Cardiothoracic Ratio (CTR) of Normal Newly Enrolled Undergraduate Students Of University of Jos, North Central Nigeria Using Plain Chest Radiographs

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Abstract
Results of previous research studies have presented racial difference as a function of body size. Several literatures on racial variation of heart sizes also abound. This research was aimed at determining a more accurate relationship to calculate cardiothoracic ratio (CTR) and assessing its relation to the age, height, weight and Body Mass Index (BMI) of normal newly enrolled undergraduate students of University of Jos. A total of 80, standard postero-anterior chest radiographs of normal young Nigerian students (40 males and 40 females) of ages 16 – 24 years in University of Jos Health Centre were viewed. From the chest radiographs, the cardiac diameter (CD) was measured at the widest point of the cardiac silhouette. The thoracic diameter (TD) was taken at the costophrenic insertion of the diaphragm. Using these data, the cardiothoracic ratio (CTR) was computed. Body mass index was also calculated while CTR was determined by dividing the CD by the TD. Degree of correlation was assessed for all the study parameters and analysis was made for regression and correlation coefficients using IBM SPSS statistical package version 21.The mean age of the study group was found to be 19.2±2.2 years. The average cardiothoracic ratio (CTR) for the studied group was 0. 46 ± 0.03, mean cardiac diameter (CD) was found to be 12.23 ± 1.06 cm and mean value of the Thoracic diameter (TD) was found to be 26.54 ± 2.04cm.The mean Body Mass Index (BMI), mean height and mean weight of the studied group were found to be 22.65 ± 3.87kgm-^{2}, 166.82±7.71cm and 62.99±11.43kg respectively. The Cardio-Thoracic Ratio (CTR) was found to correlate significantly only with CD with correlation coefficient, r = 0.488 at (P< 0.01).

Keywords*: Cardiothoracic ratio (CTR), Cardiac diameter (CD), Thoracic diameter (TD) and Body Mass Index (BMI)*

1. Introduction

Interest is growing in the value of the cardiothoracic ratio (CTR) in clinical evaluation of patients and the factors that influence its relevance. The ratio of the transverse cardiac diameter (the horizontal distance between most rightward and leftward borders of the heart as seen on a Postero -Anterior (PA) Chest radiograph) to the transverse chest diameter (measured from the inside rib margin at the widest point above the costophrenic angles on a PA chest film) is today commonly referred to as the cardiothoracic ratio (CTR) [1]. It is a useful screening method to detect cardiomegaly which is the enlargement of the heart.

This ratio has over time stood out as the simplest and most common way of ascertaining the abnormal heart size from the chest radiograph. Ability to measure the heart size has provided very objective means for clinical investigations, serial evaluation and population studies of cardiac size, despite known limitations [2]. Easy availability, affordability and simple nature of chest radiographs in assessing cardiac size have made it the most common method despite other advanced imaging techniques such computed tomography (CT- Scan), magnetic resonance imaging (MRI), echocardiography, angiography etc [3,4].

Cardiac enlargement may give the first indi-

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cation of some of the cardiac diseases in man like hypertensive heart disease, rheumatic heart disease, coronary heart disease, inflammatory heart disease, ischemic heart disease and stroke etc. In rural areas where advanced investigating tools are not available or beyond the reach of common man, the cardiac enlargement can be evaluated by routine chest radiographs by the cardio-thoracic ratio (CTR). Clinicians continued to use this useful screening method to detect cardiac size where a quick decision is required under urgent situations, especially in the emergency departments (EDs) or intensive care units (ICUs). An enlarged heart may or may not be indicative of underlying cardiac disease; In other words a normal sized heart does not guarantee the absence of cardiac disease. But still an enlarged heart may give the first hint of underlying cardiac disease in routine Chest X-radiographs.

With the current high cost of advanced medical imaging modalities, the poverty level in our society, complexity and unavailability of the modern imaging equipment in rural areas that will not let patients with suspected cardiac problems have an assessment of their cardiac status, it is more economical to have assessment of the cardiac status on one or two film projections to establish preliminary assessment of cardiovascular diseases. The standard erect Postero-Anterior (PA) films that are the most common view done routinely for those who come for medical consultations in any hospital can be used to determine the cardiothoracic ratio (CTR). Cardiac diseases are common, and have high morbidity and mortality rates and as such we need some reliable index in monitoring the heart as quickly as possible, as cheaply as possible and as reproducible as possible for prompt and early intervention despite the hazards of ionizing radiation in the management of cardiac patients. Establishing normal parameters in order to facilitate an early and firm diagnosis of the heart diseases among Nigerian population will be an asset. A question which easily comes to mind is 'Are these values of cardiac indices influenced by other body parameters like age, height, weight, and Body Mass Index (BMI) in normal young adults?' From this values the study can come into inference that out of CD,TD, and CTR which one is least affected by the variations of the different values of body parameters. This is what work sets out to address.

