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RESEARCH PAPER

RELATIONSHIP BETWEEN CARDIOTHORACIC RATIO AND SOME SELECTED ANTHROPOMETRIC PARAMETERS IN RELATION TO GENDER IN AN ADULT NIGERIAN POPULATION

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ABSTRACT

This study investigated the normal values of the cardiothoracic ratio (CTR) and asses its relationship to other anthropometric parameters like height, weight, waist circumference, hip circumference, body mass index (BMI), body surface area (BSA), and waist hip ratio (WHR) of healthy young adult Nigerians in a University setting in relation to gender. In this prospective study, a total of 567 subjects (328 females and 239 males) with mean age of 21.93 ± 7.42 years from Nnamdi Azikiwe University, Awka, were used. CTR was obtained by dividing cardiac diameter by thoracic diameter while body mass index was calculated based on the formula Weight (Kg)/Height ^{2}(Kg/m²). The average CTR in males was 0.4310 ± 0.03 while in females it was 0.4449 ± 0.042 showing a significant difference (P≤ 0.05). The mean BMI for males and females were 22.82 ± 2.85 (Kg/m²) and 23.73 ± 4.43 (Kg/m²) respectively. The mean BSA for males and females were 1.844±0.140 and 1.716±0.169 respectively. There was a significant positive correlation between CTR and other parameters measured except for height which had a significant negative correlation. Again except BMI which had a moderate association with CTR, others only had a weak association (*P<0.05). In conclusion, the CTR in males was lower than that in females while the cardiac diameter in males were higher than that in females indicating sexual dimorphism. There was a significant positive correlation between CTR and other parameters measured except for height which had a significant negative correlation. Therefore chest x-ray is highly recommended as part of work up for cardiovascular risk assessment.

Key words: Cardiothoracic, Anthropometric, Gender, Ratio

INTRODUCTION

Cardiovascular diseases (CVDs) are among the leading causes of death in both men and women in most Western countries (Padwal *et al*, 2001). A number of clinical measurements for obesity have been used to determine susceptibility to cardiovascular diseases; these include anthropometric indices such as body mass index (BMI), waist-hip ratio (WHR) and waist circumference (WC) (Bray *et al*, 2005).

Variability in heart size has shown to be of importance in the determination of cardiovascular diseases such as hypertension, dyslipidemia, etc. (Lavie *et al*, 2013). One of the most common clinical methods for assessing cardiac enlargement is the use of chest roentgenograms (X-rays) (Dimopoulos *et al*, 2011). Overall heart size has been evaluated from chest films in a variety of ways; for example, calculation of the cardiothoracic ratio and determination of the total cardiac silhouette volume utilizing postero-antero and lateral projections (Hoffman and Rigler, 1992). Obikili and Okoye (2007) reported the use of chest radiograph images in the evaluation of heart size. Also the easy availability, affordability

and simple nature of these means of assessing cardiac size has made it the most common methods despite improved imaging technology.

For many clinical purposes, body surface area (BSA) is a better indicator of metabolic mass than body weight because it is less affected by abnormal adipose mass (Finucane *et al*, 2011).The higher prevalence of cardiovascular disease in obese individuals is indirectly mediated, to a large extent, by the increased frequency of various well known risk factors like hypertension, diabetes, and dyslipidemia, either individually or as part of the metabolic syndrome (Hemingway *et al*, 1998). The relationship between excess weight and diseases has been recognized over time (Bray *et al*, 2005). Several complex modalities have been used in the process of assessing the status of the heart in humans (Obikili and Okoye, 2007).

Obesity has been particularly recognized as a major independent risk factor for cardiovascular diseases, diabetes mellitus, hypertension and hypercholesterolemia (Wilson, 2002). This is because increased body fat is accompanied by profound changes in the physiological and metabolic functions of the body, which are directly dependent on the degree of excess weight and on its distribution around the body (Fareed, 2014). Obesity increases adverse cardiac events in many ways. These may be indirectly mediated through risk factors associated with metabolic syndrome like dyslipidemia, hypertension, and glucose intolerance, or effects from sleep disorders associated with obesity (Malik *et al*., 2004; Shamsuzzaman *et al*., 2002).

