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NORMAL HEART SIZES OF NIGERIANS WITHIN RIVERS STATE USING CARDIOTHORACIC RATIO

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ABSTRACT

Chest radiography is the most commonly used modality for the detection of cardiomegaly and the evaluation of cardiothoracic ratio.The aim of this study was to establish the mean values of cardiac and thoracic diameters, and the cardiothoracic ratio in children, adolescents and adult Nigerians within Rivers State and to provide a database of normal heart sizes of Nigerians within Rivers State which could be used for clinical interpretation and to compare with other ethnic groups within Nigeria, Africa and the world at large. This study considered the heart sizes of three hundredand six samples of children, adolescence and adult Nigerians of both sexes within Rivers State which is as a result of racial variations which has been noted to affect the sizes of the heart. The results showed the mean heart diameter for males to be12.92 ± 1.41cm, 12.01 ± 1.38cm for females while 12.46± 1.44cm was noted for both genders. For chest diameter, the mean; 28.28 ± 2.86cm was obtained for males, 25.71 ± 2.30cm for females, and 27.00 ± 2.82cm for both genders and lastly, the mean CTR value of 45.7± 0.03 for males, 46.7 ± 0.04 for females and 46.3± 0.03 for both genders. Statistical analysis using student t- test showed that male Nigerians within Rivers State had significantly higher value ($p<0.05$) in almost all the parameters except in CTR where the females had higher CTR value ($p<0.05$).The finding of this study will serve as a basis for future studies on other Nigerian ethnic group, to enhance better clinical interpretations and also necessary for a better and more accurate evaluation of cardiovascular diseases.

Keywords: Cardiothoracic ratio, Heart diameter and Chest radiograph

INTRODUCTION

Rivers State is one of the 36 States of Nigeria. Its capital is Port Harcourt. It is bounded on the South by the Atlantic Ocean, to the North by Imo, Abia, and Anambra States, to the East by AkwaIbom States.

Rivers State is home to a variety of ethnic groups, including;

Abua, Andoni, Ekpeye,Engenni, Etche, Ibani, Ikwerre, Kalabari, Ogba/Egbema/Ndoni, Okrika and Ogoni.

Rivers State was created in 1967 with the split of the Eastern Region of Nigeria. Until 1996 the State contained the area which is now in the Bayelsa State.

Rivers State is divided into 23 Local Government Areas (LGA):

Chest radiography is the most commonly used modality for the detection of cardiomegaly and the evaluation of cardiothoracic ratio *(Kono et al.,* 1992*).*

It is an important indicator of cardiac size *(Raphael et al.,* 1998*).*

A Chest X-ray makes images of the heart, lungs, airways, blood vessels and the bones of the spine and chest visible. Therefore the normal heart is determined using Cardiothoracic ratio which is the maximum transverse diameter of the heart divided by the greatest internal diameter of the thoracic cage (from inside of rib) express in percentage as is seen on the chest radiograph*(Danzer,*1919*).*In normal people, the cardiothoracic ratio is usually less than 50%. Therefore, the cardiothoracic ratio is a handy way of separating most normal hearts from most abnormal hearts

Obilikiet al., 2010, reported the Aortic and heart dimensions of children and adolescents in a Nigerian population having found out that there is a paucity of data on aortic and heart dimensions of children and adolescents in Africans, carried out a study to establish normal values of aortic, cardiac and thoracic diameters and the cardiothoracic ratio in children and adolescent in a Nigerian population. The cardiothoracic ratio of 110 males and females aged between 5 and 19 were calculated from the cardiac and thoracic diameters in posteroanterior chest radiographs in a cross sectional study at a tertiary hospital. The subjects studied were individuals referred to the department of radiation Medicine, University of Nigeria Teaching Hospital (UNTH) Enugu for routine chest radiographs. Prediction formulae were established for aortic and cardiac diameters. The means and standard deviations of aortic, cardiac and thoracic diameters and cardiothoracic ratio were established. The mean values of cardiothoracic ratio for males in the 5 – 9, 10 – 14, and 15 – 19 age groups were 47.7%, 45.7% and 44.1% respectively. The corresponding values for females were 49.7%, 45.0% and 41.1%. The ratio decreased with age in both sexes.

