Original Article

Sonographic Determination of Gallbladder Dimension among Apparently Healthy School-aged Children in Kano Metropolis

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Abstract

Introduction: The present study was carried out to sonographically evaluate gallbladder dimensions among healthy school-aged children, thus setting up normal ranges that can be used in clinical settings. The study aimed to establish normal gallbladder dimensions in apparently healthy school-aged children within the Kano metropolis using ultrasonography. **Materials and Methods:** A prospective cross-sectional study of 276 healthy school-age children comprising 156 males and 120 were recruited randomly. Gallbladder length (GBL), width, height, volume, and wall thickness were recorded. The subject's demographic information was also obtained. Data were analyzed using the SPSS version 23. Statistical significance was considered at $P < 0.05$. **Results:** Statistical analysis highlighted mean gallbladder dimensions: length (5.31 ± 0.65 cm), width (1.57 ± 0.52 cm), height (1.68 ± 0.48 cm), volume (7.31 ± 2.72 cm^3), and wall thickness (2.59 ± 0.48 mm). While no significant differences were found between male and female gallbladder width and volume, notable distinctions were observed in GBL, height, and wall thickness between genders. Correlation analyses revealed significant associations between gallbladder dimensions (length, width, and volume) and demographic parameters such as age, height, weight, body mass index (BMI), body surface area, and gallbladder wall thickness (GBWT). Interestingly, gallbladder height showed no significant correlation with height, weight, or BMI, while GBWT exhibited correlations with various demographic factors. **Conclusion:** This research successfully established reference ranges for gallbladder dimensions in healthy school-aged children, underlining gender-specific disparities in certain measurements.

Keywords: Gallbladder dimensions, gallbladder volume, school-aged children, ultrasound

Introduction

The gallbladder, nestled beneath the liver in a fossa amid the right and quadrate lobes, serves as a pivotal reservoir capable of storing 30–50 mL of bile.[1] This anatomical structure is segmented into distinct sections: the fundus, body, and neck. The fundus, a rounded termination, fronts the body, which snugly adheres to a depression at the liver's base. Transitioning into the cystic duct, the neck of the gallbladder merges with the lesser omentum, ultimately joining the common hepatic duct to form the bile duct.[1-3] Functionally, the gallbladder orchestrates the storage, concentration, and regulated ejection of bile into the small intestine upon contraction.[4] In individuals with a closed sphincter of Oddi, bile flows through the bile ducts into the gallbladder for later usage. During this storage phase, bile undergoes concentration via water absorption.[4,5]

The gallbladder initiates emptying when food starts digestion in the upper gastrointestinal tract, notably when fatty foods reach the duodenum roughly 30 min postmeal.[6]

Gallbladder enlargement can result from various conditions such as morphologic variants, fasting, empyema, advanced age, hydrops, and diabetes mellitus.[7] Structurally, the gallbladder wall comprises three layers: mucous, muscular, and serous.[7] Augmented gallbladder wall thickness (GBWT), a nonspecific finding, might manifest in hepatitis, congestive cardiac failure, pancreatitis, and other disorders, occasionally co-occurring with acute or chronic cholecystitis in both adults and children.[8,9]

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Arua *et al*.[10] conducted a prospective cross-sectional study in Nigeria, correlating sonographic measurements of the gallbladder with somatometric variables in 400 healthy primary school-age children (6–12 years old). They established a gallbladder volume (GBV) ranging from 9.80 to 19.81 cm^3. Similarly, Yoo *et al*.[11] conducted a prospective study in South Korea, involving 610 healthy children (0–16 years old), unveiling GBVs ranging from 0.3 to 42.0 cm^3. These studies highlighted strong correlations between gallbladder measurements and age, height, weight, and body mass index (BMI), with no notable correlation between gallbladder measurements and gender Arua *et al*.[10] Notably, pediatric GBV moderately correlates with age, height, weight, and body surface area (BSA), while wall thickness exhibits minimal change with age.[8,11] However, there remains a dearth of established gallbladder dimension nomograms for pediatrics in Kano, Nigeria. Currently, borrowed reference values from other regions might lead to potential inaccuracies in diagnosis and treatment. Hence, this study aims to furnish sonographic parameters of gallbladder dimensions in apparently healthy school-aged children in the Kano metropolis, endeavoring to serve as a fundamental reference for healthcare practitioners, including sonographers, radiographers, radiologists, and referring physicians, facilitating improved patient management and treatment outcomes.