Due to the generated facts that BMI and body surface area (BSA) above normal range subjects an individual to obesity and variability in heart disease, it is a susceptible determinant of cardiovascular diseases, and so, the need to investigate the relation between cardiothoracic ratio and other anthropometric parameters is of importance.

The aim of the study is to explore the normal values of the cardiothoracic ratio and asses its relationship to some selected anthropometric parameters like height, weight, body mass index (BMI), body surface area (BSA) and waist- hip ratio in relation to gender in an adult Nigerian population.

MATERIALS AND METHODS

Study Population: The population used for this study was newly admitted students of Nnamdi Azikiwe University, Awka. Nnamdi Azikiwe University is a Federal University with students from different ethnic groups of the Federation.The research Centre for this study was; Nnamdi Azikiwe University Medical Centre Awka, Anambra State, Nigeria. The participants were candidates who came for chest X-ray examination as a requirement for admission into Nnamdi Azikiwe University Awka.

Ethical Approval: Ethical approval was obtained from Ethical Committee of Faculty of Basic Medical Sciences, Nnamdi Azikiwe University College of Health Sciences Nnewi Campus and from the medical director of the University's Medical Centre

Sample Size: The sample size is a representative part of population used for the study whose results will be generalized on the whole population (Okoli, 2011). The researcher was informed from the office of the Registrar, admissions unit of Nnamdi Azikiwe University Awka that the number of students approved to be admitted as regular students across different faculties in the university for 2016 academic year was five thousand, six hundred and sixty nine (5669), excluding those for Pre-Science and Continuous Education Programme. The sample size used for this study was 567 candidates. This sample size was derived according to Nwanna (1981), who stated that 40% of the total population is used in a population of few hundreds, 20% of the population is used in many hundreds, 10% of the total population is used in few thousands, while 5% of the population is used where the total number is in many thousands;

i.e. 10/100 x 5669/1 = 566.9; Approximately = 567.

Study Design: This study is a prospective cross sectional study. Cross-sectional in that the date was collected from the representative subset of the population at a specific point in time and prospective in that it attempts to predict the likelihood of an event or problem in the future. The study lasted from September 2016 to February 2017.

Sampling Technique: The sampling technique for this study was convenience random sampling of volunteers.

Inclusion Criteria: Participants between the age range 17 – 40 years and participants with systolic blood pressure between 100 and 120mmHg and diastolic pressure between 60 and 80mmHg were included in the study.

Exclusion Criteria: Participants with features of hypertension or any anatomical anomaly (like umbilical hernia), pregnancy. Chest radiographs with thoracic wall deformity, or poorly taken chest radiographs were excluded from the study.

MATERIALS AND METHOD

Materials: The research materials used for this study were: 1) A research form which was used in recording data from the subjects and from the X-ray films; 2) X-ray machine for taking chest images (*Meditronics 500mA with Toshiba tube head, serial Number 10F663*); 3) X-ray films on which the images appeared; 4) viewing box for clear vision during film measurement and measurement of the cardiac and thoracic diameters; 5) Stadiometer for measuring the height and weight; 6) Meter rule for taking measurements on the X-ray films; 7) Measuring tape for measuring hip and waist circumferences; and 8) a Sphygmomanometer for measuring blood pressure.

Measurements: A Research form was used to record details and measurements from the subjects. This form had three sections; Section A contained the biodata of the subjects; Section B was for records of anthropometric parameters of the subjects, while Section C was for measurements taken from the subjects' chest X-ray films. The volunteers gave their biodata, as physical examination was conducted to confirm that they were normal and that they met the inclusion criteria.

