MSI Journal of
Medicine and Medical Research (MSIJMMR)

THE CARDIAC DIMENSIONS USING CTR AND ECHOCARDIOGRAPHIC PARAMETERS IN INDIVIDUALS WITH DOMINANT BODY SOMATOTYPES

Aloysius Onuabuchi Ogoke[1], Anthony. C. Ugwu[1], Daniel. C. Ugwuanyi[1], Michael Promise Ogolodom[2*], Sharonrose Ogochukwu Nwadike[1], Victor Kelechi Nwodo[1], Emeka Ifedi Emedike[3]

[1]Department of Radiography and Radiological Sciences, Nnamdi Azikiwe University, Awka, Nigeria.

[2*]Department of Radiography, Faculty of Basic Medical Sciences, College of Medical Sciences, Rivers State University, Port Harcourt, Nigeria.

[3]Radiology Department, University on the Niger, Umunya, Anambra State, Nigeria.

*** Correspondence:** Michael Promise Ogolodom

The authors declare that no funding was received for this work.

OPEN ACCESS

Received: 01-April-2026

Accepted: 30-April-2026

Published: 09-May-2026

This article is published in the **MSI Journal of Medicine and Medical Research (MSIJMMR)**

ISSN 3049-1401 (Online)

The journal is managed and published by MSI Publishers.

Volume 3, Issue 2 (May-Aug), 2026

ABSTRACT: Background: Echocardiography and chest radiography are two common imaging modalities for measuring the size of the heart in low resource environment and on bedsides. This study was designed to determine cardiac dimensions using chest and echocardiographic parameters in individuals with dominant body somatotypes in apparently healthy subjects in selected centers in Anambra State.

Materials and methods: This prospective cross-sectional study was conducted in some selected healthcare facilities that have X-rays and Echocargiography machines in Nnewi and Awka, Anambra State, Nigeria. Standard protocols for Chest X-rays and Echocardiography were adopted for the examinations and data such as demographic variables (age, gender), body mass index (BMI), cardiac dimensions and somatotype of the participants were recorded for analysis.

Results: Interventricular septal thickness in diastole (IVSd) was similar across groups, with mean values of 8.91 ± 1.51 mm in ectomorphs, 9.07 ± 1.51 mm in endomorphs, and8.73 ± 1.19 mm in mesomorphs. Posterior wall thickness in diastole (LVPWDd) showed minimal differences among somatotypes, with mean values of 9.73 ± 1.22 mm in ectomorphs, 9.69 ± 1.39 mm in endomorphs, and 9.56 ± 1.19 mm in mesomorphs. In systole (LVPWDs), endomorphs demonstrated slightly higher values (10.56 ± 1.01 mm) compared with ectomorphs (10.50 ± 1.28 mm) and mesomorphs (10.16 ± 1.21 mm). There were significant differences for right ventricular diameter in diastole (RVDd), $F(2, 207) = 24.89$, $p < .001$, left ventricular mass index (LVMI), $F(2, 207) = 12.95$, $p < .001$ and cardiothoracic ratio (CTR), $F(2, 207) = 9.85$, $p < .001$. **Conclusion:** Cardiac dimensions across mesomorph, endomorph, and ectomorph somatotypes indicates significant differences for right ventricular diameter in diastole (RVDd), left ventricular mass index (LVMI), and cardiothoracic ratio (CTR).

Keywords: *Body mass index, Chest, Echocardiography*

INTRODUCTION

Cardiac size assessment techniques vary in their precision and applicability, with Cardiac Magnetic Resonance Imaging (CMRI), as gold standard for precise quantification of ventricular volumes and myocardial characterization [1-4]. Echocardiography remains the preferred modality due to its convenience and real time imaging capabilities, and it is favoured because of its detailed cardiac evaluation. It is the gold standard for most specific cardiac conditions such as heart failure, and cardiac effusion [5]. Computerized Tomography (CT) scan and Chest radiography offer valuable alternatives, each with specific strengths, limitations and Chest radiography is the first line in Visualization- assisted assessment [6,7]. The choice of technique depends on the clinical context, patient characteristics, specific cardiac chamber being assessed and the standard echocardiographic obtained cardiac dimensions have been shown to vary with ethnic and racial groups [8-11].

Heart size determination is very important, and it is an effective parameter in chest radiography interpretation [10, 12,13]. It offers a quick and non-invasive way to estimate heart size by measuring the cardiothoracic ratio (CTR), and it can be used as an initial screening tool in cardiopulmonary complaints [10,12]. However, its accuracy may be affected by variations in body shape, positioning, and other technical factors [14]. Some disease conditions such as obesity, mitral regurgitation, hypertension, aortic regurgitation, pericardial effusion increase the burden on the heart, predict poor cardiac outcomes and may reflect potentially treatable underlying diseases [5, 13,15].

Echocardiography and cardiac magnetic resonance imaging as already stated are considered the gold standard for the evaluation of cardiac size and functions, because they provide information on chamber volumes, ventricular systolic and diastolic functions, wall thickness, valve function and valvular hemodynamic recoil within the cardiac chambers [4,16]. However, they are rarely performed as initial investigations because of their relatively high cost, the limited availability of trained specialists in low resource settings to perform them and they are not ideal for emergency settings. Postero-anterior chest radiography in addition to easier availability, low cost and not operator dependent provides reliable alternative for cardiac size screening [16].

Somatotype is a quantification of the present shape and composition of the human body, it reflects the anatomical model of body composition, expressed as a series of three numbers each representing a particular component and it is increasingly recognized as a significant determinant of both cardiovascular risk and underlying cardiac structure [17-22]. It gives detailed information about the characteristics and anatomy of the human body and classifies human body into three major categories; ectomorph is the degree of leanness of a body, mesomorph is the degree of muscularity and well proportioned, Endomorph is round with higher body fat [23-26]. A critical observation in the evolution of somatotyping methodologies reveals a transformation from its initial pseudoscientific underpinnings, which linked body type to intelligence, moral worth and criminal potential which were later disputed by researchers, to a more rigorous quantitative approach. Despite the importance of accurate cardiac dimension assessments in the early detection of subtle cardiac structural changes in individual’s body physique, comprehensive local existing data on the relationship between dominant body somatotypes and cardiac dimensions remains limited in Anambra State. Existing global normative data, largely derived from the Caucasian populations, frequently proved inadequate for accurately assessing diverse ethnic groups such as Nigerians; hence the need for population-specific reference values using locally obtained data. It is also important to accurately and promptly assess cardiac structures and dimensions through cardiac screening because even individuals who seem to be healthy may have subtle subclinical changes in their heart structures that are important predictors of future cardiovascular morbidity and mortality [18,27]. Therefore, this study is designed to investigate every nuance between dominant body somatotypes and cardiac dimensions, as measured by chest radiography and echocardiography, in apparently healthy subjects in selected centers in Anambra State, Nigeria.

