall bladder disorder, or diabetes mellites were excluded from the study. The study subjects were 50 healthy males with an age range from 18 to 50 years.

Demographic data

Weight and standard height were measured for each participant. Body mass index (BMI) was calculated as weight (kg)/height (m2). Patients with a BMI of less than 25 were classified as overweight, and those with a BMI over 30 were classified as obese.

Ultrasound examination

An abdominal ultrasound was performed to measure the contractility of the gall bladder in participants without any complaints. A General Electric ultrasound machine (SA 2814US02) with a 3.5 MHZ curvilinear probe was used. The scan was conducted by one dedicated operator. The participants were asked to fast 6 to 8 hours before the ultrasound examination. The exam was taken with the patient supine after applying ultrasound gel to the right upper quadrant area. If the gall bladder was not clear in this position, the patient tilted slightly to the left side, and the right side was elevated. Different positioning techniques were applied when the gall bladder was not apparent. Gall bladder measurements were taken once, but in the case of imaging problems due to the accumulation of gasses, multiple measurements were performed to provide accurate results. Crania caudal length, transverse and mediolateral length (width), and anteroposterior length for gall bladders were measured and recorded. The fasting volume (FV) was calculated via software within the ultrasound system using an ellipsoid formula.

Fatty meals

After ultrasound exam was done, the candidates were asked to consume fatty meals because they act as a potential physiological alternative for cholecystokinin (CCK). Since there are limited data in the literature to determine the amount of fatty meals given to the patients, an estimate of 20gm butter and 200 ml milk, derived from the protocol of some radiology departments in Jeddah city, was utilized. This amount induces adequate emptying of the gall bladder, according to Vezina (Perdomo et al. 2023). Subsequently, the candidates were requested to wait for 45 to 60 minutes, which is the suitable time interval for the assessment of the gallbladder.

GB contractility

The percentage of the gall bladder contraction was calculated using the equation (fasting volume – residual volume), divided by the fasting volume, and multiplied by 100. This procedure was reported for each subject and calculated to evaluate the ejection fraction of the gall bladder.

Statistical assessment

The data analysis was conducted using SPSS20 (IBM). The descriptive and group statistics were calculated, and statistical significance was set at values less than 0.05. With the help of the correlation co-efficient and the percentage of explained variance, the strengths of the associations between different parameters such as age, weight and BMI, and gall bladder volume during fasting and after fatty meals were quantitatively described.

Ethical clearance

This study was executed with an ethical license certificate from the governmental ethical committee of Jeddah University with the code number HAP-02-J.094. Our study satisfied the Declaration of Helsinki. The study subjects began their participation only after signing a written consent form. If a pathology was demonstrated in the gall bladder, the participants would be sent to the medical center of Jeddah University for further investigation.

RESULTS

The present study included 50 healthy participants, all of whom were males. Their ages ranged from 18 years to 50 years, with a mean of 30 years. The heights of individuals varied from 153 cm to 185 cm, with a mean of 170 cm. The minimum weight was 48 kg, and the maximum was 110 kg, with an average of 77 kg. Regarding body mass index (BMI), the maximum was 45.8, the minimum was 17, and the average was 20.23 (see Table 1).

Table 1: Descriptive Statistics

parameter	Minimum	Maximum	Mean	Std. Deviation
Age	18	50	30.64	9.600
Height	153	185	170.24	6.579
Weight	48	110	77.40	15.722
BMI	17.0	45.8	26.766	5.6638

The present study demonstrated that the minimum length of the gall bladder (GB) was 3.15, while the maximum length was 8.6 during fasting, with a mean equal to 5.8. However, after the fatty meal, the minimum was 3.39, and the maximum was 7.95, with an average of 5.27. The minimum height of the GB among candidates who fasted was 1.7, while the maximum was 2.97, with a mean of 2.4. A decrease was observed in the height after fatty meals, with a minimum of 0.95, a maximum of 2.19, and a mean of 1.4. Concerning the width, it was 1.29 minimum and 3.77 maximum, with a mean of 2.6 during fasting; however, a reduction was detected after consuming a fatty meal, with a 0.78 minimum, 2.61 maximum, and 1.68 mean (see Table 2 and Figure 1).

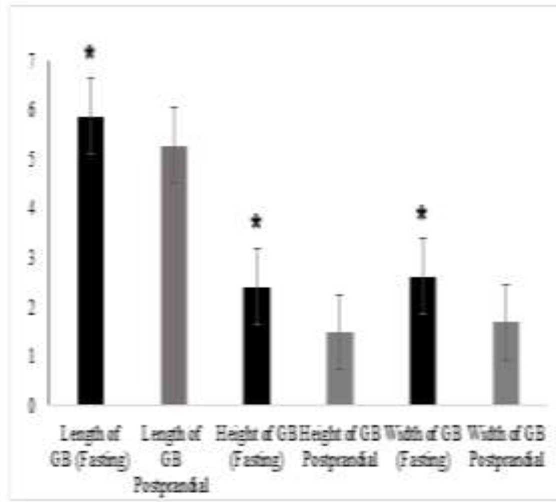

Figure 1: Comparison Between GB Measurements During Fasting and Postprandial (strikes denote significant difference)

The fasting volume of the GB ranged from 7.62 to 36.48, with an average of 20.23, while the residual volume after a fatty meal ranged from 2 to 19, with an mean volume equal to 7.23. The percentage of the GB contraction varied from 17.9 to 83.7, with a median contractility index equal to 61.78 (see Table 3).

