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Echocardiographic Evaluation of Normal Adult Left Ventricular Geometry in a Nigerian Population

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Abstract

Background: Recent studies have shown that nearly 50% of patients who die suddenly at any age and of either sex in Nigeria are affected by cardiomyopathies. Differences have shown to exist in some echocardiographic measurements that were attributed to racial, ethnic and gender. There is paucity of literature on the normal adult left ventricular geometryin our locality.

Objective: To determine echocardiographic baseline data of normal adult left ventricular (LV) geometry in Nnewi community setting of Anambra state, Nigeria.

Methods: This was a prospective cross-sectional study, in which 1,192 apparently healthy adult subjects were selected randomdly. Participants below the age of 18 years or those with congenital or acquired cardiac abnormalities and history of long-term regular physical training were excluded from the study. Ethical approval and informed consent were obtained for study. The study was conducted between March 2017 and August 2019. Trans-thoracic echocardiography was performed with Vivid T8 GE dedicated echocardiography machine with probe frequency of 1.7 to 3.2 MHz with integrated electrocardiography (ECG) recording electrodes. The study determined normal dimensions of interventricular septum (IVS), left ventricular internal diameter (LVIDd/LVIDs), and left ventricular posterior wall (LVPW) in diastole and systole of the included subjects. Both descriptive statistics and inferential statistics (Pearson's correlation and regression analysis and the t-test for two samples assuming equal variance analysis) were used statistical analysis. Statistical value less than 0.05 was considered significant. All measurements were indexed to body surface area (BSA) to obtain echocardiographic baseline normal reference values.

Results: The mean + SD values of LV parameters were: LVIDd (44.80 ± 5.71 mm vs.42.75 ± 5.21 mm), LVIDs (33.54 ± 5.37 mm vs.30.38 ± 4.81 mm), and LVPWd (8.32 ± 1.26 mm vs.7.51 ± 1.22 mm). Females had more statistically significant interventricular septum in diastole (IVSd) (8.20 ± 1.38 mm vs.7.05 ± 1.27 mm) and interventricular septum in systole (IVSs) (9.08 ± 1.42 mm vs.8.99 ± 1.33 mm) ($P<0.05$). A linear relationship existed between all echocardiographic measurements with age (r=0.017), height (r=0.009), weight (r=0.122), BMI (r=0.120) and BSA (r=0.109).

Conclusion: This research established echocardiographic baseline normal adult left ventricular geometryin the study population.

Keywords: Echocardiography; Normal values; Ventricular geometry; Nnewinigeria

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Introduction

Measurement of the size of the left ventricle of the heart provides diagnostic clues and prognostic information, and enables the clinician to follow patients in respect of disease progression or improvement [1]. Echocardiography is the most commonly used non-invasive imaging tool for the evaluation of the heart structure and functions [2]. Various measurements can be performed to determine the size, diameter, length and area of the left ventricle. These measurements are performed at distinct time points of the cardiac cycle, i.e the end of diastole and the end of systole. The end of diastole is seen when the volume of the ventricle is largest,

shortly before the mitral valve closes and the mitral annulus descends [3,4]. The end of systole is the time when the volume of the ventricle is smallest, shortly before the mitral valve opens. Therefore, in order to detect abnormalities, accurate definition of normal values of echocardiographic measurements is of paramount benefit to the clinicians for reliable decision making [3,4].

Every effort has been made in establishing normal cardiac dimensions, and such diagnoses include macroscopic examination, genetic studies, electrocardiography, cardiac magnetic resonance imaging (MRI), histological studies and echocardiography [5]. Echocardiography remains the gold standard to determine the structure and fuction of the heart [2]. It is also readily available and cheap when compared to other imaging modalities in Nigeria. The normal baseline values of echocardiographic measured left ventricule of the heart in the literature are mostly based on Caucasian populations [6]. Moreover, there is paucity of literature on the normal echocardiographic values of the left ventricle among adults in our locality. It is of great clinical importance to differentiate between normal and abnormal left ventricles and to explore the normal anatomical variation of these parameters. This will prove more difficult if the ranges of normal values are unknown for each clime. This study was designed to evaluate specific normal reference values of adult left ventricular geometry in our locality in a cross sectional study. The findings will be useful in understanding the pathological changes, treatment and management of cardiac patients in the locality.

Materials and Methods

A prospective cross-sectional design was adopted for this study. It was carried out on 1,192 apparently healthy volunteers above 18 years of age who presented for echocardiography study at Waves Medical Diagnostics and Research Center. Nnewi between March 2017 and August 2019. Participants were excluded if they had congenital or acquired cardiac abnormality, history of long-term regular physical training and any systemic disease (endocrine, collagen, metabolic, nutritional or infectious), hypertension, diabetes mellitus, chronic kidney diseases, and/or chest disease. The permission of the Ethics Committee of the Nnamdi Azikiwe University Teaching Hospital Nnewi was obtained in addition to informed consent from all the participants. The participants who wished their relatives to witness the procedure were obliged. This is to give the participants confidence so as to achieve maximum co-operation for better quality results.

Weights were measured with commercially available weighing scale (Hana model).Heights were measured by a meter rule. Height and weight were used to estimate body mass index(BMI) in kg/m^2 and body surface area (BSA) in m^2.Where BSA = square root of ([height in cm x weight in kg/3600).