MATERIALS AND METHODS:

Study design

A prospective cross-sectional design was adopted for this study. This design allows participants to be selected based on the already set inclusion and exclusion criteria for the study once without further follow up of the participants.

Area of study

This study was conducted in Nnewi and Awka in Anambra State. Nnewi is a commercial and industrial city while Awka is the capital of Anambra State, Southeastern Nigeria. Nnewi is the second largest city in Anambra State. Geographically, Nnewi falls within the tropical rain forest region of Nigeria. The city is located east of the Niger River and about 22 kilometers southeast of Onitsha. Nnewi is a metropolitan area, has two local government areas, which are Nnewi North and Nnewi South. The first indigenous car manufacturing plant in Nigeria is located in the city. As of January 2025, Nnewi has an estimated population of one million, three hundred and sixty-one thousand, eight hundred and forty (1,361,840) inhabitants [28]. The city spans over 520km2 in Anambra state. Nnewi hosts a number of institutions and places of learning and healing, which include Nnamdi Azikiwe University Teaching Hospital (NAUTH). The Nnamdi Azikiwe University Teaching Hospital, Nnewi, is in the forefront of providing excellent health services to the inhabitants of Anambra state and the neigbouring states. Awka is the capital of Anambra State, and it is located in the Eastern part of Nigeria, with a population of about four million [29]. It has many hospital and Diagnostic Centres.

The data collection was conducted in Waves Medical Diagnostics and Research Center, Nnewi, opposite Nnamdi Azikiwe University Teaching Hospital (NAUTH) and Evidence Based Medical Diagnostic Centre, Awka, Anambra State. Waves Medical Diagnostics and Research Centre near to NAUTH and Evidence Based Medical Diagnostic Centre located in Awka the capital of Anambra State, provided adequate patients throughput and spread for ECHO and CXR. Waves Medical Diagnostics and Research Center and Evidence Based Medical Diagnostic Centre have Echocardiographers, Radiographers, Radiologists and state-of-art equipment in medical imaging. The equipment includes Calibrated Vivid T8 GE with probe frequency of 1.7 MHZ to 3.2 MHZ and Philip HD xe with 2.5 MHz phased array tranducer both with integrated electrocardiography (ECG) recording electrodes. Calibrated Pica X-ray machine model, flour mounted, and Chest stand with floating table. The chest radiographs were postprocessed with digitalizer, CR- 12 X, model and printed with Drystar 5302, HP workstation and NX software.

Ethical consideration.

An ethical approval (MH/PRS/1244/224) for this study was obtained from the Department of Planning, Research and Statistics, Ministry of Health, Awka, Anambra state, Nigeria. The aim of this study was explained in the consent form. Each participant was asked to read and agree to the terms of the study contained in the inform consent form. They were informed about their level of involvement before their participation. Furthermore, the participants were assured that no identifying information about them would be used or collected at any point during the study, and that all results would remain anonymous. The voluntary nature of participation and their liberty to withdraw their informed consent was maintained and all retrieved data about the participants were treated with high level of confidentiality and used for the study only.

Sample Size Determination.

G-power software for sample size calculator version 3.1.9

F tests – ANOVA: Fixed effects, omnibus, one-way.

Analysis: A priori: Compute required sample size.

Input:

Effect size (f)	= 0.25 (medium effect)
Error probability	= 0.05
Power (1-β error probability)	= 0.8
Number of groups	= 3

Output:

Non-centrality parameter	= 9.9375000
Critical F	= 3.0540042
Numerator df (degree of freedom)	= 2
Denominator df (degree of freedom)	= 156
Total sample size (minimum)	= 159.
Total sample size used	= 210
Actual power	= 0.8048873

Sample size for each of the group

Group A: Ectomorph	= 70 participants
Group B: Mesomorph	= 70 participants
Group C: Endomorph	= 70 participants

While the sample size of 159 gives minimum desired power, increasing the sample size to 210 decreases

the margin of error by increasing the power, however sample size is not merely a matter of the bigger the better because, excessively large sample size will increase costs, prolong recruitment and expose more participants than necessary [30],

G-Power software sample calculator was used to calculate the sample size because it ensures that the study is neither underpowered nor wasteful, it incorporated statistical principles (effect size, power, significance level). These are the reasons why the researcher used G-Power to determine sample size in this study:

i. To ensure adequate statistical power because it calculates the optimal sample size needed to achieve a desired power level.

ii. It handles different study designs because it supports a wide range of statistical tests namely; t-tests, ANOVA, regression, chi-square and correlations and this means it can be tailored to the researcher's specific methodology.

iii. It incorporates effect size and this ensures that the sample size is calculated in relation to the expected magnitude of effect.

iv. It considers significant level (α) and researchers usually use α = 0.05 (5%) chance of Type 1 error. G-Power integrates this value to balance false positives (Type 1 errors) and false negatives (Type II errors) in sample size estimate.

v. It provides sample size before study which can be used to plan recruitment of participants.

The sample size of 210 participants give balanced representation among the three dominant somatotypes and is sufficiently large to capture the variations across the three groups within the Anambra State population. A sample size of 210 participants as recruited into the study using purposive sampling method

Inclusion Criteria

To ensure a robust analysis of cardiac dimensions across dominant body somatotypes using chest radiography and echocardiography, the inclusion criteria was focused on the followings:

1. Age range: Adults 18 years and above were included to avoid confounding effects of pediatric cardiac physiology.

2. Sex: Both males and females were included to account for sex-based differences in cardiac dimensions.

3. Anthropometric profiles: BMI was obtained and participants grouped based on dominant body somatotypes using Heath - Carter somatotyping method.