Measurements of the candidate's weight (in kilogram), height (in meters), waist and hip circumferences (in centimeters) and blood Pressure (mmHg) were obtained following the WHO protocol. The body mass index, body surface area and waist hip ratio were calculated. Also the cardiac and thoracic diameters were measured from the x-ray films and the cardiothoracic ratios calculated.

Blood Pressure Measurements were taken following standard protocol (Beevers *et al.*, 2001). Participants were allowed to rest at least for 20 minutes in a seated position and arm supported at the level of the heart before the blood pressure measurements for the systolic blood pressure (SBP) and diastolic blood pressure (DBP) were taken with appropriate size cuff thrice and the average recorded. Blood pressure values acceptable as normal for this study was systolic blood pressure between 100 and 120 mmHg, and the diastolic between 60 and 80mmHg.

Anthropometric measurements were done following the standard protocols for measurements. For chest x-ray measurements, the Posterior-anterior (PA) chest radiographs of all the candidates were taken in the erect position, using an X-ray machine- Meditronics 500mA with Toshiba tube head, Serial number 10F663. They were exposed at about 100 kVp and 5 mAs using film focus distance of 1.8m. The exposures were made at normal quiet inspiration.

The cardiac and chest diameters were measured by the Ungerleider and Gubnermethod.The cardiac diameter is the sum of the maximum extensions of the heart to the left and right of the midline. The chest diameter was measured from the internal surfaces of the ribs above the costal attachments of the diaphragm at the point where the chest diameter is greatest.

The cardiothoracic ratio was calculated from the cardiac and thoracic diameters using the formula as described by Danzer (1919).

$$CTR = \frac{\text{Heart Diameter x 100}}{\text{Chest diameter}}$$

The cardiac diameter in normal individuals is less than 15.5 cm in males, and less than 14.5 cm in females. A change in diameter of greater than 1.5 cm between two X-rays is significant. If the cardiothoracic ratio is greater than 50%, pathology is suspected, assuming the x-ray has been taken correctly.

Data Analysis: Degree of correlation was assessed for all the parameters and analysis was made for correlation coefficients using statistical package for social sciences (SPSS).

RESULTS

In this study a total of five hundred and sixty seven (567) subjects within the ages of 17 and 40 were used, out of which 328(57.8%) were females while 239 (42.2%) were males. The mean age for males was 22.36±4.00 whereas mean age for females was 21.70±4.78.

Table 1: Sex Distribution of Participants

Sex	Frequency	Percentage
Females	328	57.8
Males	239	42.2

Table 2: Descriptive Statistics for Females' Anthropometry

Parameters	Mean	Standard error	Standard deviation
Age	21.70	0.263	4.771
Height	1.6522	0.00391	0.07085
Weight	64.663	0.6682	12.1016
CTR	0.4449	0.00236	0.04283
BMI	23.7250	0.24482	4.43383
BSA	1.7161	0.00938	0.16986
WHR	0.8299	0.00462	0.08370

Table 3: Descriptive Statistics for Males' Anthropometry

Parameters	Mean	Standard error of mean	Standard deviation
Age	22.36	0.259	4.003
Height	1.7536	0.00518	0.08005
Weight	70.076	0.5873	9.0787
CTR	0.4310	0.00257	0.03975
BMI	22.8200	0.18414	2.84676
WHR	0.8485	0.00454	0.07019
BSA	1.8445	0.00909	0.14050

Table 4: Correlation between CTR and selected Anthropometric Parameters in Females

	Female (Mean±SD)	Coefficient(r)	P-value
CTR	0.44±0.04		
Height(m)	1.65±0.07	-0.01	0.891
Weight(kg)	64.66±12.10*	0.31	0.000
Hip circumference(cm)	89.73±10.03*	0.23	0.000
Waist circumference(cm)	74.29±9.91*	0.29	0.000
BMI(kg/m^2)	23.73±4.43*	0.32	0.000
BSA	1.72±0.17*	0.28	0.000
WHR	0.83±0.08*	0.13	0.015

There is a significant positive weak association between CTR and hip circumference, waist circumference, BSA, WHR but a significant positive moderate association with weight and BMI in females No significant correlation with height (*P<0.05).