These values were larger than those reported for the Caucasians. The study highlights the need for the use of standards based on local values for the evaluation of cardiovascular diseases in our population.

There was no significant sex difference in the aortic diameter. The correlation coefficients between the real and predicted values of aortic diameter were significant in both sexes, $P< 0.001$. Predicted aortic diameter (cm) of 10 – 19 year old males = $0.005 \times$ age + $0.013 \times$ weight + $0.021 \times$ height + 0.592.

Predicted aortic diameter (cm) of 10 – 19 year old females = $0.042 \times$ age – $0.001 \times$ weight + $0.020 \times$ height + 1.005.

The correlation coefficients between the real and predicted values were as follows: 10 -19 year males: $r = 0.7898$, $P < 0.001$, 10 – 19 year old females: $r = 0.6913$, $P < 0.001$. From their study the cardiothoracic ratio decreased with age. Also males and females in their study had larger

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cardiothoracic ratio than the values reported by Cowan in 1964 at the corresponding age groups. The correlation coefficients between the real and predicted values were as follows: 10 -19 year males: r = 0.7898, P < 0.001, 10 – 19 year old females: r = 0.6913, P < 0.001. From their study the cardiothoracic ratio decreased with age. Also males and females in their study had larger cardiothoracic ratio than the values reported by Cowan in 1964 at the corresponding age groups.

No report exists on the normal heart size of Nigerians within Rivers State hence the need for this study. Furthermore, this study will provide the data on the normal heart sizes of Nigerians within Rivers State which could become imperative to establish normal values of CTR within the Nigerians ethnicity that will enhance better clinical interpretations.

MATERIALS AND METHODS

The materials used for this study include; Chest x-ray films, a viewing machine, ruler, pen, note book, table and chair.

This is a prospective study of the cardiothoracic ratio within Nigerians residing in Rivers State. The study center was at the University of Port Harcourt Teaching Hospital (UPTH) in the Radiology Department, Rivers State, Nigeria.

The entire posteroanterior (PA) chest radiograph used for the study was made under identical conditions.

The films were non grid at 72 inches taken at 100 to 110 kvp. The tube was 1.8m from the subjects and the radiographs taken in the erect position at normal quiet inspiration

A total of three hundred and six (306) samples after physical examinations of the reports of 2010 films, reported by the Radiologist were chosen for this study.

The sample was selected from candidates that came for chest x-ray examination as a result of requirements based on pre-employments, pre-admissions and visa applications without any cardiovascular diseases symptoms and also radiographs reported such as thoracic wall deformity, inadequate inspiration, over expanded chest, inability to determine one or both heart borders with confidence, incompletely erect radiograph, mediastinal deviation and significant rotation were not used for these study.

The Cardiothoracic ratio (CTR) was calculated as the maximum transverse diameter of the heart (Figure 1) divided by the greatest internal diameter of the thoracic cage (from inside of rib) (Figure 2) express in percentage as is seen on the chest radiograph.*(Danzer, 1919)*.

$$CTR = \frac{\text{Maximum transverse diameter of the heart}}{\text{Greatest internal diameter of the thoracic cage}} \times 100$$