4. Medical history: Individuals without known structural heart disease and normal blood pressure were included after their blood pressures were measured and determined with digital blood pressure machine.

5. Cardiac Imaging Data Availability: The participants' chest radiographs were obtained first and those with normal chest radiographs were recruited for ECHO after their dominant somatotypes were obtained in line with purposive sampling method [31].

6. The participants' echocardiograms were performed within a reasonable time frame, to ensure accurate comparisons.

7. All echocardiographic measurements were indexed with BSA.

Exclusion Criteria

1. Age: Participants under 18 years were excluded.

2. Pregnancy and lactation females: Female participants who were pregnant or breastfeeding were excluded.

3. Cardiac conditions: Participants with cardiac conditions, such as; congestive heart failure, cardiomyopathy, severe valvular heart disease, cardiac arrhythmias and hypertensive disease were excluded.

4. Respiratory conditions: Participants with medical history which include the following: severe respiratory diseases, chronic obstructive pulmonary diseases (COPD), pneumonia, pulmonary embolism were excluded.

5. Neuromuscular conditions: Participants with conditions affecting muscle tone or movements, such as; muscular dystrophy, Parkinson's disease, stroke and cerebral palsy were excluded.

6. Previous cardiac surgery: Participants who have undergone cardiac surgery, including coronary artery bypass grafting and heart transplant were excluded.

7. Implantable devices: Participants with implantable cardioverter-defibrilators, peacemakers and other implantable devices that may interfere with echocardiography or chest radiography were excluded.

8. Participants with chest wall abnormalities such as pectus excavatum and pectus carinatum were excluded.

9. Participants who were unable to provide informed consent due to cognitive impairment, language barriers and other reasons were excluded.

Instruments and procedures for data collection

The instruments for data collection include; Echocardiography, Chest X-ray machine and accessories

The machines and accessories include:

For echocardiography, VIVID T8 GE, with 1.7 to 3.2 MHz probe, with integrated electrocardiography (ECG) recording electrodes.

For chest radiographs, Pica X-ray machine with floor mounted tube stand, floating table with chest stand, CR-12- X digitizer processor with Drystar printer, HP work station with NX software, 43cm x 35cm and 35cm X 35cm cassettes, and anatomical marker were used.

For heights, meter ruler was used.

For weights, commercially available weighing scale (Hana) was used. Heights and weights were used to estimate body mass index (BMI) in kg/m2 and body surface area (BSA) in m2, where BSA is equal to the square root of height in cm x weight in kg/3600.

The following variables were also assessed: age, height, weight, biepicondylar humerus breath, biepicondylar femur breath, arm flexed and tensed girth, standing calf girth, triceps skinfold, subscapular skinfold, supraspinale skinfold and medial calf skinfold and the measurements were done with the use of standard equipments and procedures, as described by Carter and Heath[22].

Chest radiography and measurements

The chest radiographs were obtained in a posterior-anterior projection using standard protocol of focus- to film distance (FFD) of 180 cm, full arrested inspiration, 35cm x 35cm or 35cm x 43cm cassette. The participants were positioned facing the cassette with the chin extended and the trunk adjusted so that the median sagittal plane is perpendicular to the cassette Feet parted to maintain stability. The dorsal aspects of the hands were placed behind and below the hips and the elbows were brought forward. Shoulders were relaxed and rotated forwards until they were in contact with the cassette [32]. Female subjects with large pendulous breasts were asked to pull the breasts upward and laterally (outwards), and the cassette was adjusted to keep them in position [33].

The horizontal central beam was directed at right-angles to the cassette at the level of the seventh thoracic vertebrae (spinous process of T7), which is coincident with the lung midpoint [34].

A pilot study was done to test the process for calculating the cardiothoracic ratio (CTR) and assesses inter-rater reliability between the radiologist, radiographer and the researchers. The heart size was evaluated using the maximum thoracic diameter which is the widest part of the chest cavity measured by drawing vertical line at the widest part of the cardiac silhouette and measuring the distance from the furthest point on the right border of the heart to the furthest point on the left border.

A cardiothoracic ratio (CTR) of 0.5 is generally considered the upper of the normal range for adults on a postero-anterior (PA) chest radiograph. However, Anibor et al [9], Ominde et al[10] and Oladipo et al[35] in their studies suggested CTR of 45.62, 45.9 and 46.3 for the general populations of Nigerians and that a ratio above these CTR cut offs suggest cardiomegaly. The images were evaluated for rotation and degree of inspiration [34,36]. If the chest radiograph was taken in the supine position (AP), it could artificially enlarge the heart size therefore, PA view was adopted for all the participants because it minimizes magnification of the heart.

Measurement of height and body weights

The heights of the participants were measured in conformity with WHO STEPS in the measurement of height [37]. The researcher instructed each of the participants at a time to remove his or her footwear, shoes, slippers, sandals and stockings, head-gear (hat, cap, hairband, comb and ribbons. Each of the participants at a time was asked to stand on the board facing the researcher. The back of the participant's head, shoulders, buttock and heels were ensured that they are in contact with the meter ruler. The feet were ensured that they are facing anteriorly and the legs separated apart (10cm) to ensure participant's stability.

The participant was asked to look ahead and not up. The researcher made sure that the eyes were on the same level. The arms were moved gently down onto the head of the participant, and the participant was asked to breathe in and stand tall.

The height was read in centimeters from the eye level of the researcher at the exact point and the participant was asked to step away from the measuring board. For participants who are taller than the researcher, supporting step was used. The height was recorded in centimeters in the Excel software sheet.

The weights of the participants were measured with commercially available scale, (Hana model). The scale was placed on a firm, flat surface in conformity with WHO STEPS and adjusted to zero reading [37]. The participants were asked to remove their footwear, shoes, slippers, sandals and stockings. A participant was asked to step onto the scale at a time with one foot on each side of the scale, stand still, face forward, place arms on the side and wait until asked to step off. The weight was read from the weighing scale in kilograms and recorded in Excel data sheet.

