

Transverse Cardiac Diameter in Frontal Chest Radiographs of a Normal Adult Nigerian Population

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ABSTRACT

Background: The possibility of racial differences in heart dimensions has not been extensively investigated in our environment. Cardiac diameter is known to correlate with some anthropometric parameters. Our study was aimed at providing age and sex specific normal standards of cardiac diameter in an adult Nigerian population. The data were correlated with various anthropometric parameters.

Methods: The transverse cardiac diameter of 303 males and females aged between 20 and 93 years were measured in normal frontal chest radiographs

Results: The mean values for the 20-39, 40-59 and the ≥ 60 year-old males were 13.3, 13.9 and 13.7cm respectively. The corresponding values for the females were 12.0, 13.4 and 13.6cm. The range was from 10.5 to 16.2cm in males and 9.5 to 15.7cm in females. Males had larger mean transverse cardiac diameter than females. The cardiac diameter showed a significant positive correlation with age, weight, body surface area, body mass index but not with height. The strongest correlation in males and females was with body mass index. The mean cardiac diameter of females in our study tended to be larger than the values for Caucasian females.

Conclusion: The strong correlation between the cardiac diameter and body mass index suggests that the cardiac diameter is principally dependent on the body build.

KEYWORDS: Radiographic cardiac diameter; Body build; Age.

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INTRODUCTION

Chest radiography remains the most commonly used imaging modality for the detection of cardiomegaly and evaluation of cardiothoracic ratio¹. In Third World countries it is readily available and affordable in comparison with newer imaging modalities like echocardiography, computed tomography and magnetic resonance imaging. Racial differences in heart dimensions have been suggested by Ashcroft and Miall² and Nickol *et al*³.

There is a dearth of studies on heart dimensions of Africans in comparison with studies on Caucasians. Our study was aimed at providing age,

weight and height specific values for transverse cardiac diameter in adult Nigerians. We felt that such values could be more confidently used as standards in hospitals in the West African sub-region, rather than those obtained from Caucasian populations.

MATERIALS AND METHODS

The subjects studied were individuals referred to the Department of Radiation Medicine, University of Nigeria Teaching Hospital, Enugu, for routine chest radiographs. They included new employees of the teaching hospital who came for pre-employment routine chest radiograph. Also included were individuals who needed routine medical examinations for visas, entry into institutions admissions, or surgery. The period of study was from 1997 to 1999. The age, sex, and indications for the chest radiographs were obtained. The subjects were asked whether they had past history of hypertension or any other disease. Subjects with hypertension or any other condition that could affect the heart size were excluded from this study. The ages of the subjects studied ranged from 20 to 93 years in males and 20 to 80 years in females. Their blood pressure, heights and weights were measured.

The focus film distance was 2 metres. At this distance projection distortion is minimal and consequently the magnification is about 5%⁴. Using the criteria formulated by Kabala and Wilde⁵ as a guide, radiographs excluded from the study included those with:

- Inadequate inspiration: when less than the 5th anterior or the 9th posterior rib is above the diaphragm⁵.
- Hyperinflated lung fields: when more than the 7th anterior or the 11th posterior rib is above the diaphragm⁵.
- Significant rotation: a difference of more than 1.5cm between the sternal end of the clavicle on each side and the centre of the spinous process⁶.
- Deformity of the thoracic chest wall.

Only good quality standard posteroanterior chest radiographs were studied. The transverse cardiac diameter of 157 males and 146 females were studied.

MEASUREMENTS

The transverse cardiac diameter was measured as the sum of the maximum extensions of the heart to the left and right of the midline (Fig. 1).

Body mass index (BMI) = W/H^2 (W = weight in kilograms, H = height in metres).

Body surface area (BSA) = $W^{0.425} \times H^{0.725} \times 0.007184$ (Weight in kilograms, height in centimetres, BSA in square metres).

Statistical Package for Social Sciences (SPSS) 6.0 for Windows was used for statistical analysis.

RESULTS

Table I shows that the mean values for the cardiac diameter of 20-39, 40-59 and the 60 year-old males were 13.3, 13.9 and 13.7cm respectively. The corresponding values for females were 12.0, 13.4 and 13.6cm. The range was from 10.5 to 16.2cm in males and 9.5 to 15.7cm in females. Males had larger mean cardiac diameter than females. The sex difference was statistically different in the 20-39 year age group, $p < 0.001$ but not in the 40-59 and the ≥ 60 year-old age groups. The same relationship is depicted in Fig. 2. In both sexes there was a significant increase in the cardiac diameter between the 20-39 and the 40-59 year age groups, $p < 0.01$. There was no significant difference between the 40-59 and the ≥ 60 year-old age groups.

Table II shows the mean and standard deviation of weight, height, body mass index (BMI) and body surface area (BSA) of males and females by age. Males had significantly larger mean height than females at all the age groups. In males, the 20-39 year-old had the largest mean weight whereas in females it was the 40-59 year-old.