Materials and Methods

Study design and ethical considerations

This prospective cross-sectional study was conducted on apparently healthy school-aged children within the Kano metropolis. Ethical clearance was obtained from the Human Research and Ethics Committee, Ministry of Health, Kano, and the State Universal Basic Education Board, Kano [Appendix 1: NHREC/17/03/2018]. Before participation, assent was acquired from the parents or guardians through the school management. Participants were assured of the confidentiality and voluntary nature of their involvement, with the option to withdraw at any time.

Sample size determination

The sample size was determined using Taro Yamane's formula:

$$N = \frac{N}{1 + N \times (e)^2}$$

where N = Sample size, N = Population size, and e = Acceptable sampling error (%).

By substituting the values (population size: 3,322,489, acceptable sampling error: 0.0601), the calculated sample size was 276.

Participant selection and exclusion criteria

The study included apparently healthy school-aged children aged 6–11 years with no history of gallbladder-related pathological conditions. Participants below 6 years and above 11 years, as well as those with a history of gallbladder-related pathologies, were excluded.

Data collection

Before data collection, intraobserver variability was assessed. Information regarding the participant's age and sex was recorded. Height was measured using a portable stadiometer (214 cm, model: HM01), while weight was measured using a weight measuring scale (Baron Fitness and General Merchandise). BMI and BSA were calculated using the standard formulas.[12,13]

Imaging procedure

Participants fasted for a minimum of 4 h before the examination to facilitate gallbladder distension and minimize gastrointestinal gas. Supine participants underwent ultrasound imaging of the right upper abdomen. The gallbladder was imaged in longitudinal and transverse views, acquiring dimensions (length, width, and height) and wall thickness measurements as seen in Figure 1. GBV was calculated using a simplified formula: length × width × depth × 0.5.

Data analysis

All measurements obtained were recorded in a data capture sheet. Both descriptive and inferential statistics were used to analyze the data. The data were tested for parametric assumptions, both Shapiro–Wilk and Kolmogorov–Smirnov test results were >0.05, and the skewness was between 0.5 and 0.5 in all the data, thus the parametric method of data analysis was used. Descriptive statistics (mean, standard deviation, and range) were utilized to summarize height, weight, BMI, and BSA. Parametric tests including independent two-sample t-tests and Karl Pearson's coefficient of correlation were employed to analyze gallbladder dimensions about gender, age, weight, height, BMI, and BSA. Statistical analyses were performed

Table 1: Age distribution, frequency, and percentage of the participants

Age (years)	Male - frequency, *n* (%)	Female - frequency, *n* (%)	Total - frequency, *n* (%)
6–6.9	36 (23.1)	18 (15.0)	54 (19.6)
7–7.9	14 (9.0)	20 (16.7)	34 (12.3)
8–8.9	12 (7.7)	16 (13.3)	28 (10.1)
9–9.9	16 (10.3)	14 (11.7)	30 (10.9)
10–10.9	32 (20.5)	16 (13.3)	48 (17.4)
11–11.9	46 (29.5)	36 (30.0)	82 (29.7)
Total	156 (56.5)	120 (43.5)	276 (100.0)