Echocardiography Scanning Protocol or Technique

Echocardiography is the most commonly used non-invasive imaging tool for the evaluation of the heart structures and functions [38]. Various measurements can be performed to determine the size, diameter, length and area of the left ventricle and these measurements are made at two different points in the cardiac cycle, namely end-diastole and end-systole. The cardiac diameter is largest at the end of diastole because the ventricles contain the greatest volume of blood [39]. The availability of Doppler facility is an added advantage because it helps in the determination of the direction of blood flow within the chambers and vessels of the heart in real time.

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 machine with sector probe with frequency range from 1.7-3.2MHz. The choice of the probe was made to get adequate visualization of the heart structures through the intercoastal spaces. Each examination was performed with the participant observing quiet breathing while lying in the left lateral decubitus position as described by [5,11,40]. Ultrasound gel was applied to ensure proper coupling of the transducer and good transmission of the ultrasound beam into the participant's thoracic cavity. From the parasternal window, the 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 towards the right shoulder. In a true long axis view, which is perpendicular to the center of the true long axis of the left ventricle (LV), M-mode image was obtained between the papillary muscle and at the tip of the mitral valve [41]. Measurements were made from the leading edge of the septal endocardium to the leading edge of posterior wall endocardium [40,42]. Measurements for the interventricular septum at end diastole (IVSd), LV internal dimensions at diastole (LVIDd) and LV posterior wall thickness at end diastole (LVPWDd). Also, measurements were obtained at end of systole for each of the parameters mentioned above. The measured values were divided by BSA to obtain indexed measurements as described by Ugwuanyi et al [11], Misssiri et al [38], Basal et al [43] and recorded in excel data sheet.

The study measured and obtained the following dimensions:

Interventricular Septum (IVSd), Interventricular Septum (IVSs), Left Ventricular Internal Diameter in diastole (LVIDd), Left Ventricular Internal Diameter in systole (LVIDs), Left Posterior Ventricular Diameter in diastole (LVPWDd), Left Posterior Ventricular Diameter in systole (LVPWDs), Right Ventricular Diameter (RVDd), Left Ventricular Mass (LVmass), Left Ventricular Mass Index (LVMI), Right Wall Thickness (RWT).

Somatotype calculation from ten parameters.

The Heath-Carter method for appraising human body somatotype was used instead of BMI because BMI does not distinguish between lean and fat mass, which is particularly relevant for mesomorphic body fat and it expresses an individual's body physique as a three-digit rating, namely: endomorphy, mesomorphy and ectomorphy [22]. All anthropometric measurements were collected in accordance with WHO and International Standards for Anthropometry Assessment and Kinanthropometry, ISAK and each anthropometric parameter was measured three times by the researcher, and the meaning of the values were used for the analysis [44].

The somatotype rating was derived from a standard set of 10 essential parameters of anthropometric measurements namely; height, weight, four skinfolds, two bone breadths and two limb girths [22]. Height was measured as described earlier and recorded in centimeters. Weight was measured as described earlier and recorded in kilograms. Triceps skinfold, the vertical fold on the back of the arm was measured at the midpoint between the acromion and olecranon process and recorded in millimeters. Subscapular skinfold, a diagonal fold at the inferior angle of the scapula was measured and recorded in millimeters. Supraspinale skinfold, a diagonal fold located at a 45-degree angle above the iliac spine was measured and recorded in millimeters. Medial calf skinfold, a vertical fold on the medial side of the calf muscle at the level of its maximal girth was measured and recorded in millimeters. Humerus breadth, width between the medial and lateral epicondyles of the humerus was measured and recorded in centimeters. Femur breath, width between the medial and lateral epicondyles of the femur, was measured and recorded in centimeters. Flexed biceps girth, the circumference of the upper arm, was measured at the maximum point and recorded in centimeters. Maximal calf girth, the circumference of the calf at the level of its maximum girth was measured and recorded in centimeters.

There are many software Apps which can calculate body somatotype; however, the three somatotype components were calculated by the researcher using a series of mathematical formulas, which provided a precise, objective rating. While the original method utilized rating forms and tables, modern practice which the researcher adopted relies on explicit formulas for greater efficiency and accuracy.

Endomorphy: $E = -0.7182 + 0.1451 \times \sum SF - 0.00068 \times \sum SF^2 + 0.0000014 \times \sum SF^3$

Where $\sum SF$ = (triceps + subscapula + supraspinale skinfolds) x (170.18/height in cm).

This sum is corrected for the subject's height by multiplying it by the ratio of a standard height (170.18 cm) to the subject's measured height. While traditional rating forms used tables to convert the height-corrected sum into a score, the modern approach uses a polynomial regression formula to derive the endomorphy rating.

Mesomorphy: M = 0.858(Humerus) +0.601 (Femur) + 0.188 (corrected biceps) + 0.161 (corrected calf) – 0.131 (height) + 4.5.

Ectomorphy

Height / cube root of weight = Height : Weight (HWR).

If HWR >_ 40.75: Ectomorphy = 0.732 x HWR – 28.58

If HWR < 40.75 and > 38.25: Ectomorphy = 0.463 x HWR - 17.63

If HWR <_ 38. 25: Ectomorphy = 0.1

Individual somatotypes can be plotted as somatoplots on a 2-D somatochartbusing X,Y coordinates and component ratings.

X = Ectomorphy – Endomorphy

Y – 2(Mesomorphy) – Endomorphy + Ectomorphy).

Somatotype Scales

½ - $2_{1/2}$ = Low

3- 5 = Moderate

$5_{1/2}$ - 7 = High

$7_{1/2}$ and above = extremely high (Carter and Heath, 1990).

Data analysis

Microsoft Excel data sheet was used to record the data which include the subject age, gender, weight, height, BMI, Carter and Heath 10 somatype parameters, systolic blood pressure, diastolic blood pressure, CTR and ECHO measurements. Data were analyzed using SPSS version 20 (IBM corps, 2015). Summary of the data for cardiac size measurements included: mean, standard deviation, median and range. Participants were categorized based on dominant body somatotypes obtained using Heath and Carter[22] method of somatotyping. Inferential statistics such as ANOVA to ascertain the needed results and the level of statistical significance was set at $p < 0.05$.