Scanning protocol or technique

The participants were scanned using 2D, M-mode and Doppler measurements. Standard trans-thoracic echocardiographic studies with machine-integrated ECG recording were performed using Vivid T8 GE machine with sector probe of frequency range from 1.7-3.2 MHz. The choice of the probe was to get adequate visualization of the heart through the intercoastal space. The examinations were done with patients observing quiet breathing while lying in the left lateral decubitus position as described by [7,8]. Ultrasound gel was applied to ensure proper coupling of the transducer and good transmission of the ultrasound beam into the subjects. From the parasternal window, parasternal long axis views were obtained by placing the transducer in the left third or fourth intercostal space adjacent to the sternum with the knob pointing toward the right shoulder. After confirming a true long axis view that was perpendicular to the centre of the true long axis of the left ventricle (LV),M-mode image was taken between the papillary muscle and at the tip of the mitral valve [9]. Measurements were made from the leading edge of the septal endocardium to the leading edge of posterior wall endocardium [8]. Measurements for the interventricular septum at end diastole (IVSd), LV internal dimensions at end diastole (LVEDd) and LV posterior wall thickness at end diastole (LVPWd) were obtained. Also the measurements were obtained at end systole for each of the parameters mentioned above. All measurements were done on a frozen M-Mode image. The measured values were divided by BSA to obtain indexed measurements as described by [2,6].

Statistical analysis

The data collected were analyzed using Microsoft's™ Statistical Package for Social Sciences (SPSS) version 20. Descriptive statistics such as mean, standard deviation, and frequencies were generated and calculated for Interventricular septum, left ventricular internal diameter, and left ventricular posterior wall for all age groups. Pearson's correlation and regression analysis were used to determine the relationship between left ventricular parameters with age, height, body weight, body mass index, and body surface area. The relationship between left ventricular baseline values with gender was also determined using correlation and regression analyses. The t-test for two samples assuming equal variance analysis was carried out to assess gender differences in left ventricular parameters. The values of left ventricular parameters generated in the study was compared with the previous studies in Caucasian population to assess inter racial differences using t-test for equality of mean. The level of statistical significance was at ($P<0.05$).

Results

The majority of the participants were within the age group of 58-62 years 12% (n=143), followed by age group 68-72 years, 11.41% (n=136) and the least were within the age group of 18-22 years, which is 4.11% (n=49) with overall mean age of 57.44 ± 19.10 years **(Figure 1).** Out of 1,192 participants, males were highest in number, 53.6% (n=639) when compared with their females counterparts, 46.40% (n=553) with male to female ratio of 1:1.2 **(Figure 2).**

With regards to the participants height, large proportion of them were within the height range of 1.66-1.70 m 15.5% (n=185), followed by 1.61-1.65 m 15.4% (n=184) and the least was 1.35-1.40 m, which is 0.4% (n=5) with overall mean height of 1.69 ± 0.12 m **(Table 1**). The participant's weight was evaluated and the results showed that greater numbers of the participants were within the weight range of 71-75 kg 13.5% (n=161) and the least

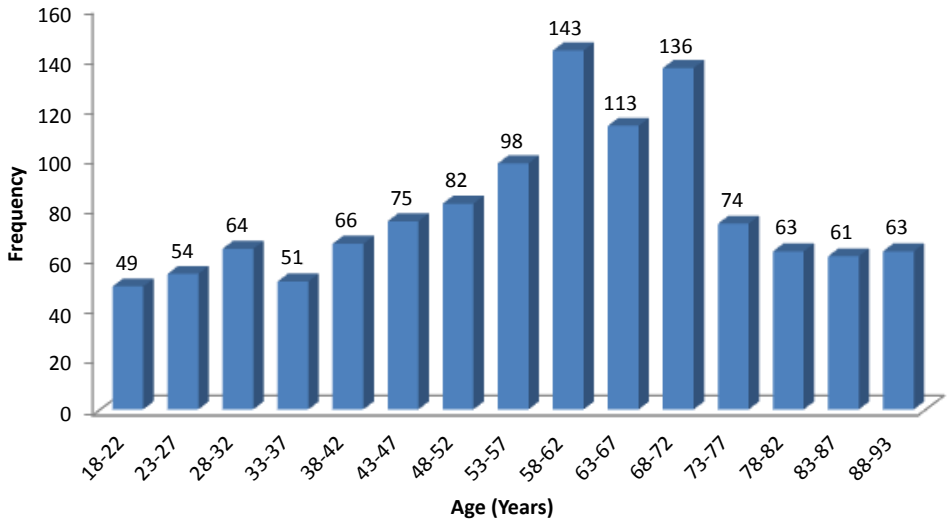

Figure 1 Age distribution of the participants.

