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DETERMINATION OF CARDIOTHORACIC RATIO (CTR) OF NORMAL FRESH UNDERGRADUATE STUDENTS OF UNIVERSITY OF JOS 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 the normal values of the cardiothoracic ratio (CTR) and assessing its relation to the age, height, weight and Body Mass Index (BMI) of normal fresh undergraduate students of University of Jos, Plateau state, Nigeria. A total of 80, standard postero- anterior chest radiographs taken from normal young Nigerians (40 males and 40 females) of ages 16 – 24 years in University of Jos Health Care Centre were viewed. From the chest radiographs, the cardiac diameter (CDs) 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 SPSS statistical package. The age range of all the subjects was from 16-24years with a mean age of 19.1900 ± 2.146) years. The average cardiothoracic ratio (CTR) for the whole group was 0. 460 ± 0.026, mean cardiac diameter (CD) was found to be 12.230 ± 1.058 cm and mean value of the Thoracic diameter (TD) was found to be 26.543 ± 2.037cm.The mean Body Mass Index (BMI) of the study group was found to be 22.645 ± 3.865kgm-^{2}, mean heights was found to be 166. 815 ± 7.708 cm and the mean weight was found to be 62.994 ± 11.431 kg. The CardioThoracic Ratio (CTR) was found to correlate significantly ONLY with CD with correlation coefficient factor r of 0.488** at (P< 0.01 level (2-tailed)).*

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

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) (Anyanwu et al 2007). It is a useful screening method to detect (cardiomegaly) enlargement of the heart. This ratio has over time stood out as the simplest and most common way of ascertaining the 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

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limitations (Obnerman et al, 1967). Easy availability, affordability and simple nature of these means of assessing cardiac size have made it the most common methods despite improved imaging technology like computed tomography (CT- Scan), magnetic resonance imaging (MRI), echocardiography, angiography (Tatsu et al, 1992, Obikili and Okoye, 2007)

Cardiac enlargement may give the first indication of some of the cardiac diseases in man like hypertensive heart disease, rheumatic heart disease, coronary heart disease, inflammatory heart disease, ischemic heart disease, stroke, e.t.c. In rural areas, where the aforementioned sophisticated investigating tools are not available or beyond the reach of common poor people, the cardiac enlargement can be evaluated by routine chest X-ray by the cardio-thoracic ratio (CTR). However, 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 department (ED) or intensive care unit (ICU). An enlarged heart may or may not be indicative of underlying cardiac disease; other way round a normal sized heart does not guarantee the absence of cardiac disease. But still then an enlarged heart in respect of age, height, weight and Body Mass Index (BIM) may give the first hint of underlying cardiac disease in routine Chest X-ray.

With the current cost of films production, the poverty level in our society, complexity and unavailability of the modern imaging techniques that will not let patients with suspected cardiac problems have an assessment of their cardiac status, it is more economical to have some criteria for assessment of the cardiac status on one film projection only and to have a full knowledge of the other clinical indices that can modify the relevance of the results of measurements. The standard erect Postero-Anterior (PA) film that is the commonest 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 sensitive index in monitoring the heart as quickly as possible, as cheaply as possible and as reproducibly as possible for prompt and early intervention in the management of cardiac patient, if not absolutely at the first visit, at least on a serial film bases done at intervals to monitor progress. 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 the work set out to address.

MATERIALS AND METHODS

Cardiothoracic ratio (CTR) can be measured by using some instrument/ equipment. The materials used for the research include:

Mobile X-ray machine, Plain chest X-ray radiograph (PA view), X-ray viewing box, Weighing scale, a wall height chart, a tape, a transparent rule, Pencil and Eraser

ISSN 2055-009X(Print), ISSN 2055-0103(Online)

METHODOLOGY

In this research study, cardiac diameters (CDs), thoracic diameters (TDs) and cardiothoracic ratio (CTRs) were observed and tried to establish any correlation between these cardiac parameters with age, height, weight, and Body Mass Index (BMI) in young adult Nigerians. The research centre for this study was; University of Jos Health Care Centre. 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 examination into University Jos were obtained and viewed using 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. A mobile X-ray Machine with programmed facilities for distance measurements to capture the images prior to measurements was used.