Table 2: Descriptive Statistics – GB Measurements

	Minimum	Maximum	Mean	Std. Deviation
Length of GB (Fasting)	3.15	8.60	5.8692	1.24182
Length of GB Postprandial	3.39	7.95	5.2706	1.12910
Height of GB (Fasting)	1.70	2.97	2.4032	0.37457
Height of GB Postprandial	0.95	2.19	1.4916	0.41350
Width of GB (Fasting)	1.29	3.77	2.6170	0.55204
Width of GB Postprandial	0.78	2.61	1.6886	0.41949

Table 3: GB Volume and Contractility Index

	Minimum	Maximum	Mean	Std. Deviation
Volume of GB (Fasting)	7.62	36.48	20.3318	7.73408
Volume of GB after Fatty Meal	2.03	19.03	7.2398	3.52011
GB Contractility Index	17.9	83.7	61.788	17.8481

Table 4 indicates the age, weight, height, and BMI factors associated with fasting volume, residual volume, and contractility index. Only the weight exhibited a significant positive correlation with both fasting and residual volume because it was less than 0.05. No correlation was observed between weight and the contractility index. Regarding the other parameters (age, height, and BMI), the study uncovered no significant correlations between them and the two volumes, in addition to the contractility index (see Table 4 and Figure 2 (a and b)).

Table 4: Correlation Between Age, Weight, Height, and BMI and Fasting Volume, Residual Volume, and Contractility Index

		Volume of GB (Fasting)	Volume of GB After Fatty Meal	GB Contractility Index
Age	Pearson Correlation	.005	-.058	.243
	Sig. (2-tailed)	.972	.689	.090
	N	50	50	50
Height	Pearson Correlation	.271	.158	-.049
	Sig. (2-tailed)	.057	.275	.736
	N	50	50	50
Weight	Pearson Correlation	.396**	.320*	.124
	Sig. (2-tailed)	.004	.024	.393
	N	50	50	50
BMI	Pearson Correlation	.260	.245	.118
	Sig. (2-tailed)	.068	.087	.414
	N	50	50	50

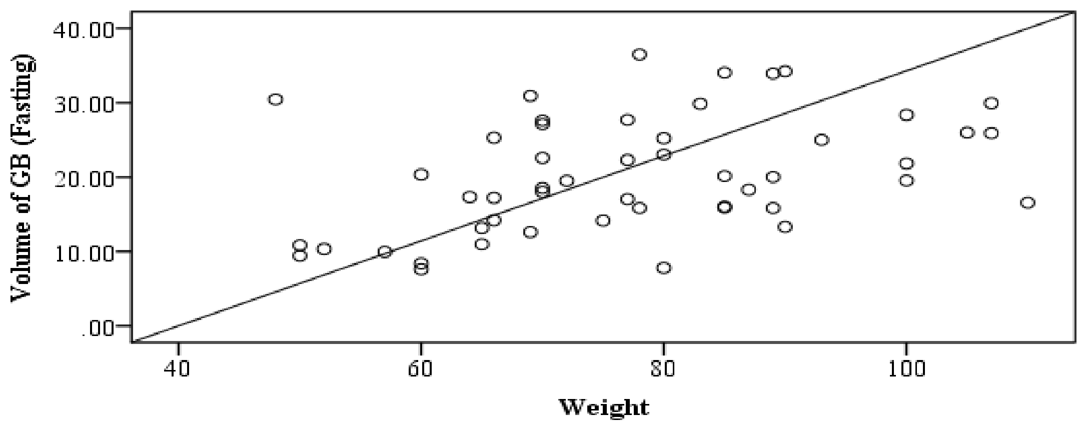

Figure (2a): Correlation was significant between weight and fasting volume.

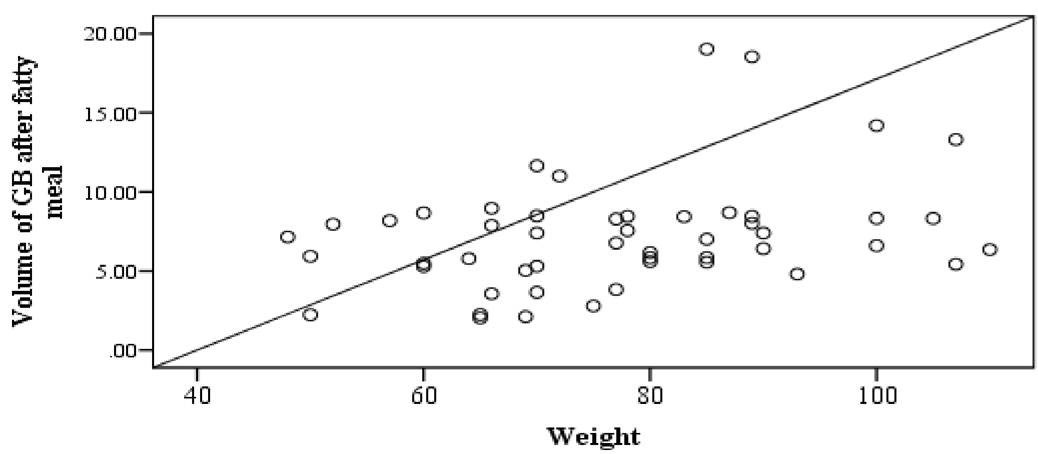

Figure (2b): Correlation was significant between weight and fasting volume.