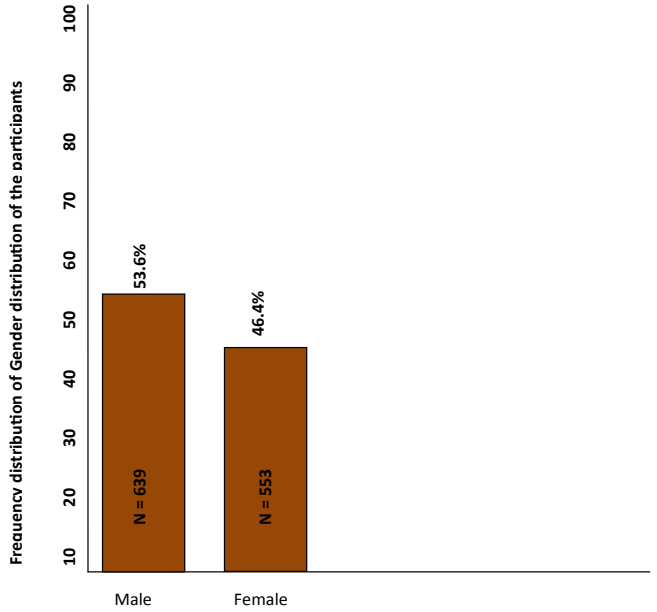

Figure 2 Gender distribution of the participants.

was weight range of 41-45 kg, which is 0.1% (n=1) with overall mean weight of 75.95 ± 15.74 kg (Table 1).

The overall mean of the participant's body mass index (BMI) was 26.48 ± 5.15 kg/m^2 with most of them found having normal BMI, 44.4% (n=530), followed by overweight subjects 36% (n=429) and the least were underweight subjects, which is 0.9% (n=11) **(Table 2).** The BSA was calculated and the overall mean was 1.88 ± 0.24m^2. The majority of the participants were within the BSA range of 1.80-2.10 m^2, 43.5% (n=519) and the least were within BSA range of 1.20-1.50m^2, which is 4.6% (n=55) (Table 2).

The baseline normal echocardiographic values of the left ventricular parameters were evaluated and the results revealed,

Table 1 Frequency and percentage distribution of Height and Weight of the participants.

	Normal Subjects (n=1192)	
Range	F (%)	Mean height ± SD=1.69 ± 0.12m
Height (m)		
1.16-1.20	-	
1.35-1.40	5 (0.4)	
1.41-1.45	11 (0.9)	
1.46-1.50	65 (5.5)	
1.51-1.55	88 (7.4)	
1.56-1.60	97 (8.1)	
1.61-1.65	184 (15.4)	
1.66-1.70	185 (15.5)	
1.71-1.75	172 (14.4)	
1.76-1.80	170 (14.3)	
1.81-1.85	104 (8.7)	
1.86-1.90	59 (4.9)	
1.91-1.95	52 (4.4)	
Weight (kg)		
Range	F %	mean weight ± SD 75.95 ± 15.74 kg
41-45	1 (0.1)	
46-50	62 (5.2)	
51-55	67 (5.6)	
56-60	96 (8.1)	
61-65	103 (8.6)	
66-70	132 (11.1)	
71-75	161 (13.5)	
76-80	135 (11.3)	
81-85	99 (8.3)	
86-90	87 (7.3)	
91-95	87 (7.3)	
96-100	68 (5.7)	
101-105	51 (4.3)	
106-110	43 (3.6)	

that the mean septum in diastole and systole were 8.12 ± 1.33 mm and 9.03 ± 1.37 mm respectively. The LV diameter in diastole was 44.78 ± 5.48 mm and the LV diameter in systole was 33.47 ± 5.12 mm. Post wall in diastole and systole, were 8.31 ± 1.24 mm and 9.47 ± 1.26 mm respectively while relative wall thickness was 0.38 ±0.08 mm **(Table 3).**

The normal echocardiographic values of the left ventricular dimensions according to age are; age group 18-22 years had the least mean of septum in diastole 7.53 ± 0.99 mm, post wall in diastole 7.72 ± 0.94 mm, post wall systole 8.97 ± 1.10 mm and LV mass 105.92 ± 22.07 kg. Those aged 43-47 years had highest mean of septum in diastole 8.67 ± 1.12 mm, septum in systole 9.75± 1.30 mm, post wall in diastole 8.67± 1.30 mm, and post wall in systole 10.00 ± 1.14 mm. Those aged 78-82 years were associated with highest mean LV diameter in systole 34.85 ± 4.84 mm, while those aged 83-87 years were associated with highest mean LV diameter in diastole 47.08 ± 3.88 mm. Highest mean in RWT was 0.40 ± 0.08 mm was among those aged 63-67 and 68-72 years **(Table 4).**

With regards to baseline normal echocardiographic values of the left ventricular parameters according to gender, females had higher mean septum in diastole 8.20 ± 1.38 mm, septum in

Table 2 Frequency and percentage distribution of BMI and BSA of the participants.

	Normal subjects (n=1192)	
	F (%)	mean BMI ± SD26.48 ± 5.15 kg/m ^{2}
BMI (Kg/m^2)		
Underweight	11(0.9)	
Normal weight	530(44.5)	
Overweight	429(36.0)	
Obese	222(18.6)	
BSA(m^2)		Mean BSA ± SD 1.88 ± 0.24m^2
1.20-1.50	55 (4.6)	
1.50-1.80	378(31.7)	
1.80-2.10	519 (43.5)	
2.10-2.40	240 (20.1)	

F= Frequency and %= Percentage

Table 3 Baseline normal echocardiographic values of the left ventricular parameters.