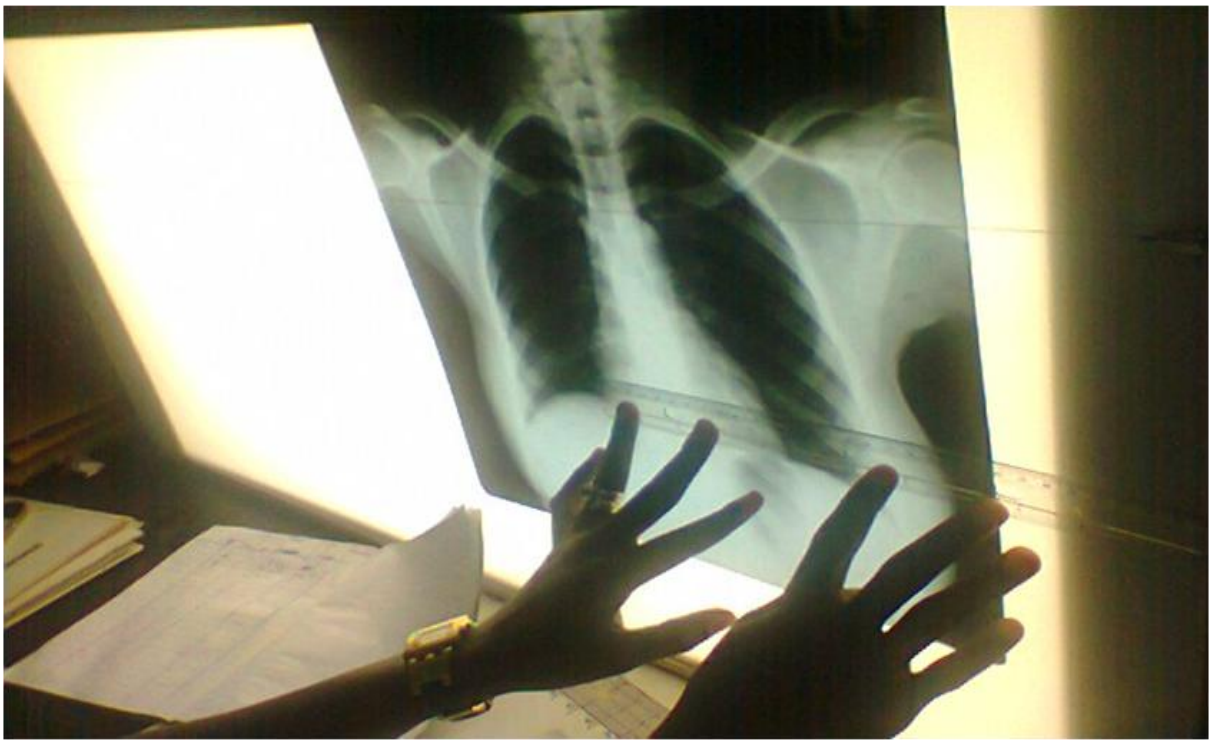

Figure 1: Measurement from present study of the maximum transverse diameter of the heart