RESULTS

Table 1 summarizes the descriptive statistics for cardiac measurements across the three dominant body somatotypes. Interventricular septal thickness in diastole (IVSd) was similar across groups, with mean values of 8.91 ± 1.51 mm in ectomorphs, 9.07 ± 1.51 mm in endomorphs, and 8.73 ± 1.19 mm in mesomorphs. A comparable pattern was observed for interventricular septal thickness in systole (IVSs), with endomorphs demonstrating slightly higher values (10.13 ± 1.41 mm) compared with ectomorphs (9.93 ± 1.32 mm) and mesomorphs (9.85 ± 1.02 mm). Left ventricular internal diameter in diastole (LVIDd) was largest in ectomorphs (45.13 ± 3.71 mm), followed by endomorphs (44.26 ± 4.72 mm) and mesomorphs (43.80 ± 4.35 mm). A similar trend was noted for left ventricular internal diameter in systole (LVIDs), with ectomorphs exhibiting a mean of 33.00 ± 3.29 mm, endomorphs 32.80 ± 5.49 mm, and mesomorphs 32.59 ± 4.02 mm. Posterior wall thickness in diastole (LVPWDd) showed minimal differences among somatotypes, with mean values of 9.73 ± 1.22 mm in ectomorphs, 9.69 ± 1.39 mm in endomorphs, and 9.56 ± 1.19 mm in mesomorphs. In systole (LVPWDs), endomorphs demonstrated slightly higher values (10.56 ± 1.01 mm) compared with ectomorphs (10.50 ± 1.28 mm) and mesomorphs (10.16 ± 1.21 mm). Right ventricular diameter in diastole (RVDd) was highest among endomorphs (24.77 ± 0.98 mm), followed by mesomorphs (24.10 ± 1.56 mm), and lowest in ectomorphs (23.01 ± 1.79 mm). Left ventricular mass was greatest in ectomorphs (140.66 ± 28.99 g), slightly lower in endomorphs (137.61 ± 32.42 g), and lowest in mesomorphs (131.26 ± 30.33 g). Left Ventricular Mass Index (LVMI) was greater in mesomorphs (82.82±18.48), slightly lower in ectomorphs (72.73±1.11), and lowest in endomorphs (69.16±16.49). Relative wall thickness values were comparable across somatotypes, with means of 0.43 ± 0.06 in ectomorphs, 0.44 ± 0.08 in endomorphs, and 0.44 ± 0.05 in mesomorphs. Cardiothoracic ratio values were marginally higher in ectomorphs (0.47 ± 0.01) and endomorphs (0.47 ± 0.013) compared with mesomorphs (0.46 ± 0.00)(Table 4.1).

To compare cardiac dimensions across the three dominant body somatotypes, using both chest radiography and echocardiography.

One-way ANOVAs were conducted in table 2 to examine the differences in cardiac dimensions across mesomorph, endomorph, and ectomorph somatotypes. Results indicated significant differences for right ventricular diameter in diastole (RVDd), $F(2, 207) = 24.89$, $p < .001$, left ventricular mass index (LVMI), $F(2, 207) = 12.95$, $p < .001$ and cardiothoracic ratio (CTR), $F(2, 207) = 9.85$, $p < .001$. No significant differences were found among somatotypes for interventricular septal thickness in diastole (IVSd) or systole (IVSs), left ventricular internal diameters in diastole (LVIDd) or systole (LVIDs), posterior wall thickness in diastole (LVPWDd) or systole (LVPWDs), left ventricular mass (LV Mass), or relative wall thickness (RWT), all $p > .05$