	Range	Median	Mean ± SD	Interquartile Range
Normal Subjects (n=1192)				
Septum Diastole	6.0-17.0	8.0	8.12 ± 1.33 mm	7.0-9.0
LV Diastole	26.0-67.4	46.0	44.78 ± 5.48 mm	41.0-49.0
Post Wall Diastole	6.0-14.0	8.0	8.31 ± 1.24 mm	7.2-9.0
Septum Systole	5.0-14.3	9.0	9.03 ± 1.37 mm	8.0-10.0
LV Systole	21.0-57.6	34.0	33.47 ± 5.12 mm	29.5-37.0
Post Wall Systole	6.0-17.8	9.5	9.47 ± 1.26	8.9-10.1
Relative Wall Thickness	0.20-0.79	0.36	0.38 ± 0.08	0.32-0.42

Table 4 Baseline normal echocardiographic values of the left ventricular parameters according to Age.

Age (yrs)	Septum Diastole	Septum Systole	Postwall Diastole	Postwall Systole	LV Diastole	LV Systole	LV Mass	RWT
18-22	7.53 ± 0.99*	8.61 ± 1.45	7.72 ± 0.94*	8.97 ± 1.10*	44.68 ± 4.52	33.19 ± 4.45	105.92 ± 22.07*	0.35 ± 0.06*
23-27	7.55 ± 1.27	8.46 ± 1.48*	7.99 ± 1.00	9.29 ± 0.93	45.18 ± 4.98	34.41 ± 4.46	110.79 ± 25.60	0.36 ± 0.06
28-32	7.69 ± 1.07	8.72 ± 1.34	8.25 ± 1.22	9.49 ± 0.91	45.58 ± 4.47	33.80 ± 4.04	116.00 ± 24.75	0.37 ± 0.08
33-37	7.92 ± 1.10	8.54 ± 1.11	8.10 ± 1.11	9.55 ± 1.04	45.63 ± 5.81	34.47 ± 5.32	117.38 ± 29.84	0.36 ± 0.08
38-42	8.06 ± 1.19	9.02 ± 1.32	8.27 ± 1.00	9.70 ± 1.34	44.13 ± 5.94	33.83 ± 4.96	113.43 ± 25.09	0.38 ± 0.08
43-47	8.67 ± 1.12+	9.75 ± 1.30+	8.67 ± 1.30+	10.00 ± 1.14+	45.01 ± 4.85	33.56 ± 5.00	127.33 ± 28.82+	0.39 ± 0.08
48-52	8.21 ± 0.93	9.52 ± 1.04	8.45 ± 0.95	9.65 ± 1.15	44.42 ± 4.78	32.13 ± 4.45	117.81 ± 23.84	0.39 ± 0.06
53-57	8.35 ± 1.30	9.22 ± 1.32	8.45 ± 1.35	9.48 ± 1.25	44.56 ± 5.38	33.44 ± 5.16	120.88 ± 33.73	0.38 ± 0.07
58-62	8.40 ± 1.38	9.10 ± 1.43	8.47 ± 1.39	9.58 ± 1.30	44.27 ± 5.83	33.58 ± 5.07	120.42 ± 34.45	0.39 ± 0.08
63-67	8.50 ± 1.37	9.23 ± 1.33	8.51 ± 1.13	9.58 ± 1.41	43.31 ± 6.65*	31.73 ± 6.84*	117.58 ± 35.66	0.40 ± 0.08+
68-72	8.22 ± 1.56	8.92 ± 1.51	8.49 ± 1.42	9.39 ± 1.36	43.68 ± 5.86	32.72 ± 4.61	115.58 ± 30.46	0.40 ± 0.09+
73-77	7.95 ± 1.40	9.04 ± 1.41	8.20 ± 1.21	9.29 ± 1.28	45.80 ± 5.30	33.79 ± 5.42	119.17 ± 28.91	0.36 ± 0.08
78-82	7.76 ± 1.21	8.74 ± 1.35	7.87 ± 1.07	8.99 ± 1.32	46.00 ± 4.48	34.85 ± 4.84+	114.74 ± 23.98	0.35 ± 0.07*
83-87	7.94 ± 1.64	8.90 ± 1.19	8.09 ± 1.42	9.26 ± 1.34	47.08 ± 3.88+	34.61 ± 4.79	124.48 ± 41.98	0.35 ± 0.07*
88-93	7.80 ± 1.16	8.96 ± 1.22	8.25 ± 1.21	9.44 ± 1.28	45.66 ± 5.87	34.60 ± 4.79	118.80 ± 33.03	0.37 ± 0.07

a=not considered for least or highest (as n=1); * = least mean; + = highest mean

systole 9.08 ± 1.42 mm, post wall in systole 9.50 ± 1.26 mm and LV mass 118.23 ± 30.02 kg. Males had higher mean LV diameter in diastole 44.80 ± 5.71 mm, post wall in diastole 8.32 ± 1.26 mm and LV diameter in systole 33.54 ± 5.37 mm. Both male and femal had the RWT 0.38 ± 0.08 mm **(Table 5).**

The left ventricular echocardiography measurements according to BMI was evaluated and the results showed that the underweight had the least mean septum diastole 7.74 ± 0.84 kg, LV diameter in diastole 39.80 ± 6.31 mm, LV diameter in systole 29.10 ± 4.58 kg, post wall in systole 9.25 ± 1.18 kg and LV mass 94.31 ± 28.29 kg. Highest mean septum in diastole 8.35 ± 1.33 kg, post wall in systole 9.64 ± 1.36 kg and LV mass 120.92 ± 31.91 kg were observed among the overweight. Highest mean post wall in diastole 8.47 ± 1.34 kg and septum in systole 9.26 ± 1.41 kg were observed among the obese **(Table 6).**