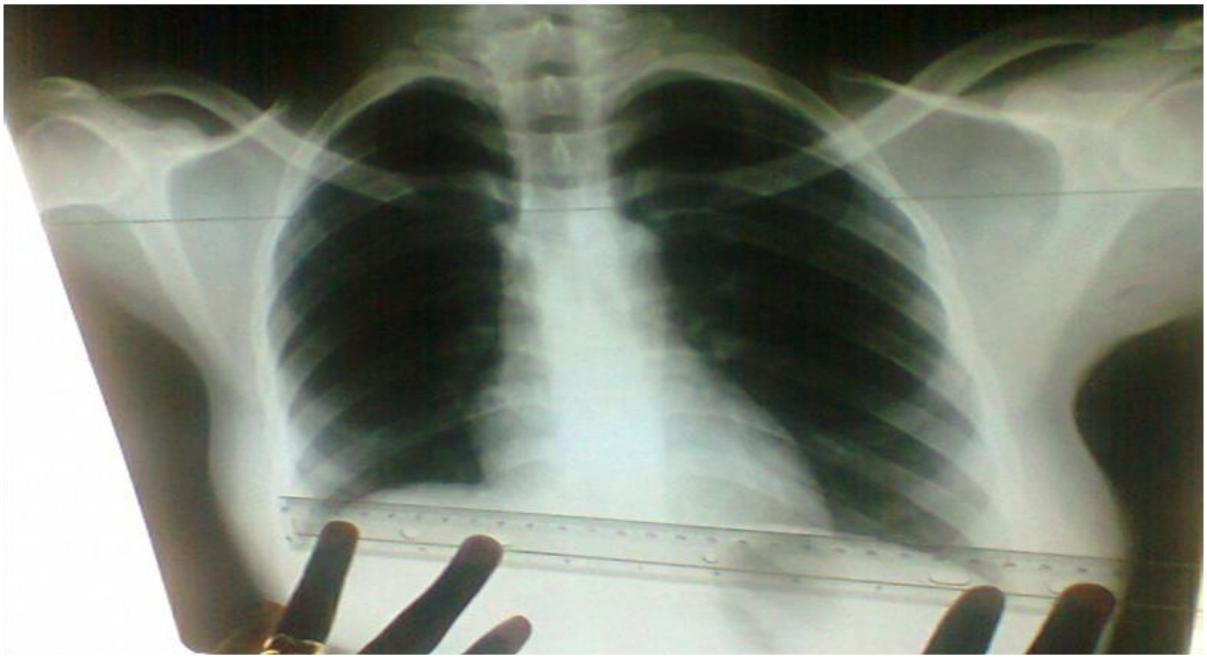

Figure 2: Measurement from present study of the greatest internal diameter of the thoracic cage.

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Statistics

The data were analyzed using some simplified statistical mathematical relations to show the analysis for these measurements.

Pearson's Correlation (r): Was used to determine the relationship between Age and Heart diameter, Age and Chest diameter and Age and Cardiothoracic ratio. Students t - test: This was used to determine the significance of the correlation at $P < 0.05$ and $P < 0.01$.

RESULTS

Out of the three hundred and six (306) samples aged from four (4) to eighty (80) years used for this study, males were one hundred and forty five (145) while females were one hundred and sixty one (161) of the sampled population.

Age was measured in years. The results are shown in table 1-5 and figure 1-3.

From table1; the sampled population gave a mean heart diameter of 12.92 ± 1.41cm for males, 12.01 ± 1.38cm for females and 12.46± 1.44cmwas noted for both males and females. Males showed a larger value of heart diameter.

In table 5, heart diameter correlated positively with age and was highly significant.

The r- value, p value at 0.01 and 0.05 are shown in Pearson's correlation(R) for the Relationship between heart size and age in figure 3.

From table 2, the sampled population gave a mean chest diameter of28.28 ± 2.86cm for males, 25.71 ± 2.30cm for females, and 27.00 ± 2.82cm for both males and females. Males showed a larger value of chest diameter. In Table 5, chest diameter correlated negatively with age but highly significant.

The r- value, p value at 0.01 and 0.05 are shown in Pearson's correlation(R) for the relationship between thoracic cage and age in figure 4.

From table 3; the result showed the distribution which gave a mean CTR of 45.7 ± 0.03 for males, 46.7 ± 0.04 for females and 46.3 ± 0.03 for both males and females. Females recorded larger values of CTR than males with about the same deviation from the means. In table 5, CTR correlated positively and negatively with age. The r- value, p value at 0.01 and 0.05 are shown in Pearson's correlation(R) for the Relationship between CTR and age in figure 5

Table 1: Relationship of Age and Heart Diameter (cm)