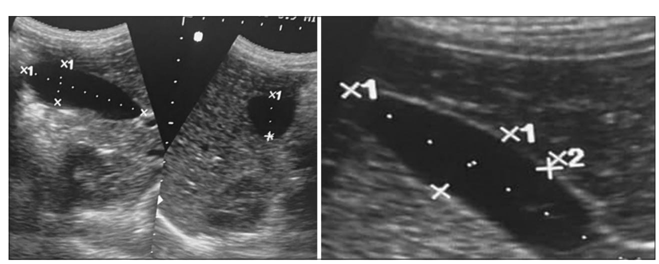

Figure 1: Gallbladder length, width height, and wall thickness measurements

Table 2: Demographic information and comparison based on gender

Variable	Male (*n*=156), mean±SD (range)	Female (*n*=120), mean±SD (range)	Total (*n*=276), mean±SD (range)	*P*
Age (years)	8.85±1.98 (6–11)	8.82±1.87 (6–11)	8.83±1.92 (6–11)	0.900
Height (m)	1.27±0.11 (1.03–1.45)	1.27±0.09 (1.01–1.44)	1.27±0.10 (1.01–1.45)	0.880
Weight (kg)	25.29±5.19 (15–38)	24.22±5.10 (12–42)	24.83±5.17 (12–42)	0.086
BMI (kg/m²)	15.60±1.38 (12.60–19.20)	14.97±1.71 (10.52–21.73)	15.33±1.56 (10.52–21.73)	0.001
BSA (m²)	0.09±0.01 (0.06–0.124)	0.09±0.01 (0.06–0.127)	0.09±0.01 (0.062–0.127)	0.170

BMI: Body mass index, BSA: Body surface area, SD: Standard deviation

Table 3: Sonographic measurements of the normal gallbladder by age group

Age (years)	GBL (cm), mean±SD (range)	GBW (cm), mean±SD (range)	GBH (cm), mean±SD (range)	GBV (cm³), mean±SD (range)	GBWT (mm), mean±SD (range)
6–6.9	5.15±0.66 (4–6)	1.26±0.44 (1–2)	1.69±0.47 (1–2)	6.17±2.25 (3–11)	2.22±0.42 (2–3)
7–7.9	5.06±089 (3–6)	1.41±0.50 (1–2)	1.53±0.62 (1–3)	6.00±2.36 (2–10)	2.29±0.46 (2–3)
8–8.9	5.00±0.54 (4–6)	1.36±0.49 (1–2)	1.57±0.50 (1–2)	6.00±2.47 (3–11)	2.07±0.26 (2–3)
9–9.9	5.40±0.89 (4–7)	1.53±0.51 (1–2)	1.60±0.49 (1–2)	7.53±2.32 (5–11)	2.53±0.51 (2–3)
10–10.9	5.46±0.65 (4–7)	1.79±0.50 (1–3)	1.83±0.38 (1–2)	8.17±2.47 (2–12)	2.37±0.49 (2–3)
11–11.9	5.63±0.58 (5–7)	1.80±0.46 (1–3)	1.76±0.43 (1–2)	8.54±2.67 (3–14)	2.49±0.55 (1–3)
Total	5.31±0.65 (3–7)	1.57±0.52 (1–3)	1.68±0.48 (1–3)	7.31±2.72 (2–14)	2.59±0.48 (1–3)

GBL: Gallbladder length, GBV: Gallbladder volume, GBW: Gallbladder width, GBWT: Gallbladder wall thickness, GBH: Gallbladder height, SD: Standard deviation

Table 4: Comparison of mean gallbladder length, gallbladder width, gallbladder height, gallbladder volume, and gallbladder wall thickness between male and female participants

Gallbladder dimension	Male, mean±SD	Female, mean±SD	*P*
GBL (cm)	5.62±0.58	5.30±0.52	0.000
GBW (cm)	1.55±0.55	1.57±0.53	0.445
GBH (cm)	1.74±0.44	1.66±0.43	0.029
GBV (cm³)	1.62±0.52	1.60±0.50	0.581
GBWT (mm)	2.61±0.49	2.64±0.47	0.009

GBL: Gallbladder length, GBV: Gallbladder volume, GBW: Gallbladder width, GBWT: Gallbladder wall thickness, GBH: Gallbladder height, SD: Standard deviation

using SPSS version 23 (IBM SPSS, Version 23.0. Armonk, NY: IBM Corp.), with significance considered at $P \leq 0.05$.

Results

A total of 276 apparently healthy school-aged children were included in the study, comprising 156 (56.5%) males and 120 (43.5%) females. The highest participation was observed within the 11-year-old age group, with 82 (29.7%) participants, as shown in Table 1.

Table 2 displays the mean age, height, weight, BMI, and BSA for all participants, which were calculated as follows mean age, height, weight, BMI, and BSA were 8.83 ± 1.92 years, 1.27 ± 0.10 m, 24.83 ± 5.17 kg, 15.33 ± 1.56 kg/m², and 0.09 ± 0.01 m², respectively. An independent *t*-test revealed a statistically significant difference in BMI between male and female participants.