Body Surface Area of 1.50-1.80 m^2 had the least mean septum in diastole 7.98 ± 1.44 mm, septum in systole 8.75 ± 1.42 mm and post wall in systole 9.26 ± 1.26 mm. Highest mean septum diastole was 8.41 ± 1.55 mm and septum in systole was 9.67 ± 1.27 mm were observed among those with BSA of 1.20-1.50 m^2. Those with BSA of 1.80-2.10 m^2 had the highest mean in LV mass of 120.39 ± 30.05 kg **(Table 7).**

The results of the relationship between age, height, weight, BMI, BSA, sex and left ventricular parameters showed that there was significant relationship between the following parameters. Age, had a weak negative correlation with post wall systole (r_s = -.066, p = .023). For height, it had a weak negative correlation with LV systole (r_s = -.156, p < .001) and also a weak but positive correlation with post wall systole (r_s = .076, p = .009). Weight had a weak positive correlation with septum diastole (r_s = .130, p < .001), post wall diastole (r_s = .058, p = .044), septum systole (r_s = .122, p < .001), post wall systole (r_s = .090, p = .002) and RWT (r_s = .113, p < .001), and a weak negative correlation with LV diastole (r_s = -.117, p < .001) and LV systole (r_s = -.149, p < .001). BMI had a weak positive correlation with septum diastole (r_s = .182, p < .001), post wall diastole (r_s = .124, p < .001), septum systole (r_s = .120, p < .001), post wall systole (r_s = .077, p = .008) and RWT (r_s = .168, p < .001) and a weak negative correlation with LV diastole (r_s = -.120, p < .001) and LV systole (r_s = -.061, p = .037). For BSA, there was weak positive correlation with septum diastole (r_s = .107, p < .001), septum systole (r_s = .109, p < .001), post wall systole (r_s = .098, p = .001) and RWT (r_s = .093, p = .001) and weak negative correlation with LV diastole (r_s = -.108, p < .001) and LV systole (r_s = -.166, p < .001). For sex, it had no significant relationship with the parameters (r_s = -.006, p < .001). No other significant relationship existed **(Table 8).**

The indexed baseline echocardiographic normal reference values of the left ventricular parameters of the participants were evaluated and the mean for the indexed left ventricular parameters were distributed thus: indexed septum in diastole 4.38 ± 0.91 mm, indexed septum in systole 4.86 ± 0.95 mm, indexed LV diameter in diastole 24.21 ± 4.46 mm, indexed LV diameter in systole 18.11 ± 3.79 mm indexed post wall in diastole 4.49 ± 0.89 mm, indexed post wall in systole 5.10 ± 0.90 mm, and indexed LV mass 63.73 ± 19.31 mm. Specifically for sex-based distribution, females had higher mean indexed septum in diastole 4.42 ± 0.9 mm, indexed septum in systole 4.88 ± 0.9 mm, indexed post wall in systole 5.11 ± 0.8 mm and indexed LV mass 63.94 ± 19.6 mm. Males had higher indexed post wall in diastole (4.49 ± 0.90 mm), indexed LV diameter in diastole (24.22 ± 4.53 mm) and indexed LV diameter in systole (18.16 ± 3.90 mm) **(Table 9).**

Table 5 Baseline normal echocardiographic values of the left ventricular parameters according to gender.

M ± SD	Male	Female
Septum Diastole	8.05 ± 1.27	8.20 ± 1.38⁺
LV Diastole	44.80 ± 5.71⁺	42.75 ± 5.21
Post wall Diastole	8.32 ± 1.26⁺	7.51 ± 1.22
Septum Systole	8.99 ± 1.33	9.08 ± 1.42⁺
LV Systole	33.54 ± 5.37⁺	30.38 ± 4.81
Post wall Systole	9.45 ± 1.26	9.50 ± 1.26⁺
LV Mass	117.52 ± 31.49	118.23 ± 30.02⁺
RWT	0.38 ± 0.08	0.38 ± 0.08

+ = highest mean.

Table 6 Baseline normal echocardiographic values of the left ventricular parameters according to BMI of the participants.

BMI (kg/m^2)	Septum Diastole	LV Diastole	Postwall Diastole	Septum Systole	LV Systole	Postwall Systole	LV Mass	RWT
Underweight	7.74 ± 0.84*	39.80 ± 6.31*	8.31 ± 1.05	8.98 ± 1.42	29.10 ± 4.58*	9.25 ± 1.18*	94.31 ± 28.29*	0.43 ± 0.09⁺
Normal weight	7.86 ± 1.28	45.34 ± 5.04⁺	8.15 ± 1.19*	8.83 ± 1.32*	33.84 ± 4.72⁺	9.36 ± 1.17	116.02 ± 28.88	0.37 ± 0.08*
Overweight	8.35 ± 1.33⁺	44.66 ± 5.60	8.43 ± 1.24	9.16 ± 1.38	33.03 ± 5.01	9.64 ± 1.36⁺	120.92 ± 31.91⁺	0.38 ± 0.07
Obese	8.33 ± 1.34	43.89 ± 6.01	8.47 ± 1.34⁺	9.26 ± 1.41⁺	33.63 ± 6.03	9.42 ± 1.25	117.47 ± 32.49	0.39 ± 0.09

a = not considered for least or highest (as n = 1); * = least mean; + = highest mean

Table 7 Baseline normal echocardiographic values of the left ventricular parameters according to BSA.