Sex	Age	Mean	N	SD
Male	4-10	9.85	12.00	0.75
	11-20	12.71	18.00	1.26
	21-30	12.93	46.00	1.13
	31-40	13.00	26.00	1.00
	41-50	13.10	19.00	1.02
	51-60	14.10	9.00	0.79
	61-70	14.64	10.00	1.00
	71-80	13.00	5.00	0.25
	Total	**12.92**	**145.00**	**1.41**
Female	4-10	9.83	10.00	1.06
	11-20	11.76	28.00	1.20
	21-30	11.93	55.00	1.28
	31-40	12.69	36.00	1.25
	41-50	12.64	18.00	1.27
	51-60	12.98	8.00	0.43
	61-70	12.85	4.00	0.71
	71-80	11.40	2.00	1.70
	Total	**12.01**	**161.00**	**1.38**
Both	4-10	9.84	22.00	0.88
	11-20	12.24	46.00	1.29
	21-30	12.43	101.00	1.30
	31-40	12.85	62.00	2.05
	41-50	12.87	37.00	1.16
	51-60	13.54	17.00	0.85
	61-70	13.75	14.00	1.05
	71-80	12.20	7.00	1.06
	Total	**12.46**	**306.00**	**1.44**

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Table 2: Relationship of Age and Chest Diameter (cm)

Sex	Age	Mean	N	SD
Male	4-10	21.34	12.00	1.74
	11-20	28.10	18.00	1.69
	21-30	29.28	46.00	2.01
	31-40	29.20	26.00	1.73
	41-50	29.64	19.00	1.78
	51-60	30.58	9.00	1.71
	61-70	29.47	10.00	1.52
	71-80	28.66	5.00	1.20
	Total	**28.28**	**145.00**	**2.86**
Female	4-10	22.10	10.00	3.54
	11-20	25.57	28.00	1.60
	21-30	26.48	55.00	1.84
	31-40	27.42	36.00	1.95
	41-50	27.14	18.00	1.54
	51-60	26.24	8.00	1.21
	61-70	26.40	4.00	2.33
	71-80	24.35	2.00	5.16
	Total	**25.71**	**161.00**	**2.30**
Both	4-10	21.72	22.00	2.66
	11-20	26.84	46.00	2.04
	21-30	27.90	101.00	2.37
	31-40	28.31	62.00	2.05
	41-50	28.40	37.00	2.07
	51-60	28.41	17.00	2.66
	61-70	27.94	14.00	2.22
	71-80	26.51	7.00	3.13
	Total	**27.00**	**306.00**	**2.82**

Table 3: Relationship of Age and CTR

Sex	Age	Mean	N	SD
Male	4-10	46.2	12.00	0.03
	11-20	45.2	18.00	0.03
	21-30	44.2	46.00	0.03
	31-40	44.5	26.00	0.03
	41-50	44.2	19.00	0.03
	51-60	46.1	9.00	0.01
	61-70	49.7	10.00	0.02
	71-80	45.4	5.00	0.02
	Total	**45.7**	**145.00**	**0.03**
Female	4-10	44.5	10.00	0.05
	11-20	46.0	28.00	0.04
	21-30	45.1	55.00	0.04
	31-40	46.3	36.00	0.03
	41-50	46.6	18.00	0.03
	51-60	49.5	8.00	0.02
	61-70	48.7	4.00	0.02
	71-80	46.8	2.00	0.03
	Total	**46.7**	**161.00**	**0.04**
Both	4-10	45.4	22.00	0.04
	11-20	45.6	46.00	0.04
	21-30	45.7	101.00	0.04
	31-40	45.4	62.00	0.03
	41-50	45.4	37.00	0.03
	51-60	47.8	17.00	0.02
	61-70	49.2	14.00	0.02
	71-80	46.1	7.00	0.14
	Total	**46.3**	**306.00**	**0.03**