Table 3 indicates that the overall mean gallbladder length (GBL) (cm), gallbladder width (GBW) (cm), gallbladder height (GBH) (cm), GBV (cm³), and GBWT (mm) were 5.31 ± 0.65, 1.57 ± 0.52, 1.68 ± 0.48, 7.31 ± 2.72, and 2.59 ± 0.48, respectively. Respective values for specific ages are indicated in Table 3.

Table 4 indicates that males' GBL (5.62 ± 0.58 cm) and GBH (1.74 ± 0.44) were statistically greater than female's with $P = 0.000$ and $P = 0.029$, respectively. No statistically significant was seen between males and females GBW (1.55 ± 0.55) and GBV (1.62 ± 0.52) with $P = 0.445$ and $P = 0.581$, respectively. Female GBWT was significantly greater than male GBWT with $P = 0.009$.

Pearson's correlation coefficients were utilized to examine relationships between gallbladder dimensions and participant characteristics, as highlighted in Table 5.

Discussion

The study encompassed 276 participants, with a higher representation of males than females. Participant ages ranged from 6 to 11 years, with the highest participation observed among 11-year-olds, while fewer participants fell within the 8–9-year-old range. This discrepancy in age distribution, differing from previous studies such as Arua *et al*.[10] and Yoo *et al*.,[11] where participants up to 16 years were included, may be attributed to challenges encountered in engaging and preparing younger subjects for data collection, potentially affecting their cooperation. Table 2 reveals that the mean height, weight, and BMI of the current participants were lower compared to the values reported by Arua *et al*.[10] This variance might be attributed to the narrower age range

Table 5: Correlation of gallbladder length, gallbladder width, gallbladder height, gallbladder volume, and gallbladder wall thickness with anthropological variables

Gallbladder dimension	Age	Height	Weight	BMI	BSA	GBWT
GBL	0.299 (0.000)	0.270 (0.000)	0.327 (0.000)	0.229 (0.000)	0.322 (0.000)	0.203 (0.001)
GBW	0.419 (0.000)	0.318 (0.000)	0.340 (0.000)	0.183 (0.002)	0.346 (0.000)	0.392 (0.000)
GBH	0.141 (0.019)	0.110 (0.068)	0.113 (0.061)	0.069 (0.253)	0.118 (0.050)	0.254 (0.000)
GBV	0.395 (0.000)	0.331 (0.000)	0.343 (0.000)	0.174 (0.004)	0.354 (0.000)	-
GBWT	0.215 (0.000)	0.121 (0.045)	0.178 (0.003)	0.179 (0.003)	0.170 (0.005)	-

P-values in parentheses. GBWT: Gallbladder wall thickness, GBL: Gallbladder length, GBV: Gallbladder volume, GBW: Gallbladder width, GBH: Gallbladder height, BMI: Body mass index, BSA: Body surface area

of participants in the current study in contrast to the wider range in previous studies. Notably, there were no significant differences in mean age, height, weight, and BSA between male and female participants, except for BMI, where males exhibited a significantly higher mean compared to females. Table 3 displays mean gallbladder dimensions for different age groups. The mean GBL was consistent with values reported by Arua *et al*.[10] and Yoo *et al*.[11] However, discrepancies in GBW and GBV were noted, with higher values reported in previous studies. These differences might stem from variances in participant demographics, anthropometric parameters, and study locations. It is noteworthy that while Arua *et al*.[10] and Yoo *et al*.[11] did not include GBWT, McGahan *et al*.[8] and Khammas and Mahmud[14] reported higher GBWT values, signifying the nonspecific nature of greater GBWT and potential variations due to fasting levels and age differences. Statistically significant differences between male and female gallbladder dimensions were observed in GBL, GBH, and GBWT, with males exhibiting greater measurements. The observed differences in gallbladder dimensions between boys and girls may result from a combination of anatomical, hormonal, genetic, and lifestyle factors. Further research is needed to elucidate the underlying mechanisms driving these disparities and their potential implications for gallbladder health and function. This contrasts with some previous studies but aligns with others, particularly regarding GBW and GBV, where no significant differences were found between genders. This similarity in findings with Arua *et al*.[10] could be attributed to the comparable nature of the studied population, focusing on school-aged children.