BSA (m^2)	Septum Diastole	LV Diastole	Postwall Diastole	Septum Systole	LV Systole	Postwall Systole	LVM	RWT
Normal Subjects (n=1192)								
1.20-1.50	8.41 ± 1.55⁺	45.17 ± 4.59	7.85 ± 1.22*	9.67 ± 1.27⁺	32.03 ± 4.82	9.33 ± 0.98	118.44 ± 42.03	0.35 ± 0.07*
1.50-1.80	7.98 ± 1.44*	45.37 ± 5.04⁺	8.30 ± 1.37	8.75 ± 1.42*	34.74 ± 4.74⁺	9.26 ± 1.26*	119.02 ± 30.87	0.37 ± 0.08
1.80-2.10	8.15 ± 1.27	44.97 ± 5.50	8.47 ± 1.20⁺	9.00 ± 1.32	33.56 ± 5.15	9.61 ± 1.25⁺	120.39 ± 30.05⁺	0.38 ± 0.08⁺
2.10-2.40	8.22 ± 1.18	43.32 ± 6.04*	8.10 ± 1.06	9.39 ± 1.31	31.60 ± 5.07*	9.52 ± 1.31	110.40 ± 28.24*	0.38 ± 0.08⁺

* = least mean; + = highest mean

Table 8 Correlation of left ventricular Parameters and Body Parameters of the participants.

	Age	Height	Weight	BMI	BSA	Sex
Statistic	r_s	r_s	r_s	r_s	r_s	r_{pb}
Septum Diastole	0.005	-0.014	.130*	.182*	.107*	0.057
	0.872	0.624	< .001	< .001	< .001	0.051
LV Diastole	0.051	-0.047	-.117*	-.120*	-.108*	-0.004
	0.081	0.103	< .001	< .001	< .001	0.889
Post wall Diastole	-0.001	-0.006	.058*	.124*	0.041	-0.006
	0.972	0.827	0.044	< .001	0.156	0.845
Septum Systole	0.017	0.009	.122*	.120*	.109*	0.033
	0.556	0.747	< .001	< .001	< .001	0.266
LV Systole	0.003	-.156*	-.149*	-.061*	-.166*	-0.016
	0.924	< .001	< .001	0.037	< .001	0.59
Post wall Systole	-.066*	.076*	.090*	.077*	.098*	0.02
	0.023	0.009	0.002	0.008	0.001	0.489
LVM	0.04	-0.051	-0.022	0.029	-0.031	0.012
	0.172	0.081	0.453	0.309	0.287	0.691
RWT	-0.013	0.019	.113*	.168*	.093*	-0.006
	0.655	0.511	< .001	< .001	0.001	0.849

Statistics: r_s = Spearman Correlation; r_{pb} = Point-biserial Correlation;
Correlation Coefficient (lighted); p-value (bolded); * implies significant relationship ~ significance exists at p < .05

Table 9 Indexed echocardiographic baseline normal values of the left ventricular parameters of the participants.

Sex	Statistic	SeptumDiastole Index	Septum Systole Index	PostWall Diastole Index	PostWall Systole Index	LV Diastole Index	LV Systole Index	LV Mass Index
Male	Range	2.60-7.84	2.99-8.10	2.78-7.43	2.60-8.19	12.97-35.81	10.05-30.80	21.09-135.18
	Median	4.21	4.72	4.37	5.05	24.37	18.01	62.18
	M ± SD	4.34 ± 0.88	4.85 ± 0.94	4.49 ± 0.90+	5.10 ± 0.93	.22 ± 4.53+	18.16 ± 3.90+	63.55 ± 19.01
	IQRange	3.69-4.85	4.18-5.37	3.86-4.96	4.45-5.65	21.08-27.15	15.19-20.93	50.39-74.07
Female	Range	2.81-12.43	2.65-8.98	2.93-10.24	3.09-7.80	12.99-40.22	10.39-30.60	27.24-285.78
	Median	4.28	4.78	4.41	5.10	24.12	18.03	62.31
	M ± SD	4.42 ± 0.9+	4.88 ± 0.9+	4.48 ± 0.88	5.11 ± 0.8+	24.19 ± 4.39	18.05 ± 3.67	63.94 ± 19.6+
	IQRange	3.80-4.79	4.20-5.37	3.93-4.94	4.53-5.59	21.3327.04	15.4720.54	51.63-73.65
All	Range	2.6012.43	2.65-8.98	2.7810.24	2.60-8.19	12.9740.22	10.0530.80	21.09285.78
	Median	4.25	4.75	4.39	5.07	24.25	18.03	62.24
	M ± SD	4.38 ± 0.91	4.86 ± 0.95	4.49 ± 0.89	5.10 ± 0.90	24.21 ± 4.46	18.11 ± 3.79	63.73 ± 19.31
	IQRange	3.75-4.81	4.19-5.37	3.89-4.96	4.49-5.62	21.19-27.08	15.36-20.71	50.60-73.77
+ = highest mean (between male and female)								