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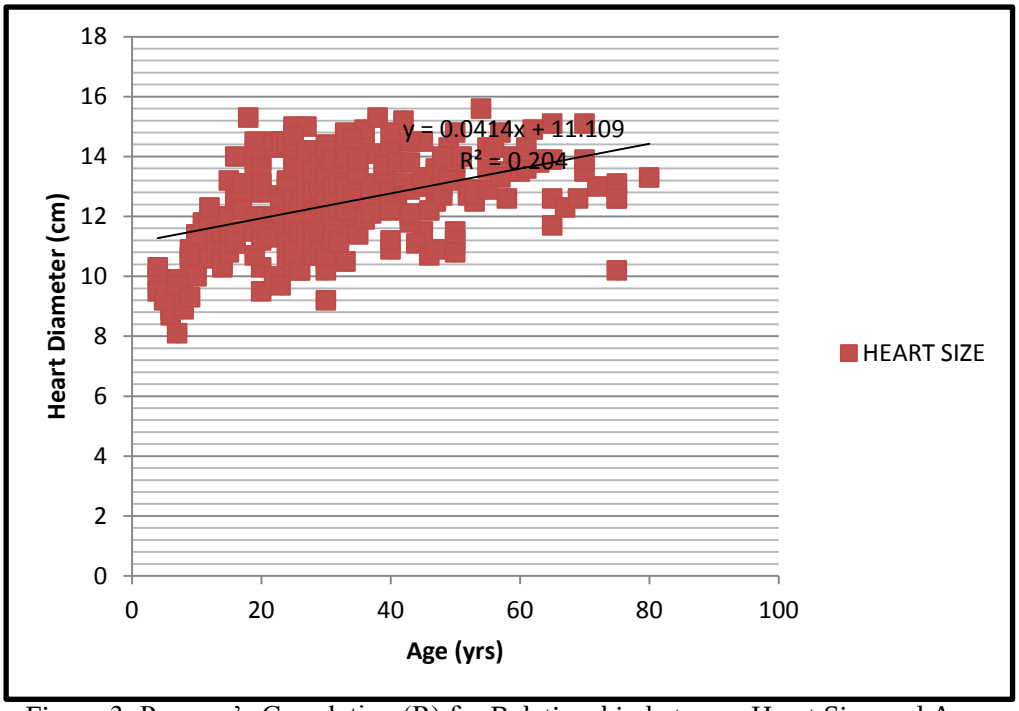

Figure 3: Pearson's Correlation (R) for Relationship between Heart Size and Age

Pearson's correlation (r) = $\sqrt{0.204}$ = 0.45

There is positive correlation between age and heart diameter

Significant test for correlation at P Value = 0.05 & 0.01

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} = \frac{0.45\sqrt{306-2}}{\sqrt{1-0.204}} = 5.2$$

Calculated t value = 5.23

Table value of p at 0.05 = 0.113

Table value of p at 0.01 = 0.148

There is a highly significant association

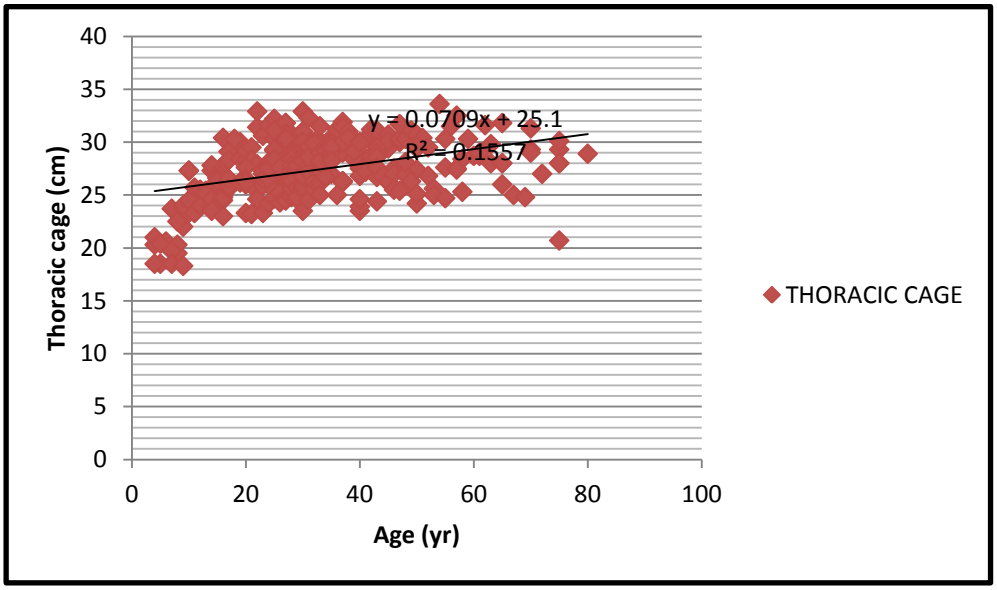

Figure 4: Pearson's Correlation (R) for Relationship between Thoracic Cage and Age