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 measured the TD 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

$$\text{Cardiothoracic ratio (CTR)} = \frac{Cardiac\ Diameter(cm)}{Thoracic\ Diameter(cm)} \quad - - - - - \quad (1)$$

The subject's heights and weights were measured using a weighing scale and a wall height chart respectively. Weight was recorded in kilograms (kg) with subjects in light clothing only. Height was then read off on the wall chart in centimeters (cm).Without shoes or head gear, subject's stood feet apposed and touching the walls. The subject's Body mass index (BMI) was calculated based on the formula:

$$\text{BMI} = \frac{Wetght\ (kg)}{\text{Height}^2\text{m}^2}\ ((\text{Kg}m^{-2}) \quad - - - - - - - - \quad (2)$$

This study was performed only on subjects that had Chest X-ray (CXRs) for the purpose of medical examination into 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

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- Significant rotations.

The CXRs of subjects satisfying aforementioned criteria were mounted on X-ray light viewing box with uniform but with adjustable intensity for diagnosis.

STATISTICAL METHOD

Using Statistical Passage for Social Sciences (SPSS) version 22 software, the following values were determined.

- Mean and standard deviation, 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 CardioThoracic Ratio (CTR).

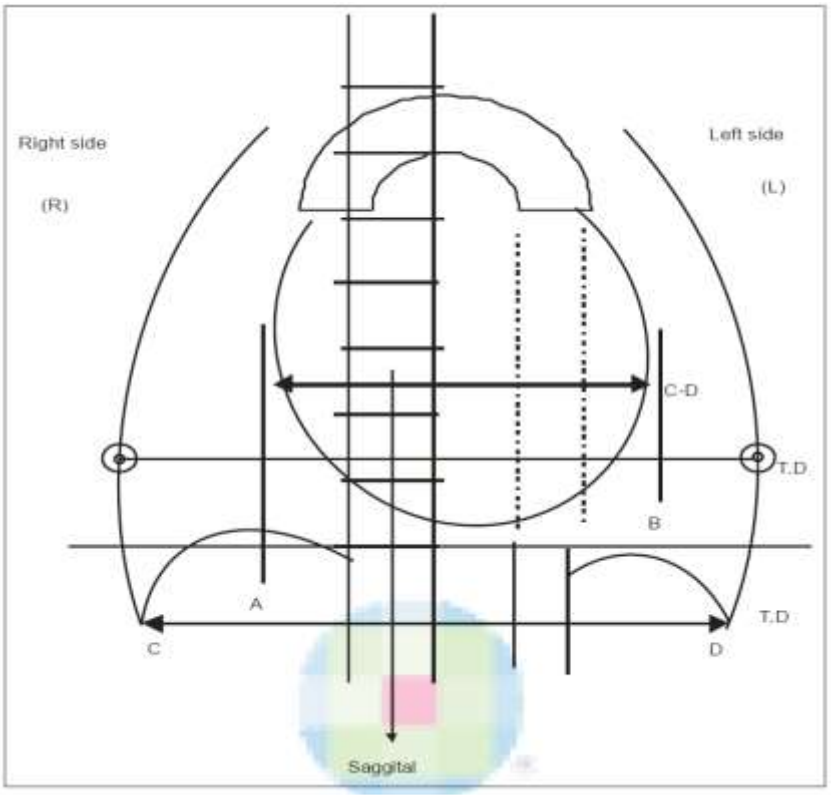

Figure1 : A schematic representation of the chest showing the different measurements done on the chest and the points from which measurements were done (a) Tangent to the cardiac silhouette at the most lateral part on the right (R) side of the heart shadow. (b) Tangent to the cardiac silhouette at the 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).