A comparison between Left ventricular measurements from our study and those of American society of echocardiography (ASE) and European association of cardiovascular imaging (EACVI) were done and the results showed that for LV diastole, 70.6% males and 89.7% females in our study; 79.4% subjects altogether were within the specified ASE and EACVI reference values. The indexed LV diastole was 57.0% males, 54.4% females and 55.8% subject's altogether. 89.7% males, 62.6% females and 77.1% subjects' altogether were found within the LV systole ASE and EACVI reference values while 64.9% males, 70.3% females and 67.4% subjects altogether were found within indexed LV in systole reference values. For LV mass, the distribution was thus: 80.1% males, 92.2% females and 85.9% subject's altogether; while for indexed LV mass, it was 75.6% males, 84.8% females and 79.9% subjects. For septum diastole, 94.8% males, 82.3% females and 89.0% subjects altogether were within the specified ASE and EACVI reference values for septum diastole, while for posterior wall diastole, 93.3% males, 81.0% females and 87.6% subjects altogether were within its specified reference values **(Table 10).**

Discussion

In this study, various measurements of the left ventricular dimensions in apparently normal subjects were obtained and indexed to BSA. This agrees with findings from other similar studies which reported that indexing echocardiographic parameters to BSA produces more reliable data [2,6]. The study by [10] described only the profile of cardiomyopathy in Nigeria among children in Jos Northern part of Nigeria. Another study

Table 10 Findings of Echocardiography Measurements in Comparison to ASE and EACVI measurements.

Parameter	Male (n=639)			Female (n=553)			Overall (n=1192)
	ASE & EACVI	This Work M ± SD (Range)	With ASE & EACVI n (%)	ASE & EACVI	This Work M ± SD (Range)	Within ASE & EACVI n (%)	Within ASE & EACVI n (%)
LV diastole	42-58	44.80 ± 5.71 (27.1-67.4)	451 -70.6	38-52	44.75 ± 5.21 (26-64)	496 -89.7	947 -79.4
Indexed LV diastole	22-30	24.22 ± 4.53 (12.97-35.81)	364 -57	23-31	24.19 ± 4.39 (12.99-40.22)	301 -54.4	665 -55.8
LV systole	25-40	33.54 ± 5.37 (21.0-57.6)	573 -89.7	22-35	33.38 ± 4.81 (22-51)	346 -62.6	919 -77.1
Indexed LV systole	13-21	18.16 ± 3.90 (10.05-30.80)	415 -64.9	13-21	18.05 ± 3.67 (10.39-30.60)	389 -70.3	804 -67.4
LV mass	88-224	117.52 ± 31.49 (45.9-234.0)	512 -80.1	67-162	118.23 ± 30.02 (54.5-390.8)	510 -92.2	1022 -85.9
Indexed LV mass	49-115	63.55 ± 19.01 (21.1-135.2)	483 -75.6	43-95	63.94 ± 19.66 (27.2-285.8)	469 -84.8	952 -79.9
Septum diastole	06-Oct	8.05 ± 1.27 (6-13)	606 -94.8	06-Sep	8.20 ± 1.38 (6-17)	455 -82.3	1061 -89
Indexed Septum diastole	-	4.34 ± 0.88 (2.6-7.8)	-	-	4.42 ± 0.94 (2.8-12.4)	-	-
Septum systole	-	8.99 ± 1.33 (6.0-13.0)	-	-	9.08 ± 1.42 (5.0-14.3)	-	-
Indexed Septum systole	-	4.85 ± 0.94 (3.0-8.1)	-	-	4.88 ± 0.96 (2.7-9.0)	-	-
Post wall diastole	06-Oct	8.32 ± 1.26 (6-13)	596 -93.3	06-Sep	8.31 ± 1.22 (6-14)	448 -81	1044 -87.6
Indexed Post wall diastole	-	4.49 ± 0.90 (2.8-7.4)	-	-	4.48 ± 0.88 (2.9-10.2)	-	-
Post wall systole	-	9.45 ± 1.26 (6.0-17.8)	-	-	9.50 ± 1.26 (6.0-17.0)	-	-
Indexed Post wall systole	-	5.10 ± 0.93 (2.6-8.2)	-	-	5.11 ± 0.87 (3.1-7.8)	-	-

by [9] in western Nigeria also described only the profile of cardiomyopathy in Nigeria among children in the region. Thus there is still need for echocardiographic normal values in adult population in Nigeria.

In this study, 1192 apparently healthy subjects were studied to establish baseline normal reference values of left ventricular dimensions. In general it was discovered that left ventricular dimensions increases with increase in age and morphology until mid-age in this present study. This was in agreement with the work done by [2], which stated that the size and morphology of the left ventricle varies with age and from person to person. This study, ensured inclusion of nearly 97% of subjects (from the 3rd to 97th percentile) in producing the baseline normal echocardiographic values of the study population. This implied that there was adequate subject representation in the study. The mean and standard deviation of left ventricular internal diameter in diastole (LVEDD) and systole (LVESD) were 44.78 ± 5.48 mm and 33.47 ± 5.12 mm, respectively. Males had larger LVEDD (44.80 ± 5.71 mm), LVESD (33.54 ± 5.37 mm), and PWd (8.32 ± 1.26 mm) than females (p<0.001). Left ventricular mass (118.23 ± 30.02 kg), IVSd (8.20 ± 1.38 mm) and IVSs (9.08 ± 1.42 mm) were higher in females (p<0.001). These were similar with a study on normal reference values of echocardiographic measurements in young Egyptian adults where males also had larger values than females in these parameters [2].