Pearson's correlation (r) = $\sqrt{0.155}$ = 0.39
There is positive correlation between age and chest diameter
Significant test for correlation at P Value = 0.05 & 0.01

$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} = \frac{0.39\sqrt{306-2}}{\sqrt{1-0.155}} = 7.88$
Calculated t value = 7.88
Table value of p at 0.05 = 0.113
Table value of p at 0.01 = 0.148
There is a significant association

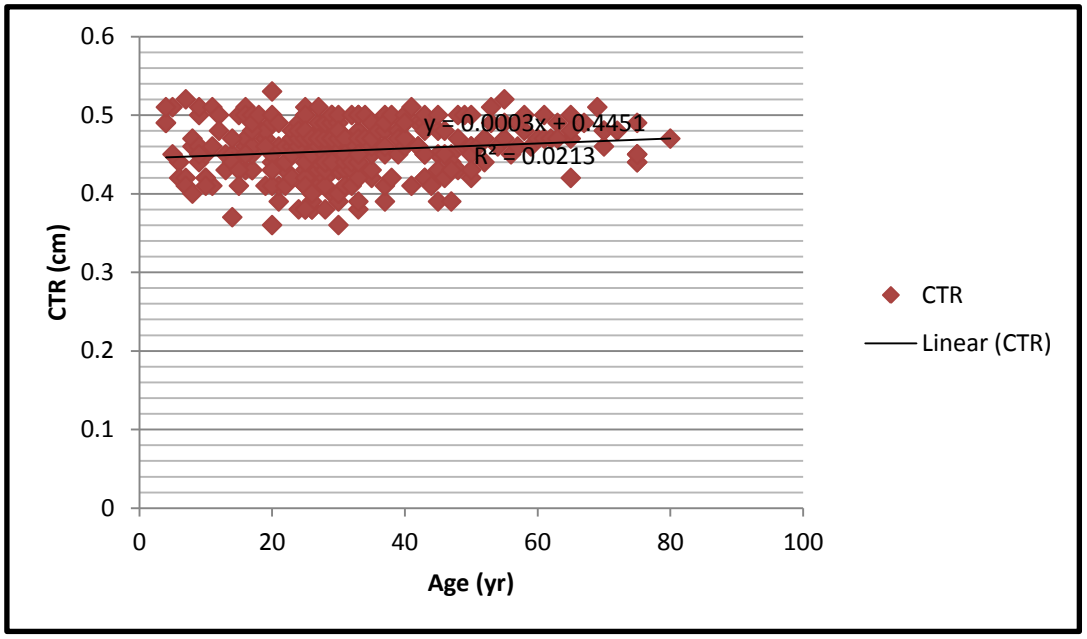

Figure 5: Pearson's Correlation (R) for Relationship between CTR and Age

Pearson's correlation (r) = $\sqrt{0.021}$ = 0.14
There is positive correlation between age and CTR
Significant test for correlation at P Value = 0.05 & 0.01

$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} = \frac{0.14\sqrt{306-2}}{\sqrt{1-0.21}} = 2.50$
Calculated t value = 2.50
Table value of p at 0.05 = 0.113
Table value of p at 0.01 = 0.148
There is a significant association

Table 4: A Sex Differential Observation in Chest and Heart Diameters

Age	Difference in Heart Diameter	Difference in Chest Diameter	Ratio	Ratio Of Difference in %
4-10	0.02	0.76	0.03	2.63
11-20	0.95	2.53	0.38	37.55
21-30	1.00	2.80	0.36	35.71
31-40	0.31	1.78	0.17	17.42
41-50	0.46	2.50	0.18	18.40
51-60	1.12	4.34	0.26	25.81
	1.79	3.07	0.58	58.31
	1.60	4.31	0.37	37.12
	61-70			
MEAN	71-80	2.76	0.29	29.12