DISCUSSION

Although the physiology of the gall bladder (GB) is complex, with extrinsic and intrinsic factors affecting its contractility, variations in the GB's volume and contractility index have become accepted by clinicians and surgeons as valuable for diagnosis of many GB disorders. Ultrasounds are a ubiquitous and indispensable diagnostic tool for evaluating the GB's volume and ejection fraction (EF). limited techniques and positioning protocols were needed to calculate the fasting and residual volume of GBs.

Regarding GB measurements, the present study showed that the maximum length of a GB was 8.6 cm, and the maximum width was less than 4 (3.7 cm), as illustrated in Figure 1. These values correspond with the literature (Al-Muqbel et al. 2009, Dodds et al 1985, Idris et al. 2016, Li W-G et al. 2020). The length and width values decreased after fatty meals, but these differences in length and width were not statistically significant. This may be due to subject-related differences because of wide individual variations. A similar finding was observed in Canada (Donald and Buckley 1991). However, Hederstrom et al. 1988 found that the anterior-posterior diameter (AP) of the GB was unchanged for patients with calcular gall bladder disease.

Concerning the volume and contractility index of the GB, the maximum volume with candidates fasting was 36.4, while the top contractility index was 83.7. A decrease was observed in both parameters after the participants consumed a fatty meal, but it was not statistically significant. Comparatively, the GB volumes for the study group were higher than those found in India and Nigeria and lesser than those found in Canada (Donald 1991, Hederström et al. 1988, Chavva and Karpur 2018). This is due to ethnic and dietary differences. There is no established range in the contractility index for GBs because several factors are implicated, producing wide variability in the results obtained.

A correlation was established between participants' age and GB volume during fasting and after the fatty meals. The study revealed that there is no significant correlation between age and volumes of GBs. This coincides with a study in India (Mehra, et al. 2015) that demonstrated that age did not exert a significant effect on GB volume. However, Caroli-Bosc et al. from France (Caroli-Bosc et al. 1999) and Brain Ngure et al. from Africa (Kariuki et al 2017) disclosed that GB volume was significantly increased in subjects over 50 years. There is insufficient data to determine the relationship between age and volume of GB in the Kingdom of Saudi Arabia. Additionally, a non-significant correlation was detected between age and the contractility index of GBs in the study group. This may be due to a lack of reference values for ejection fracture and the presence of a wide range of variance because of many uncontrolled factors related to the subject.

The findings of the current study reveal that the volunteers' weight was a significant independent factor associated with fasting and the residual volume of the GB. As the weight, increased the volume increased (see Figure 2a and 2b). Similar findings were reported in previous studies (Ewunonu 2016, Vezina et al. 1990). This is because organ volume is crudely proportional to body size. On the other hand, no association was detected between weight and the contraction of the GB. However, a study in Canada revealed that the rate of GB emptying in obese people was lower than in people with the average size of 4; this increased the incidence of GB stones among obese people.

Concerning the volumes of GB and body mass index, the current study indicated no significant correlation between the two variables. However, a study of Iranian adults uncovered an association between the volume of the GB when fasting and body mass index (Joukar et al. 2023).

These data do not support the role of GB emptying, but if the condition of the patient was carefully controlled, and the dataset was sufficiently large and inclusive of female participants, ultrasounds could be considered an accurate, reproducible, and non-invasive tool for detecting the contraction of the GB.

CONCLUSIONS

As this is a descriptive study, it has been limited by the small sample size and the lack of females included in the study. Thus, its conclusion cannot be generalized.

In human males living in Jeddah city, age did not affect the volume and contractility index of the GB. The study concluded that the maximum length and width of the GB among fasting participants in the KSA was the same as in other countries, while the volume and contractility index were different. The weight was positively and significantly associated with the volume of the GB before and after fasting. There was no significant correlation between the BMI and the volume of the GB. Special ultrasound attention should be devoted to the measurement of GB width, since the decrease after fatty meals was higher. Clinical attention should be dedicated to obese people because they had a higher incidence of GB stone formation.

Supplementary materials

The supplementary material / supporting for this article can be found online and downloaded at: https://www.isisn.org/article/

Author contributions

All author contributed in all parts of the paper. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was approved by the Bioethical Committee of scientific and medical research UJ-REC-131

Informed Consent Statement

Not applicable.

Data Availability Statement

All of the data is included in the article/Supplementary Material.

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Conflict of interest

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

OR The authors declare no conflict of interest.

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