DISCUSSIONS

Interventricular septal thickness in diastole (IVSd) was similar across groups, with endomorphs demonstrating slightly higher mean values. A comparable pattern was observed for interventricular septal thickness in systole (IVSs), with endomorphs also demonstrating slightly higher values compared with ectomorphs and mesomorphs. Left ventricular internal diameter in diastole (LVIDd) was largest in ectomorphs when compared with endomorphs and mesomorphs. A similar trend was noted for left ventricular internal diameter in systole (LVIDs), with ectomorphs exhibiting a mean value slightly higher than that of endomorphs and mesomorphs. Posterior wall thickness in diastole (LVPWDd) showed minimal differences among somatotypes, with mean values of slightly higher in ectomorphs than in endomorphs, and mesomorphs, repectively. In systole (LVPWDs), endomorphs demonstrated slightly higher values compared with ectomorphs and mesomorphs. Right ventricular diameter in diastole (RVDd) was highest among endomorphs than in mesomorphs and ectomorphs. Left ventricular mass was greatest in ectomorphs, slightly lower in endomorphs, and lowest in mesomorphs. Left Ventricular Mass Index (LVMI) was greater in mesomorphs, slightly lower in ectomorphs, and lowest in endomorphs. Relative wall thickness values were comparable across somatotypes, with means in ectomorphs, in endomorphs, and in mesomorphs. Cardiothoracic ratio values were marginally higher in ectomorphs and endomorphs compared with mesomorphs. These findings shows that the different parameters measured vary from one somatotype to another. This finding is in agreement with the findings of the studies conducted by Addetia *et al* [1], Bigdehu *et al* [8], Ibrahim *et al*[18], Khan and Qama [45]. In Bigdelu *et al* [45] study, which was conducted to evalaute impact of obesity on echocardiographic parameters in individuals free of CVD using anthropometric measurements and aimed to understand the effects of obesity on cardiac structure and function in the absence of other confounding comorbid conditions among 196 participants, reported that in obese (endomorph) adults without cardiovascular conditions, there is significant variation in cardiac structure, diastolic and systolic functions. The anthropometric features and BMI is the most frequently correlated with abnormalities however BSA is the strongest parameter to predict abnormality. BMI >_ 25kg/m^2 was associated with enlargement in left atrial dimensions, increase in LVEDD, LVESD, LVM, Ejection mitral inflow velocity, Systolic mitral velocity and left ventricular diastolic pressures. The findings support that BMI and BSA are better than other anthropometric measurements in predicting remodeling and change of cardiac function. The main limitation of the study is the small sample size from a single institution. According to Addetia *et al*[1], in their study, which assess the normal values of 3D right ventricular size and function measurements: results of the world alliance of societies of echocardiography study, is aimed to assess the worldwide capability of three- dimensional (3D) imaging and the measurements of the right ventricle, size, function, including their dependency on age, sex and ethnicity. The researchers used sample size of 1,051, aged 18 years and above in apparently healthy subjects in 19 centers in 15 countries, representing six continents and the normal values for 3D RV volume, EF were determined. For male: End-diastolic volume (EDV) and BSA are 48 and 95 ml/m^2, End-systolic volume (ESV) and BSA are 19 and 43 ml/m^2, Ejection fraction (EF) is 44% and 58%. For female: EDV and BSA are 42 and 81 ml/m^2, ESV and BSA are 16 and 36 ml/m^2, EF is 46% and 61% and 3D RV. The study established that men have larger EDV, ESV and SV even after indexing with BSA and RV volumes are smallest in Indians. The study noted that reliability of 3D RV acquisition is low worldwide underscoring the importance of future improvement in imaging technique and recommended that sex and race must be taken into consideration in the assessment of RV volume and EF. Ibrahim *et al* [18], in a study about the prevalence and significance of T-wave inversion on the electrocardiogram of patients with marfan syndrome is a prospective study with a sample size of 116 patients' which were age 18 years and above, it aimed to provide valuable insights into the relationship between body habitus and electrocardiographic (ECG) abnormalities in patients with Marfan syndrome (MFS) in Europe. It characterized the ECG in adult Marfan patients fulfilling the Ghent criteria and assessed the relationship between ECG abnormalities, body habitus, chest, and back deformities. The study shows that a positive left ventricular hypertrophy (LVH) criteria and vertical QRS axis were more common in patients who were younger, taller and with lower BMI. Pathological T wave inversion (TWI) was present in almost a fifth of MFS patients and patients with pectus excavatum were more likely to have anterior TWI. The study emphasizes the need for clinicians to consider body habitus, chest wall asymmetry when interpreting ECG and echocardiographic results. Understanding these associations can lead to more accurate diagnoses with tailored treatment plans for patients with Marfan syndrome. This research contributes to a more nuanced approach to cardiac imaging, taking into account the physical characteristics of the individual although the sample population was Caucasians. Khan and Qama[45], Titled a morphological study comparing heart size measurement on chest radiograph with echocardiography in a local population is aimed to compare heart size measurements on chest radiograph and echocardiography in Karachi, Pakistan. It is a cross-sectional study with 79 participants who underwent both chest radiography and echocardiography. Heart size was measured on chest radiographs using the cardiothoracic ratio (CTR) and on 2-dimensional transthoracic echocardiography. The measurements were compared to assess the correlation and agreement between the two modalities. The study found a moderate correlation between CTR on chest radiographs and LVEDD on echocardiography ($r = 0.65$, $p < 0.001$). The study highlights the limitations of using chest radiography alone for assessing heart size. The specificity and sensitivity of chest radiograph were 54.35% and 90.90%, respectively. The positive and negative predictive values were 89.28% and 58.82% respectively. The accuracy of chest radiograph in identifying an enlarged heart was 69.62% and it shows that the cardiac silhouette on a chest radiograph could demonstrate heart size through simple measurements with high specificity and reasonable accuracy. However, a normal size on chest radiograph may not have a normal function. The study demonstrated the importance of using echocardiography as a reference standard for diagnosing and managing cardiovascular diseases.

CONCLUSION

Interventricular septal thickness in diastole (IVSd) was similar across groups, with endomorphs demonstrating slightly higher mean values. A comparable pattern was observed for interventricular septal thickness in systole (IVSs), with endomorphs also demonstrating slightly higher values compared with ectomorphs and mesomorphs.

Cardiac dimensions across mesomorph, endomorph, and ectomorph somatotypes indicates significant differences for right ventricular diameter in diastole (RVDd), left ventricular mass index (LVMI), and cardiothoracic ratio (CTR). No significant differences were found among somatotypes for interventricular septal thickness in diastole (IVSd) or systole (IVSds), left ventricular internal diameters in diastole (LVIDd) or systole (LVIDs), posterior wall thickness in diastole (LVPWDd) or systole (LVPWDs), left ventricular mass (LV Mass), or relative wall thickness (RWT). The measured variables were similar across the various somatotypes.

Conflict of interest: None declared among the authors

References

1. Addetia, K., Miyoshi, T., Amuthan, V., Citro, R., Daimon, M., Fajardo, G., ... & Badano, L. P. (2023). Normal values of 3D right ventricular size and function measurements: Results of the World Alliance of Societies of Echocardiography study. *Journal of the American Society of Echocardiography*, *36*(7), 716–728. https://doi.org/10.1016/j.echo.2023.04.011

2. Moghadam, R. N., Aryan, N., Mina, S., Nasim, N., Mohammad, H., Ahmadia, Y., Mohammad, S. A., & Seid, K. R. (2021). *Comparing cardiac CT angiography and MR angiography in evaluating left ventricular function and volumes*. Semantics Scholar.https://pdfs.semanticscholar.org/f1e7/2376f8e0b7cb5f71c1cb334e87fedb99610f.pdf

3. Simkus, P., Gutierrez Gimeno, M., Banisauskaite, A., Noreikaite, J., McCreavy, D., Penha, D., & Arzanauskaite, M. (2021). Limitations of cardiothoracic ratio derived from chest radiographs to predict real heart size: Comparison with magnetic resonance imaging. *Insights into Imaging*, *12*(1), 158. https://doi.org/10.1186/s13244-021-01097-0

4. Surkova, E., Muraru, D., Iliceto, S., & Badano, L. P. (2016). The use of multimodality cardiovascular imaging to assess right ventricular size and function. *International Journal of Cardiology*, *214*, 54–69. https://doi.org/10.1016/j.ijcard.2016.03.074

5. Singh, M., Sethi, A., Mishra, A., Subrayappa, N., Stapleton, D., & Pellikka, P. (2020). Echocardiographic imaging challenges in obesity: Guideline recommendations and limitations of adjusting to body size. *Journal of the American Heart Association*, *9*(5), e014609. https://doi.org/10.1161/JAHA.119.014609