Table 5: Correlation between CTR and Selected Anthropometric Parameters in Males

	Male (Mean±SD)	Coefficient (r)	P-value
CTR	0.43±0.04		
HEIGHT(m)	1.75±0.08*	-0.23	0.000
WEIGHT(kg)	70.08±9.08	0.11	0.099
HIP CIRCUMFERENCE(cm)	89.21±7.82	0.02	0.823
BMI(kg/m^2)	22.82±2.85*	0.28	0.000
BSA	1.84±0.14	0.02	0.809
WHR	0.85±0.07*	0.23	0.000
WAIST CIRCUMFERENCE(cm)	75.51±7.43*	0.21	0.001

There is a significant weak positive association between CTR and BMI, WHR, waist circumference but a negative weak association with height in males. There is no significant relationship between CTR and weight, hip circumference and body surface area (*P<0.05)

Table 6: Correlation between CTR and Selected Anthropometric Parameters of both Genders

	Mean±S.D	Coefficient(r)	P-value
CTR	0.44±0.04		
HEIGHT (m)	1.69±0.089*	-0.1	0.000
WEIGHT (Kg)	66.95±11.24*	0.19	0.000
HIP CIRCUMFERENCE(cm)	89.51±9.16*	0.16	0.000
WAIST CIRCUMFERENCE(cm)	74.80±8.96*	0.25	0.000
BMI(kg/m^2)	23.34±3.87*	0.32	0.000
BSA	1.77±0.17*	0.11	0.008
WHR	0.84±0.08*	0.15	0.000

In table 6 above, correlation between CTR and Selected Anthropometric Parameters of both Genders irrespective of age, there was a significant positive correlation between CTR and other parameters measured except for height which had a significant negative correlation. Again except BMI which had a moderate association with CTR, others only had a weak association (*P<0.05).

Table 7: Correlation between gender and Anthropometric Parameters

	Male (Mean±SD)	Female (Mean±SD)	Mean Difference	P-value
CTR	0.43±0.04*	0.44±0.04*	-0.14	0.000
CARDIAC DIAMETER(cm)	12.85±0.05*	11.86±0.09*	0.99	0.005
THORACIC DIAMETER(cm)	29.84±1.92*	26.68±1.81*	3.16	0.000
HEIGHT(m)	1.75±0.08*	1.65±0.07*	0.10	0.000
WEIGHT(kg)	70.08±9.08*	64.66±12.10*	5.41	0.000
BSA(cm^2)	1.84±0.14*	1.72±0.17*	0.12	0.000
WHR	0.85±0.07*	0.83±0.08*	0.02	0.005
BMI(kg/m^2)	22.82±2.85*	23.73±4.43*	-0.91	0.003

In table 7 above, correlation between male and females with respect to their anthropometric parameters measured showed that there was a significant difference in the mean value of all the parameters measured ($P \leq 0.05$). Males had significantly (*) higher cardiac diameter, thoracic diameter, height, weight, BSA, WHR but significantly (*) lower CTR and BMI than females.

DISCUSSION

In the present study is was noted that the average cardiothoracic ratio in females was 0.4449 ± 0.042 while in males was 0.4310 ± 0.03 as shown in tables 4 and table 5. This is larger than values recorded for Caucasians as reported by Nickol and Wade (1982).

In studying the relationship between males and females with respect to their anthropometric parameters measured including cardiothoracic ratio of this study, it was identified that the cardiac diameters of the males were significantly higher than that of the females ($P \leq 0.05$). This agrees with Ukoha *et al*, (2012) who reported that the mean values for cardiac diameter for males were significantly higher than that of the females (i.e. 13.8±1.89 and 13.2±1.28cm respectively) in a study conducted on Evaluation of cardiac sizes of normal Nigerians using posterior anterior chest radiographs in subjects 16 years and above.