2. Materials and Methods

The materials used for the research include:
Mobile X-ray machine, Plain chest X-ray radiographs (PA view), X-ray viewing box, Weighing scale, a wall height chart, a measuring tape, a transparent rule, Pencil and Eraser.

In this study a total of eighty (80) standard Postero- Anterior (PA) chest radiographs taken from newly enrolled undergraduate students (40males and 40 females) that had Chest X-ray (CXRs) for the purpose of medical examinations into the University of Jos were obtained and viewed using a X-ray viewing box. The age range was within 16 – 24 years. Measurements of the cardiac parameters were taken on the radiographs using a transparent ruler.

Two sets of reading were taken:
Cardiac diameter (CD): This was measured as the distance between the two tangents to the cardiac silhouette at its most lateral points on the right and the left, drawn parallel to the mid‑saggital plane (i.e. the horizontal distance between the most rightward and leftward borders of the heart, measured out from the chest radiograph was used as the transverse diameter of the heart [Figure 1].
Thoracic diameter (TD): This was measured on the line passing through the costophrenic insertions of the diaphragm on both sides of the thorax. The distance is from one costophrenic insertion to the other costophrenic insertion (i.e. the horizontal distance inside the rib at the widest point above the costophrenic angles, measured from the chest radiograph was used as the transverse chest diameter) [Figure 1].

From these two cardiac parameters the cardiothoracic ratio (CTR) was calculated using the formula:
Cardiothoracic ratio (CTR) = (Cardiac Diameter (cm)) / (Thoracic Diameter (cm))- - (1)

The subject's heights and weights were measured using a weighing scale and a wall height chart respectively. Weight was recorded in kilo

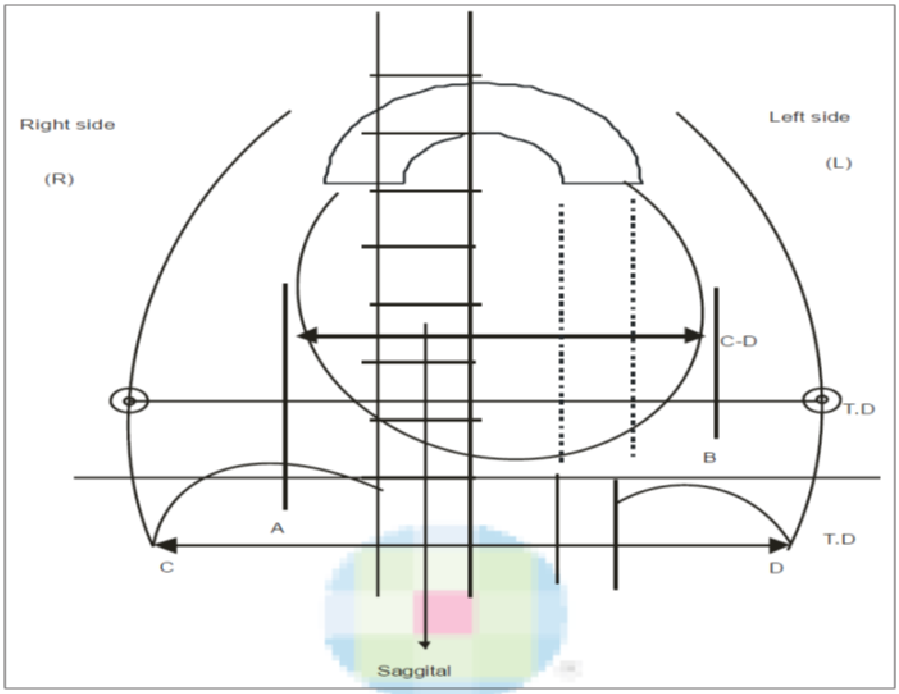

Figure1 : A schematic representation of the chest showing the different measurements done on the chest and the points from which measurements were done (a) Tangent to the cardiac silhouette at the most lateral part on the right (R) side of the heart shadow. (b) Tangent to the cardiac silhouette at the most lateral part on the left (L) side of the heart shadow. (c) Right costophrenic insertion of the diaphragm (d) Left costophrenic insertion of the diaphragm. (Ekedigwe et al.,2014).

Table 1: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
AGE	80	16.00	24.00	19.563	2.146
HEIGHT	80	150.50	185.00	166.815	7.708
WEIGHT	80	42.00	109.00	62.994	11.431
BMI	80	16.26	38.62	22.645	3.865
CD	80	10.00	15.20	12.230	1.058
TD	80	22.30	31.80	26.543	2.037
CTR	80	.40	.50	.460	.026
Valid N (listwise)	80				

grams (kg) with subjects in light clothing and height was read off on the wall chart in centimeters (cm). The subjects body mass indices (BMI) were calculated using the formula:

$BMI = (Weight\ (kg))/(Height^2\ (m^2))\ (kg.m^{-2})$ - (2)

This study was performed only on subjects that had Chest X-ray (CXRs) for the purpose of medical examinations into the University of Jos. Subjects whose CXRs were not well positioned were excluded. Such rejected radiographs were those that showed any of the following:

- Thoracic wall deformity
- Inadequate inspiration
- Over expanded chest
- Inability to determine one or both heart borders with confidence and
- Significant rotations.