6. Saad, M., Zaidi, S., Bhandari, M., Bella, J., & Vittorio, T. (2019). Reliability of cardiac percussion technique to determine left ventricular size in comparison with cardiothoracic ratio and transthoracic echocardiography. *Journal of Cardiac Failure*, *25*(8), S116. https://doi.org/10.1016/j.cardfail.2019.07.106

7. Klem, I., Heiberg, E., Van Assche, L., Parker, M., Kim, H. W., Grizzard, J. D., Arheden, H., & Kim, R. J. (2017). Sources of variability in quantification of cardiovascular magnetic resonance infarct size: Reproducibility among three core laboratories. *Journal of Cardiovascular Magnetic Resonance*, *19*(1), 62. https://doi.org/10.1186/s12968-017-0378-y

8. Bigdelu, L., Talab, S. M. M., Shah, M. U., Niknafs, P., Rezaiyan, M. K., & Naqvi, S. Y. (2024). Impact of obesity on echocardiographic parameters in individuals free

of CVD using anthropometric measurements. *British Journal of Cardiology*, *31*, 115. https://doi.org/10.5837/bjc.2024.035

9. Anibor, E., Ahama, E., & Ezeife, C. (2023). *Radiographic determination of cardiothoracic ratio and cardiac size in the Ijaw ethnic group of Nigeria*. ResearchGate. https://www.researchgate.net
10. Ominde, B. S., Enakpoya, S., Ikubor, J., & Ovovwero, O. (2023). Assessment of the cardiothoracic ratio and its association with gender and age: A Nigerian study. *Galician International Journal of Special Research*. https://doi.org/10.52403/gijsr.20230204
11. Ugwuanyi, D., Eze, C., Nwagbara, C. T., Chiegwu, H., Eze, J. C., & Ogolodon, M. (2021). Echocardiographic evaluation of normal adult left ventricular geometry in a Nigerian population. *Health Science Journal*, *15*(1), 782. https://doi.org/10.36648/1791-809X.15.1.782
12. Gaillard, F., Sharma, R., & Bell, D. (2020). *Cardiothoracic ratio*. Radiopaedia.org. https://doi.org/10.53347/rID-15283
13. Monfared, A., Farajollah, S., Sabour, F., Farzanegan, R., & Taghdisi, S. (2015). Comparison of radiological findings of chest X-ray with echocardiography in determination of the heart size. *Iranian Red Crescent Medical Journal*, *17*(10), e18242. https://doi.org/10.5812/ircmj.18242
14. Kou, S., Caballero, L., Dulgheru, R., Voilliot, D., De Sousa, C., Kacharava, G., ... & Lancellotti, P. (2014). Echocardiographic reference ranges for normal cardiac chamber size: Results from the NORRE study. *European Heart Journal – Cardiovascular Imaging*, *15*(6), 680–690. https://doi.org/10.1093/ehjci/jet284
15. Gwaba, N., Isaacs, F., & Harneck, M. (2018). Echocardiography in patients with chest X-ray diagnosis of cardiomegaly at an academic hospital in Zambia. *Medical Journal of Zambia*, *45*(4), 196–202.
16. Rahayu, A., Murtala, B., Asriyani, S., Zainuddin, A. A., Muzakkir, & Latief, N. (2019). *Comparison of cardiac size in posteroanterior chest X-ray and echocardiography*. Semantics Scholar. https://www.semanticscholar.org

17. Kapoor, A. K., Dhall, M., Tungdim, M. D., & Kapoor, S. (2024). *Anthropology: Human growth and development*. e-PG Pathshala. https://epgp.inflibnet.ac.in/

18. Ibrahim, B., Poveda, P., Kasiakogias, A., Tojalsi, L., De Frutos, F., Potterton, A., & Tome, M. (2023). Electrocardiographic abnormalities of adult patients with Marfan syndrome and their associations with body habitus and chest wall asymmetry. *European Journal of Preventive Cardiology*, *30*(Supplement_1). https://doi.org/10.1093/eurjpc/zwad125.176

19. Kathirgamam, V., Ambike, M., Bokan, R., Bharambe, V., & Prasad, A. (2020). Analyzing the effects of exercise prescribed based on health-related fitness assessment among different somatotypes. *Journal of Health Sciences*, *10*(1), 83–89. https://doi.org/10.17532/jhsci.2020.876

20. Ajayi, A., Edjomariegwe, O., Abraham, K., & Ibeabuchi, N. M. (2016). Somatotype of undergraduate medical students of the University of Lagos. *Journal of Applied Life Sciences International*, *8*(1), 1–8. https://doi.org/10.9734/JALSI/2016/20022

21. Ibikunle, P. O. (2014, February 7). *Influence of dominant body somatotype and sex difference on Q-angle and some selected skeletal measures of young adults in South-Eastern Nigeria* [Paper presentation]. World Physiotherapy Africa Region Biennial Conference, Lusaka, Zambia.

22. Carter, J. E. L., & Heath, B. H. (1990). *Somatotyping: Development and applications*. Cambridge University Press.

23. Gurarie, M. (2024, December 14). *What your body type means for your health*. Health.com. https://www.health.com/body-type-8699069

24. Lokhandwala, D., Hacking, C., & Milton, B. (2024, October 19). *Body habitus*. Radiopaedia.org. https://doi.org/10.53347/rID-159684

25. Bernard, T. J., Chauhan, Y., Duignan, B., & Nirala, S. (2020). *William Sheldon: American psychologist*. Encyclopedia Britannica. https://www.britannica.com/biography/William-Sheldon

26. Ogoke, A., Ugwu, A., Ugwuanyi, D., Ohagwu, C., & Ogolodom, M. (2020). The impact of body habitus and body mass index on rotation in chest radiographs. *Health Science Journal*, *14*(7). https://doi.org/10.366248/1989-5216.12.1.303

27. World Health Organization. (2025, July 31). *Cardiovascular diseases (CVDs)*. https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds

28. World Population Review. (2025). *Nnewi population 2025*. https://worldpopulationreview.com/cities/nigeria/nnewi

29. Nnamdi Azikiwe University. (2026). *Living in Awka*. https://unizik.edu.ng/schools/postgraduate-studies-in-awka

30. Kose, O., & Aslan, A. (2025). The importance of sample size calculation and power analysis in research studies. *Acta Medica Alanya*, *9*(6), 162–164. https://doi.org/10.30565/medalanya.1850488

31. Tajik, O., Golzar, J., & Noor, S. (2024). Purposive sampling. *International Journal of Education and Language Studies*, *2*(2), 1–9. https://doi.org/10.22034/ijels.2025

32. Sutherland, R., Bown, G., & Graham, D. (2003). *Pocketbook of radiographic positioning* (2nd ed.). Churchill Livingstone.