The correlation of cardiac diameter with various parameters is show in Table III. The correlation with age was more marked in females than in males (males: $r=0.1892$, $p < 0.05$; females: $r = 0.5009$, $p < 0.001$). In both sexes, the cardiac diameter had a significant positive correlation with weight, body mass index and body surface area ($p < 0.001$), but not with height. It correlated best with body mass index (Fig. 3).

Fig. 4 illustrates comparative data on cardiac diameter of older males and females as reported by various authors. The mean values of cardiac diameter in the present study were not statistically different from the values reported for Jamaican and Welsh males and females and American males. On the contrary, they were significantly greater than the values reported for American females ($p < 0.001$).

Using multiple regression of SPSS 6.0 for Windows software, prediction formulas for cardiac

diameter were obtained using age, weight and height of our subjects as variables. The correlation coefficients between the actual and the predicted values were statistically significant ($r = 0.6174$, $p < 0.001$ for males; $r = 0.6732$, $p < 0.001$ for females)

Predicted cardiac diameter (cm) of males:
 = $0.018 \times \text{age (yr)} + 0.062 \times \text{weight (kg)}$
 - $0.030 \times \text{height (cm)} + 13.935$.

Predicted cardiac diameter (cm) of females:
 = $0.046 \times \text{age (yr)} + 0.054 \times \text{weight (kg)}$
 - $0.015 \times \text{height (cm)} + 9.893$.

Table I. Cardiac diameter (cm) of males and females by age

Age (yr)	Males			Females			P
	No.	Mean	SD	No.	Mean	SD	
20-39	108	13.3	1.1	108	12.0	1.3	<0.001
40-59	36	13.9	1.1	28	13.4	1.1	NS
≥ 60	13	13.7	1.4	10	13.6	1.1	NS

Table II. Weight, height, body mass index (BMI) and body surface area (BSA) of males and females by age

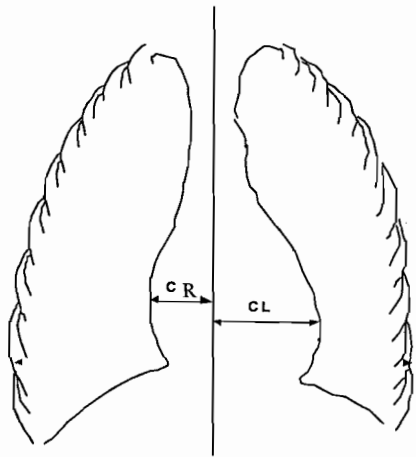
	Age (yr)	No.	Weight (kg)		Height (cm)		BMI		BSA (m ²)	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
Males	20-39	82	69.7	11.2	174.5	7.3	22.8	2.9	1.8	0.2
	40-59	34	66.2	10.8	166.7	6.5	23.8	3.2	1.7	0.2
	60+	10	58.5	14.9	163.2	8.1	21.8	4.7	1.6	0.2
Females	20-39	86	61.6	11.2	162.6	6.9	23.3	4.0	1.7	0.2
	40-59	28	69.9	12.6	160.6	4.9	27.0	4.1	1.7	0.2
	60+	9	49.1	8.1	153.3	6.1	20.9	3.2	1.4	0.1

Table III. Correlation of cardiac diameter with age, weight, height, body mass index (BMI) and body surface area (BSA) in adult males and females

	Age	Weight	Height	BMI	BSA
Male CD	0.1892 [^]	0.5009*	0.0699	0.5917*	0.3951*
Female CD	0.5048*	0.4692*	-0.0151	0.5138*	0.3796*

* Statistically significant at $p < 0.001$

[^] Statistically significant at $p < 0.05$



Cardiac diameter = CL+CR; CL and CR are the maximum extensions of the heart to the left and right of the midline respectively

Figure 1. Cardiac Diameter Measurement

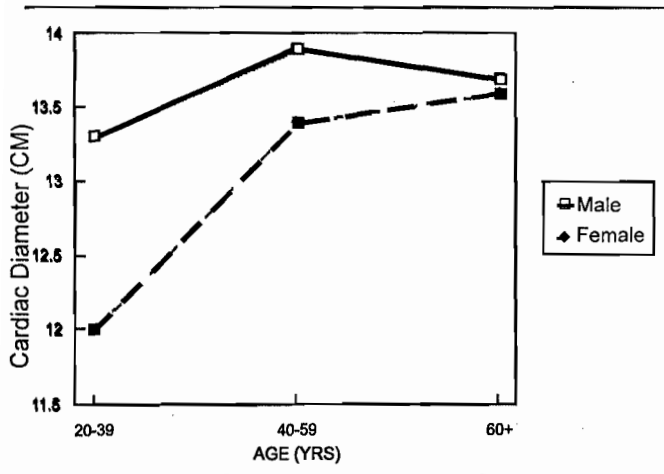


Figure 2. Cardiac diameter of males and females by age

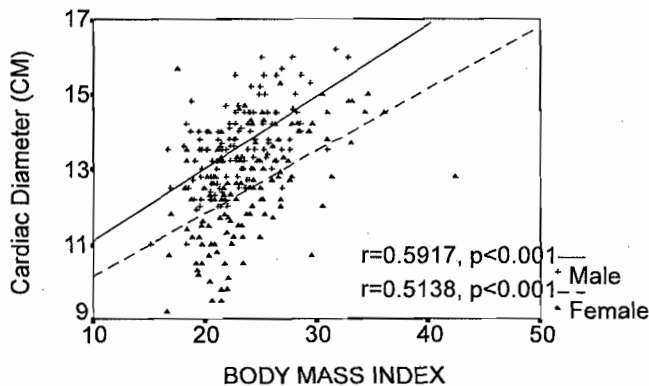


Figure 3. Correlation of cardiac diameter with body mass index in males and females