Statistical Method

Using IBM Statistical Package for Social Sciences (SPSS) version 22 software, the following analyses were carried out.

- Means and standard deviations, i.e. descriptive statistics of all the study parameters.
- Pearson correlation coefficients among all the study parameters.
- Regression lines of best fit between Cardiac Diameter (CD) and Cardio-Thoracic Ratio (CTR).

3. Results

The descriptive statistics of the study parameters are given in table 1.

The correlation coefficients among the study parameters are given in table 2.

Table 2: Correlations coefficient

		AGE	*HEIGHT*	*WEIGHT*	*BMI*	*CD*	*TD*	*CTR*
AGE	Pearson Correlation	1	.065	.350**	.326**	.396**	.387**	.122
	Sig. (2-tailed)		.568	.001	.003	.000	.000	.282
	N	80	80	80	80	80	80	80
HEIGHT	Pearson Correlation	.065	1	.359**	-.151	.287**	.383**	-.066
	Sig. (2-tailed)	.568		.001	.180	.010	.000	.561
	N	80	80	80	80	80	80	80
WEIGHT	Pearson Correlation	.350**	.359**	1	.866**	.497**	.489**	.118
	Sig. (2-tailed)	.001	.001		.000	.000	.000	.298
	N	80	80	80	80	80	80	80
BMI	Pearson Correlation	326**	-.151	.866**	1	.359**	.307**	.147
	Sig. (2-tailed)	.003	.180	.000		.001	.006	.193
	N	80	80	80	80	80	80	80
CD	Pearson Correlation	.396**	.287**	.497**	.359**	1	.757**	488**
	Sig. (2-tailed)	.000	.010	.000	.001		.000	.000
	N	80	80	80	80	80	80	80
TD	Pearson Correlation	.387**	.383**	.489**	.307**	.757**	1	-.173
	Sig. (2-tailed)	.000	.000	.000	.006	.000		.125
	N	80	80	80	80	80	80	80
CTR	Pearson Correlation	.122	-.066	.118	.147	.488**	-.173	1
	Sig. (2-tailed)	.282	.561	.298	.193	.000	.125	
	N	80	80	80	80	80	80	80

**. Correlation is significant at the 0.01 level (2-tailed).

The coefficients of regression equation and the graph are shown in table 3 and figure 2 respectively.

4. Discussion

All together 80 newly enrolled students (40 males and 40 females) participated in this study. From the descriptive statistics, the mean values of age, height, weight, and Body Mass Index (BMI) were found to be 19.6±2.2 years, 166.82±7.71cm, 62.99±11.43kg

Table 3: Regression equation Coefficients

	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
CD	0.012	0.002	0.488	4.943	0.000
Constant	0.314	0.030		10.614	0.000

and 22.65±8.87kg/m2 respectively. The mean values of cardiac diameter (CD) and thoracic diameter (TD) of this study group were found to be 12.23±1.06cm and 26.54±2.04cm, while Cardio Thoracic Ratio (CTR) had a mean value of 0.46±0.03.

From the correlation analysis, it was found that the was significantly and positively correlated (P< 0.01) with weight, BMI, CD, and TD. However, in this study group age was not correlated significantly with the CTR but it had a weak positive relationship with age. The height and the weight both had significant positive correlations with CD and TD. However, weight was found to correlate stronger than height with both CD and TD in this group. Also, BMI had a significant positive correlation with both CD and TD. No study parameter was found to correlate significantly with CTR except CD. It was also discovered that a strong, significant and positive correlation existed between CD and TD (r =0.757, p < 0.01). Since BMI had a significant, positive correlation (r = 0.359, p < 0.01) with CD, this suggests that young adults who are overweight and obese may have larger cardiac diameters than the normal BMI category.