Oberman, (1967) also reported that women have higher cardiothoracic ratio than males. Men had larger cardiac diameter than women. The higher cardiothoracic ratio in women was due to their smaller thoracic diameter. This report supports the present study. Edge, (1984) also reported that the increase in cardiothoracic ratio with age found particularly in women was mainly due to contraction of the thoracic diameter rather than an increase in the cardiac diameter.

Other anthropometric data such as height, weight and BSA were significantly higher in males than that of the females while average BMI in females was noted to be higher than that in males and is in agreement with findings in the study by Ekedigwe *et al*, (2014); and the findings of Ogunlade and Adalumo (2015) that concluded that BMI was significantly higher in females while other anthropometric parameters such as weight, height and BSA were significantly higher in males in their study on the mean values, normal limits and sex differences of anthropometry of young adults in a University Community in Nigeria.

Also there were significant differences ($P \leq 0.05$) between the CTR and BMI of males and females where the mean difference between their CTR and BMI values were negative, that is, the mean values for CTR and BMI in males were

lower than the CTR and BMI for females. This disagree with Ekedigwe *et al,* (2014) in the study of Cardiothoracic ratio and body mass index in normal young adult Nigerians in Jos, revealing that the average CTR in males was slightly higher than that in females.

This study also showed a positive mean difference between the cardiac diameter, thoracic diameter, BSA, weight, height and WHR of males when compared to the females. The cardiac diameter of the males was significantly higher than that of the females and also for the BSA, weight, height and WHR ($P \leq 0.05$). This implies that BSA, weight, height and WHR are determinants of cardiac diameter and thoracic diameter with BSA and Weight being the strongest and this is in agreement with Anyanwu *et al,* (2007) who studied CTR and body habitus in a young Nigerian population and concluded that body surface area as the strongest predictor of cardiac diameter followed by weight.

From the relationship between CTR and other anthropometric parameters in males in this study, it was revealed that there was a significant weak positive association between CTR and BMI. This corresponds with the study of Ekedigwe *et al,* (2014) who identified a very weak relationship between CTR and BMI in males in the study on cardiothoracic ratio and body mass index in normal young adult Nigerians in Jos. There was also a significant weak positive association between CTR and WHR as well as waist circumference but a negative weak association with height. This implies that, WHR and waist circumference may be used as fair determinants of CTR because of the weak association but height cannot be used because males are generally taller in the environment of study (World Web Centre, 2007). However, there was no association between CTR and weight, hip circumference and BSA.

A significant positive moderate correlation between CTR and BMI in females was also noted in this present study. This is in line with the study of Ekedigwe *et al,* (2014) who identified a relationship between CTR and BMI in females in the study on Cardiothoracic ratio and body mass index in normal young adult Nigerians in Jos. Also there was significant association between CTR and BSA which corresponds to the study of Bahareh *et al,* (2010) who showed that body surface area of female swimmers in Iran had significant relationship with their CTR. A significant weak positive association was also observed between CTR and hip circumference, waist circumference, BSA, WHR of females.

In the correlation between CTR and other anthropometric parameters of both sexes, it was revealed that there was a significant positive association between CTR and other anthropometric parameters except height (which had a significant negative correlation) and BMI (which had a moderate association). This disagrees with Ekedigwe *et al,* (2014) who stated that relationship with the CTR and BMI of both sexes is very weak. This implies that height alone cannot be used as a determinant for CTR; however other parameters such as Weight, hip circumference, waist circumference and BSA can be used as determinant factors for CTR.

CONCLUSION

In conclusion, the mean cardiothoracic ratio of the population studied was 0.44cm. It was also observed that CTR in males was lower than that in females while the cardiac diameter in males were higher than that in females indicating sexual dimorphism. There was a significant positive correlation between CTR and other parameters measured except for height which had a significant negative correlation. Therefore chest x-ray is highly recommended as part of work up for cardiovascular risk assessment.

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AUTHOR'S CONTRIBUTIONS

All authors contributed in one way or the other to the success of this work.