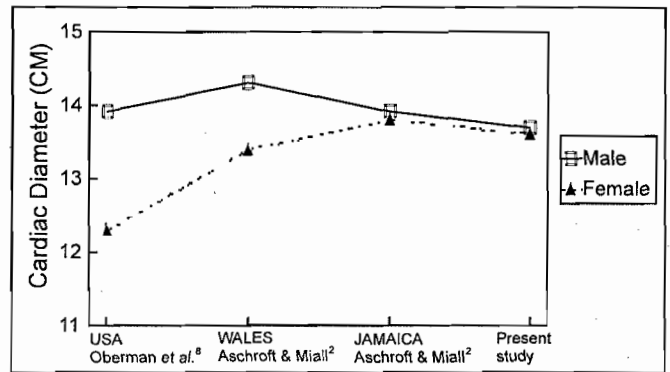


Figure 4. Cardiac diameter (cm) of males and females in the older age group as reported by various authors.

DISCUSSION

In our study, the cardiac diameter ranged from 10.5 to 16.2cm in males and 9.5 to 15.7cm in females whereas Raphael and Donaldson⁷ reported an upper limit of 16cm for males and 15cm for women. The sex differences in the means ranged from 0.1 to 1.3 cm. Men tended to have a larger cardiac diameter than women. These observations are in keeping with the findings of Oberman *et al.*⁸. They noted that in every age group, men had larger cardiac diameter than women. They reported a difference of 0.5 to 1.0cm between men and women at all age groups of comparable weights and heights. Cowan⁹ also noted that throughout most of the adult life the cardiac diameter was on the average about 0.8cm more in males than in females. Kabala and Wilde⁵ in their study of anteroposterior radiographs also showed that the cardiac diameter was significantly larger in males than in females.

Our study showed a significant positive correlation of cardiac diameter with age in both sexes. This observation is in consonance with the findings of Cowan⁹ and Potter *et al.*¹⁰. The latter noted that the cardiac diameter tended to be greater in the older age group than in the younger group. The 20-39 year-old males in our study had significantly larger mean cardiac diameter than the females of corresponding age. In the older age groups, although the males still had larger cardiac diameter than the females, the sex difference was no longer statistically significant. This trend is because the correlation of cardiac diameter with age was more marked in females than in males. This observation agrees with the findings of Edge *et al.*¹¹. Who noted a higher increase of cardiac diameter with age in females than in males.

The body mass index and the weight were the anthropometric parameters that best correlated with cardiac diameter in both sexes. The contribution of

height was minimal. For Cormeau and White¹², weight and body surface area best correlated with cardiac diameter. Height was of less significance. Our study showed that at any given weight, the taller the subject the smaller the cardiac diameter, while the shorter the subject the larger the cardiac diameter. This finding corroborates the reports of Bedford and Treadgold¹³ and Oberman *et al*⁸. According to Bedford and Treadgold¹³, the proportion between weight and height is an index of the body build and it determines the shape of the chest and the lie of the heart. A man who is tall for his weight tends to have a long and narrow chest with a vertically lying heart. A man who is short for his weight tends to have a short and broad chest with a horizontally lying heart.

Nickol and Wade³ indicated that Africans tended to have a larger cardiac diameter than Asians or Caucasians. Ashcroft and Miall² also noted that a number of authors have commented on the apparently large size of the heart in healthy Africans. They indicated that Africans may have a type of physique in which the heart tends to lie more horizontally than is usual in Caucasians. In our study, the mean values of cardiac diameter of males and females were not statistically different from the values reported for the British and Jamaicans of corresponding age groups. They were also not significantly different from the values for American males who were 60 years and above. On the contrary they were significantly larger than the values for American males below the age of 60 as well as younger and older American females. In general, the mean cardiac diameter of females in our study tended to be larger than the values for Caucasian females of comparable age. Since in our study, cardiac diameter best correlated with body mass index, it is possible that the racial differences in this parameter may account for this observation. Differences in physical activity between the various populations may also be a contributory factor.

Kerwin¹⁴, in a study of Peruvians living in high altitudes, expressed the opinion that cardiac hypertrophy may be a means of acclimatization to high altitudes. He postulated that the individual weight and height differences have greater importance in determining the heart size than the racial differences. He agreed with Cormeau and White¹² that heart size in normal individuals is

principally dependent on body build, and that genetic, racial and environmental factors are important in so far as they affect the body build. The strong correlation between the cardiac diameter and the body mass index that we noted in our study suggests that the cardiac diameter is principally dependent on body build. Our values could be more confidently used as standards in our hospitals than those obtained from Caucasian populations.

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