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Table 5: Descriptive Statistical Data, Pearson's Correlation and Test of Significance for the Correlation of Age with Heart Size, Chest Diameter and Cardiothoracic Ratio

Parameters	Sample Size	Mean(CM)	S. D	r - Value	Cal. t-Score	Crit.t-Score At		Inference
						0.05	0.01	
Heart size	306	12.46	± 1.44	0.45	+ve cor. 5.23	0.113	0.148	Highly significant
Chest diameter	306	27.00	±2.82	0.39	-ve cor. 7.88	0.113	0.148	Highly significant
CTR	306	46.3	±0.03	0.14	±cor. 2.50	0.113	0.148	Significant

S.D = Standard deviation
Cal. T = Calculated t score
Crit. T = Critical t score
R = Pearson's correlation
+VE COR = Positive
-VECOR = Negative

DISCUSSION

In our study the mean values for the heart diameter, chest diameter and CTR in males were: 12.92±1.41cm, 28.28±2.86cm, 45.7±0.03 respectively while in females the values were; 12.01±1.38cm, 25.71±2.30cm, and 46.7±0.04 respectively. The mean values for the heart diameter, chest diameter and CTR for the entire sample studied (both genders) were; 12.46±1.44cm, 27.00±2.82cm, and 46.3±0.03 respectively. The results in this study indicate that there is sexual variation in all parameters measured, as females showed significantly lower values for both heart and chest diameters but higher CTR values than males. This is consistent with earlier studies (Oberman et al, 1967; Amundsen, 1999; Inoune et al, 1999; Sorkin et al, 1999, Anyawu and Angwuna, 2007).

Sexual variation in heart diameter may be attributed to differences in morphology (body size) and levels of physical activities between genders (Zdansky, 1965)

Besides, sex, age, body size, race and ethnicity are other factors that have been attributed to influence the heart diameter and CTR (Nickol and Wade, 1982; Walker 1985; Aschroft and Maill, 1969; Patrick and Boyd, 1986).

The progressive increase in Heart diameter with age as reported in earlier studies (Oberman et al, 1965, Obikili et al, 2010) is more apparent across the entire age ranges in males than in females in the result of this study.

A summary of previous works on CTR has shown the CTR values of Africans to be slightly higher than those of Caucasians (Nickol

and Wade, 1982; Kabala and wide, 1987). All the subjects in this series were healthy and thus the entire ranges of CTR, heart and chest diameters may be regarded as normal.

In our study, the mean CTR of 45.7% obtained for males (Table 3) is closely related to the mean CTR of 45.9% reported by Nickol and Wade, 1987. Also, the overall mean CTR of 46.3% in our study is similar to the mean CTR of 46% reported in another study by Danzer in 1919.
The use of CTR, which is a function of heart dimension, in clinical settings finds its relevance in prediction of coronary heart disease mortality and risks of cardiovascular diseases as reported by Hemingway et al, 1998, Rautaharju et al,1988. Thus, this study which provides the data on the normal heart sizes of Nigerians within Rivers state will be useful to clinicians in their evaluation of cardiovascular diseases among Rivers state population.

This study has been able to establish the mean CTR values of Nigerians within Rivers State. Close comparison of the CTR values of this work for the various age groups with Caucasian values of same age groups shows the research values slightly larger than the Caucasian values.
This goes to confirm earlier reports by Obikili*et al.*,(2004);Nickol and Wade (1982); that Africans have slightly larger CTR values than Caucasians and Asians.
Finally, this study will serve as a basis for future studies on other Nigerian ethnic group, to enhance better clinical interpretations and also necessary for a better and more accurate evaluation of cardiovascular diseases.

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