Correlation of age, height, weight, BMI and BSA, with left ventricular echocardiographic parameters

Age had a weak negative relationship with left ventricular posterior wall in systole (r_s = -0.066, p=0.023) while height, had a weak negative relationship with LV end-systolic diameter (r_s = - 0.156, p<0.001) Weight had a weak positive relationship with interventricular septum in diastole (r_s = .130, p < .001), Relative wall thickness has a weak negative relationship with LV end-diastolic diameter (r_s = -.117, p < .001). These implied that these measurements can been taken at any age, height and weight. Body mass index had a weak positive relationship with interventricular septum in diastole (r_s = .182, p < .001), left ventricular posterior wall in diastole (r_s = .124, p < .001), interventricular septum in

systole (r_s = .120, p < .001), left ventricular posterior wall in systole (r_s = .077, p = .008) and RWT (r_s = .168, p < .001). However, BMI had a weak negative relationship with LV end-diastolic diameter (r_s = -.120, p < .001) and LV end -systolic diameter (r_s = -.061, p = .037).

Body surface area had weak positive relationship with interventricular septum in diastole (r_s = .107, p < .001), interventricular septum in systole (r_s = .109, p < .001), left ventricular posterior wall in systole (r_s = .098, p = .001) and RWT (r_s = .093, p = .001). BSA had weak negative relationship with LV end-diastolic diameter (r_s = -.108, p < .001) and LV end -systolic diameter (r_s = -.166, p < .001). The study showed that a linear correlation existed between all echocardiographic measurements with age, height, weight, BMI and BSA which is similar to the findings of [11]. These imply that echocardiographic parameters can be indexed to body surface area to obtain a more reliable normal reference values in our locality.

Producing normal values for dimensions and functions of the heart is very important to avoid misclassification of normal persons into the high risk category and the reverse [12] Studies have shown that using measurements indexed to BSA provides more reliable information [13]. In this study, participants' absolute LV dimensions and LV mass were smaller than the ASE-recommended normal values. These differences were significantly minimized when the values were indexed to BSA. These findings imply that the practice of using absolute values for defining normality of various cardiac chamber dimensions in our locality should be discouraged. The BSA-indexed left ventricular baseline normal reference values in our locality should be used during echocardiography investigations because there is well-developed fact that indexing allows comparisons in subjects with different body sizes [8,14,15]. These changes have also been observed among different races and ethnicities, which raised the importance of this study keeping in mind that today's baseline normalvalues are widely based on data from North American cohorts obtained in the 1970s and 80s [4,16-18,].

Specifically, males had higher indexed post wall diastole, indexed LV diameter in diastole (LVEDD) and indexed LV diameter in systole (LVEDS). Females had higher mean in indexed septum diastole, indexed septum systole, indexed post wall systole and indexed LV mass. Therefore males had larger left ventricular dimensions than females in this study.

Measurements obtained from this study were compared with the reference values of American Society of Echocardiography (ASE) and the European Association of Cardiovascular Imaging (EACVI). Thus for LVEDD, 70.6% were males and 89.7% were females, while 79.4% subjects altogether were within the specified ASE and EACVI reference ranges. The indexed LV in diastole was thus: 57.0% males, 54.4% females and 55.8% subjects altogether. Moreover, 89.7% males, 62.6% females and 77.1% subjects' altogether were found within the LV systole ASE and EACVI reference range while 64.9% males, 70.3% females and 67.4% subject's altogether were found within indexed LV systole reference values.

For LV mass, the distribution was thus: 80.1% males, 92.2% females and 85.9% subjects altogether; while for indexed LV mass, it was thus: 75.6% males, 84.8% females and 79.9% subjects. For septum diastole, 94.8% males, 82.3% females and 89.0% subjects altogether were within the specified ASE and EACVI reference ranges, while for post wall diastole, 93.3% males, 81.0% females and 87.6% subject's altogether were within the specified reference ranges.

Our results revealed that in our locality, the dimensions of LV were smaller than those of the Caucasian population with males in this study having higher upper reference limit of normal for LVEDD, LVESD and IVSD, while females had a higher upper reference limit of normal for indexed LV mass. These confirmed that in this study, males had higher indexed left ventricular internal diameters while the females had thicker left ventricular walls.

Some of the limitations in study include but not limited to; difficulty in delineating the endocardial margins on the M-Mode tracing. The M-Mode line lies between the papillary muscle and the mitral valve may be mistaken for the poster lateral wall. During the study, there was the problem of inward motion of the small ventricles (wall and portions of the papillary muscle) from the sides, which enters the field of view of the M-Mode. This may cause the investigator to underestimate end-systolic diameter. Moreover, poor image quality and oblique views made it difficult to perform measurements. Also, this work did not measure LV volume which is obtained by 2D measurement of LV length and width, thus further studies should adopt 2D measurement of the LV volume as this work used M-Mode tracing.

Conclusion

This study established baseline normal values for normal left ventricle of the heart in a population of one thousand one hundred and ninety two (1,192) by echocardiography. Left ventricular dimensions increases with increase in age and morphology until mid-age. The mean of left ventricular internal diameter in diastole (LVEDD) and systole (LVESD) were determined. The parameters varied significantly with the gender and age of the participant.

The values of LV dimensions and LV mass of this study were smaller when compared with international baseline reference values when indexed to BSA. This was attributed to racial difference. Linear correlations existed between all echocardiographic measurements with age, height, weight, BMI and BSA in the study population.

Conflicts of Interest

None-declared.

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