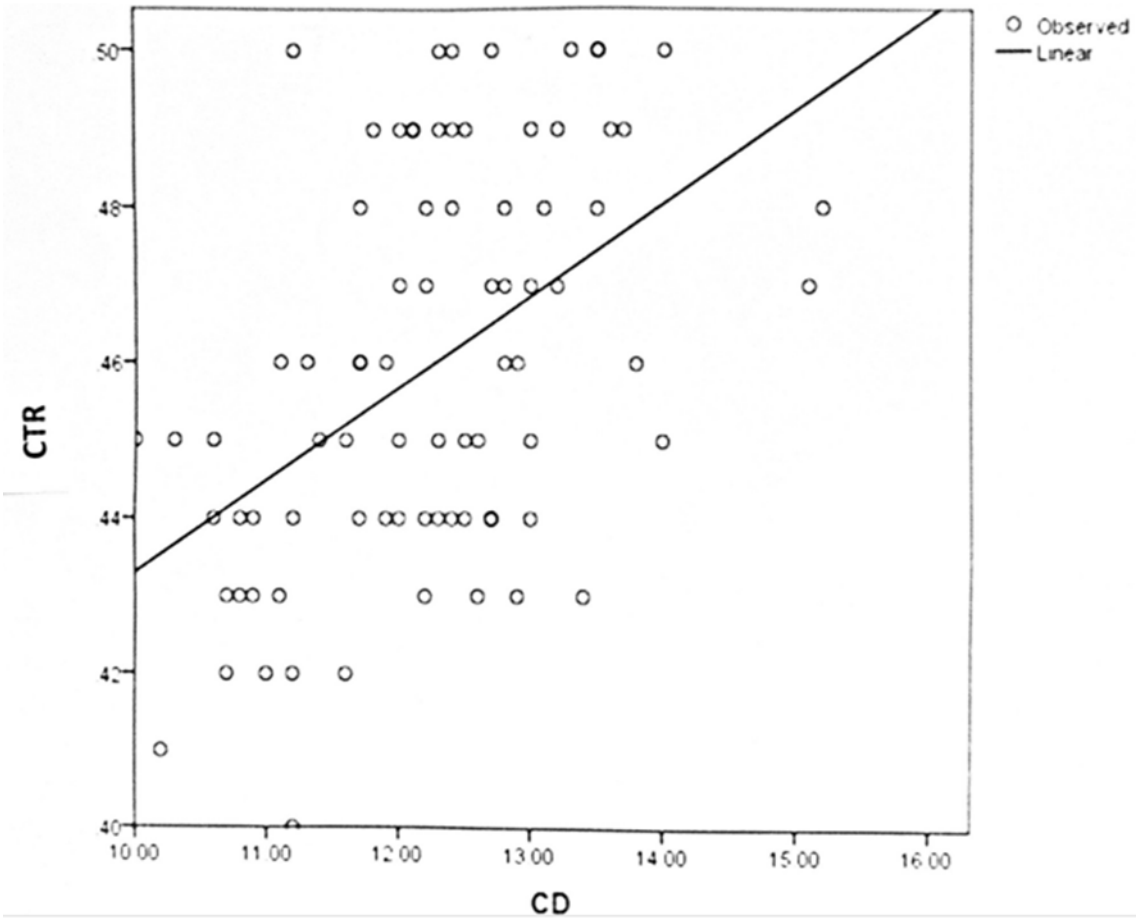

Figure 2: Regression lines of best fit between CTR and CD

From the linear regression equation between CTR and CD was found to be

$$CTR = 0.012(CD) + 0.314 \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The equation (3) above can be used for greater accuracy as a new relationship to compute the CTR for young adults in Nigeria substituting the CD measured from the chest radiographs instead of the general equation given in equation (1). TD showed weak negative correlation with CTR (r =0.173, p > 0.05) but CD showed a significant positive correlation with CTR (r = 0.488, p < 0.01).

The observation made by different researchers such as [1] on CTR and body habitus in Nigerian population, [3] on CTR and BMI in normal young adult Nigerians and [2] on correlation of CD and CTR with body habitus in Bankura district of West Bengal, India, revealed that CD has a better correlation over CTR when predicting heart size using various demographic and anthropometric indices such as age, height, weight, BMI and BSA. This means that CTR is least affected by body parameters. However, CD remains as the most accurate measurement in determining CTR in this study population. The mean CD of the present study was 12.23±1.06cm and the mean CTR was 0.46±0.03. This suggests that CD values exceeding 13.29cm may indicate heart enlargement and the CTR values exceeding 0.49 indicates cardiomegaly in young Nigerians.

5. Conclusion

The cardiothoracic ratio (CTR) main results of this study have conclusively established the CTR of normal, newly admitted undergraduate students of the University of Jos within the age range of 16 – 24 years. The CTR is positively correlated significantly only with CD. The study also revealed that CTR varies with age ranges when compared with other previously made observations. Care should be born in mind in setting up the normal reference values in predicting cardiac enlargement as CTR is least affected by the variations of the dimension of body built as mentioned above. So CTR is a better indicator in predicting cardiac enlargement than TD in routine chest X-radiographs for the computation of CTR. Therefore the relationship established in equation (3) is found to be more reliable than the relationship given in equation (1) for calculating CTR of young adult Nigerians such as newly admitted undergraduate students participated in this study. However, in this study, the age and BMI were not significantly correlated with CTR.

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