33. Ahmad, N. (2001). *Good positioning is key to PA chest X-ray exams*. AuntMinnie.com. https://www.auntminnie.com

34. Whitley, A. S., Sloane, C., Hoadley, G., Moore, A. D., & Alsop, W. C. (2005). *Clark's positioning in radiography* (12th ed.). Arnold.

35. Oladipo, G. S., Okoh, P. D., Kelly, E. I., Arimie, G. O. D., & Leko, B. J. (2012). Normal heart sizes of Nigerians within Rivers State using cardiothoracic ratio. *International Journal of Biomedical and Health Sciences*, *8*(2). https://www.ajol.info/index.php/article/view/15689

36. Hardy, M., Scotland, B., & Herron, L. (2015). Assessing sagittal rotation on posteroanterior chest radiographs: The effect of body morphology on radiographic appearances. *Journal of Medical Imaging and Radiation Sciences*, *46*(3), 365–371. https://doi.org/10.1016/j.jmir.2015.06.002

37. World Health Organization. (2008). *Waist circumference and waist–hip ratio: Report of a WHO expert consultation*. WHO Press. https://www.who.int/publications/i/item/9789241501491

38. El Missiri, A. M., El Meniawy, K. A., Sakr, S. A., & Mohamed, A. S. (2016). Normal reference values of echocardiographic measurements in young Egyptian adults. *The Egyptian Heart Journal*, *68*(4), 209–215. https://doi.org/10.1016/j.ehj.2016.05.001

39. Lancellotti, P., Badano, L. P., Lang, R. M., Akhaladze, N., Athanassopoulos, G. D., Barone, D., ... & Maurer, G. (2013). Normal reference ranges for echocardiography: Rationale, study design, and methodology (NORRE study). *European Heart Journal – Cardiovascular Imaging*, *14*(4), 303–308. https://doi.org/10.1093/ehjci/jet008

40. Lang, R. M., Badano, L. P., Mor-Avi, V., Afilalo, J., Armstrong, A., Ernande, L., ... & Voigt, J. U. (2015). Recommendations for cardiac chamber quantification by echocardiography in adults: An update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. *Journal of the American Society of Echocardiography*, *28*(1), 1–39. https://doi.org/10.1016/j.echo.2014.10.003

41. Animasahun, B. A., Madise-Wobo, A. D., Ogunkunle, O. O., Gbelee, O. H., & Oke, D. A. (2015). A descriptive study about dilated cardiomyopathy in children in tertiary hospital in Nigeria. *Journal of Clinical & Experimental Cardiology*, *6*(2), 102.

42. Zoghbi, W. A., Adams, D., Enriquez-Sarano, M., Foster, E., Grayburn, P. A., ... & Ward, R. P. (2017). Recommendations for noninvasive evaluation of native valvular regurgitation: A report from the American Society of Echocardiography. *Journal of the American Society of Echocardiography*, *30*(4), 303–371. https://doi.org/10.1016/j.echo.2017.01.007

43. Bansal, M., Mohan, J. C., & Sengupta, S. P. (2016). Normal echocardiographic measurements in Indian adults: How different are we from the Western

populations? A pilot study. *Indian Heart Journal*, *68*(6), 772–775. https://doi.org/10.1016/j.ihj.2016.04.015

44. Ondrejova, B., Bednarcikova, L., Ferenick, N., & Zivcak, J. (2025). Validation of automated somatotype estimation proposal using full-body 3D scanning. *Bioengineering*, *12*(7), 717. https://doi.org/10.3390/bioengineering12070717

45. Khan, A. A., & Qamar, A. (2023). A morphological study comparing heart size measurement on chest radiograph with echocardiography in local population. *Journal of the Pakistan Medical Association*, *73*(2), 302–306. https://doi.org/10.47391/JPMA.5594

Table 1 Descriptive Statistics of Cardiac Measurements by Dominant Body Somatotypes

1.1 **Variables**	Ectomorph (N=70) Mean±SD	Endomorph (N=70) Mean±SD	Mesomorph (N=70) Mean±SD
IVSd(mm)	8.91±1.51	9.07±1.51	8.73±1.19
IVSs(mm)	9.93±1.32	10.13±1.41	9.85±1.02
LVIDd(mm)	45.13±3.71	44.26±4.72	43.80±4.35
LVIDs(mm)	33.00±3.29	32.80±5.49	32.59±4.02
LVPWDd (mm)	9.73±1.22	9.69±1.39	9.56±1.19
LVPWDs (mm)	10.50±1.28	10.56±1.01	10.16±1.21
RVDd (mm)	23.01±1.79	24.77±0.98	24.10±1.56
LVMass (g)	140.66±28.99	137.61±32.42	131.26±30.33
LVMI(g/m^2)	72.73±14.11	69.17±16.49	82.82±18.48
RWT	0.43±0.06	0.44±0.081	0.44±0.05
CTR	0.47±0.01	0.47±0.01	0.46±0.01

Table 2 One-Way ANOVA comparing for Cardiac Dimensions by Dominant Body Somatotype

Variables	df (within)	F	*p-value*
IVSd (mm)	207	1.03	.36
IVSs (mm)	207	0.89	.41
LVIDd (mm)	207	1.74	.18
LVIDs (mm)	207	0.16	.85
LVPWDd (mm)	207	0.34	.71
LVPWDs (mm)	207	2.37	.09
RVDd (mm)	207	24.89	< .001
LV Mass (g)	207	1.73	.18
LVMI(g/m^2)	207	12.95	< .001
RWT	207	0.44	.64
CTR	207	9.85	< .001