ISSN 2055-009X(Print), ISSN 2055-0103(Online)

RESULTS AND DISCUSSION

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				

T able 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).

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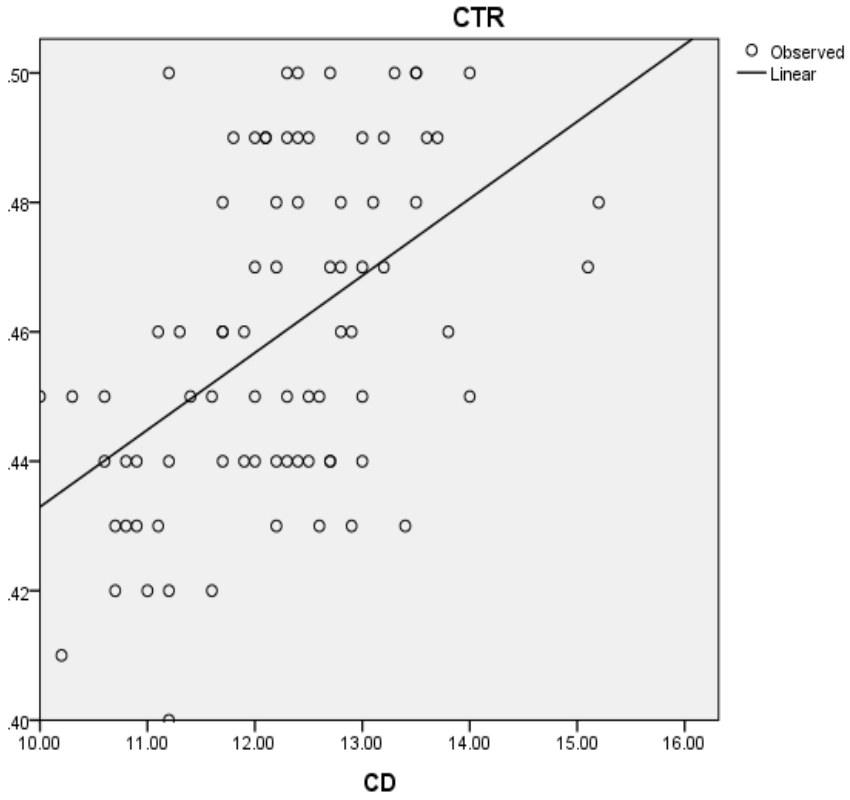
Table 3: Regression equation Coefficients

	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

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



Of all the candidates who came for medical examination in to the University of Jos, the first eighty 80 (40males and 40 females) were randomly selected. Different body parameters like age, height, weight and Body mass index (BMI) was measured and chest radiographs were taken in proper manner and from them CD, TD and CTR were calculated. Using Statistical Package for Social Sciences (SPSS) version 22software, Mean and standard deviation and correlation coefficients between CD, TD and CTR were calcukatd with measured and calculated body parameters. In both sexes, the CardioThoracic Ratio (CTR) was found to correlate significantly ONLY with CD with correlation coefficient factor r of 0.488^{**} at ($P< 0.01$ level (2-tailed)) [Table 2].

The mean age of the study group was found to be (19.1900 ± 2.146) years and the average mean range of the age was16.00 – 24.00 years.

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The mean heights of the study group was found to be (166. 815 ± 7.708) cm and the average height range was (150.50- 185.00) cm. The mean weight was found to be (62.994 ± 11.431) kg whereas the minimum and maximum averages weight range was (42.00 - 109.00) kg respectively. The mean Body Mass Index (BMI) of the study group was found to be (22.645 ± 3.865) kgm^{-2} whereas the average BMI range was 16.26 – 38.62 kgm^{-2}. The mean value of the cardiac diameter (CD) was found to be (12.230 ± 1.058) cm, whereas the minimum and maximum range of the cardiac diameter (CD) was (10.00 - 15.20) cm respectively.