The study revealed significant positive correlations between gallbladder dimensions and various body parameters, corroborating findings from several previous studies including Arua *et al*.,[10] Yoo *et al*.,[11] Khammas and Mahmud,[14] Palasciano *et al*.,[15] Caroli-Bosc *et al*.,[16] and Idris *et al*.[17] These findings emphasize the relationship between gallbladder measurements and body characteristics, underscoring the importance of considering these correlations in clinical evaluations.

The study faced limitations, including a narrower age range of participants and potential challenges in engaging younger subjects during data collection, leading to possible selection bias. Further research with larger and more diverse samples is recommended to enhance understanding and establish standardized reference values. A Standard laboratory test (bilirubin test) should be performed to rule out any abnormality of the gallbladder.

Conclusion

The overall mean GBL (cm), GBW (cm), GBH (cm), GBV (cm^3), and GBWT (mm) were 5.31 ± 0.65, 1.57 ± 0.52, 1.68 ± 0.48, 7.31 ± 2.72, and 2.59 ± 0.48, respectively. The study revealed variances in gallbladder measurements compared to previous research, emphasizing the need for establishing specific nomograms tailored to this local demographic. GBW and volume did not exhibit statistically significant differences between males and females ($P = 0.445$ and 0.581, respectively), the observed variations in GBL, height, and wall thickness underscore the importance of considering gender-specific norms in clinical assessments. These findings underscore the importance of accurate reference values for clinical assessments and diagnostic accuracy in managing gallbladder-related conditions among school-aged children. The findings present crucial norms for gallbladder dimensions among this demographic, offering potential utility in clinical settings for diagnostic and evaluative purposes. Specifically, these established standards could aid in identifying variations and abnormalities in gallbladder dimensions, particularly concerning age and gender disparities.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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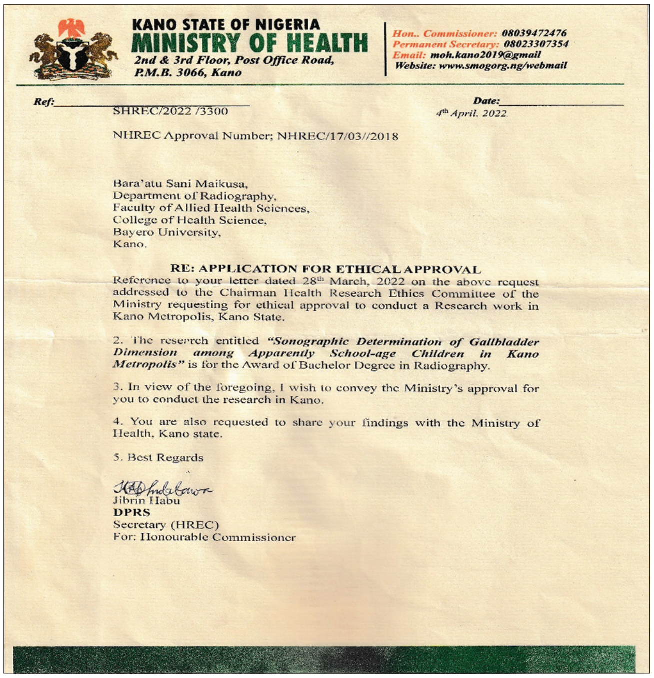

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NHREC Approval Number; NHREC/17/03//2018

Bara'atu Sani Maikusa,
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RE: APPLICATION FOR ETHICAL APPROVAL

Reference to your letter dated 28th March, 2022 on the above request addressed to the Chairman Health Research Ethics Committee of the Ministry requesting for ethical approval to conduct a Research work in Kano Metropolis, Kano State.

2. The research entitled ***"Sonographic Determination of Gallbladder Dimension among Apparently School-age Children in Kano Metropolis"*** is for the Award of Bachelor Degree in Radiography.

3. In view of the foregoing, I wish to convey the Ministry's approval for you to conduct the research in Kano.

4. You are also requested to share your findings with the Ministry of Health, Kano state.

5. Best Regards

Jibrin Habu
DPRS
Secretary (HREC)
For: Honourable Commissioner

Appendix 1: Ethical Approval letter