The mean value of the Thoracic diameter (TD) was found to be (26.543 ± 2.037) cm whereas the minimum and maximum range of the Thoracic diameter (TD) of the study group was (22.30 – 31.80) cm respectively. The mean cardiothoracic ratio (CTR) for the whole group was 0. 460 ± 0.026 and the average mean range was 0.40 – 0.50 [Table1].

There was a significant correlation between the Age and Weight, BMI, CD and TD with a correlation coefficient factor r of 0.350^{**}, 0.326^{**}, 0.396^{**} and 0.387^{**} respectively at ($P < 0.01$ level (2-tailed)) whereas no correlation with Height and CTR.

Height was found to correlate significantly with Weight, CD and TD with a correlation coefficient factor r of 0.359^{**}, 0.28^{**} and 0.383^{**} respectively at ($P < 0.01$ level (2-tailed)) whereas it was negative with BMI and CTR.

The weight was found to correlate significantly with Age, Height, BMI, CD and TD with correlation coefficient factor r of 0.350^{**}, 0.359^{**}, 0.866^{**}, 0.497^{**} and 0.489^{**} respectively at ($P < 0.01$ level (2-tailed)) whereas no correlation with CTR.

Body Mass Index (BMI) was found to correlate significantly with Age, Weight, CD and TD with correlation coefficient factor r of 0.326^{**}, 0.866^{**}, 0.359^{**}, and 0.307^{**} respectively at ($P < 0.01$ level (2-tailed)) whereas no correlation with CTR.

The Cardiac Diameter (CD) was found to correlate significantly with the Age, Height, Weight, BMI, TD and CTR with correlation coefficient factor r of 0.396^{**}, 0.287^{**}, 0.497^{**}, 0.359^{**}, 0.757^{**} and 0.488^{**} respectively at ($P < 0.01$ level (2-tailed)).

The Thoracic Diameter (TD) was found to correlate significantly with Age, Height, Weight, BMI and CD with correlation coefficient factor r of 0.387^{**}, 0383^{**}, 0.489^{**}, $0.307^{**}$and 0.757^{**} respectively at ($P < 0.01$ level (2-tailed)) whereas no correlation coefficient with CTR. [Table 2].

The Cardiac Diameter (CD) was found to correlate highly with Thoracic Diameter (TD) with correlation coefficient factor r of 0.757^{**} at ($P < 0.01$ level (2-tailed)) [Table 2]

REGRESSION EQUATION COEFFICIENTS

The linear relationship (regression equation coefficients) between CD and CTR was found to

$Y = MX + C$ where (3) - - - - - - - - (3)

M is the slope, X is the variable and C (intercept) is a constant.

This means that the CTR can be calculated and CD was derived as

$CTR = 0.012\ (CD) + 0.314$ (4) - - - - - - - - (4)

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with correlation coefficient factor r = 0.488** (p< 0.000).

The observation made by different researchers such as Anyanwu *et al*, (2007): CTR and body habitus in Nigerian population; Ekedigwe et al, (2014): CTR and BMI in normal young adult Nigerians and Dhruba et al, (2014): correlation of CD and CTR with body habitus in Bankura district of west Bengal, India, revealed that CD has a better index over CTR when predicting heart size using various indices of the body such as age, height, weight, BMI, BSA. This means that CTR is least affected by body parameters. As CD increases, CTR increase and vice versa.

CONCLUSION

The cardiothoracic ratio (CTR) main results of this study have conclusively established the CTR of normal fresh undergraduate students of the University of Jos within the age range of 16 – 24 years. The CTR correlate significantly ONLY with CD. This implies that as CD increases, CTR also increases. The study also revealed that CTR varies with age ranges when compared with other previous made observation. Care should be born in mind in setting up the normal reference values in predicting cardiac enlargement as CTR is least affected by the variation of the dimension of body built as mentioned above. So CTR is better indicator in predicting cardiac enlargement than CD in routine chest X-rays.

Note: The determination of CTR is to investigate or find out Lungs fields whether it is further diseased or not and heart diameter is normal or abnormal.

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