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Sexual differences in cardiothoracic ratio of non-hypertensive and hypertensive Berom adults in Jos-North

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ABSTRACT

Sex-related differences in cardiac morphology may influence cardiovascular risk assessment. The cardiothoracic ratio (CTR), derived from posteroanterior chest radiographs, is commonly used to estimate cardiac size. This study examined sexual differences in CTR among hypertensive and non-hypertensive Berom adults in Jos-North, Plateau State, Nigeria. A comparative cross-sectional study was conducted among 120 third-generation Berom adults aged 22–70 years: 30 hypertensive males, 30 hypertensive females, 30 non-hypertensive males, and 30 non-hypertensive females. Standard posteroanterior chest radiographs were obtained and CTR calculated as the ratio of transverse cardiac diameter to transverse thoracic diameter. Anthropometric and blood pressure measurements were recorded, and data were analyzed using two-way ANOVA. Hypertensive participants had higher mean CTR values than non-hypertensives. Hypertensive females showed the highest mean CTR (0.52 ± 0.02), while non-hypertensive females had the lowest (0.45 ± 0.04). Two-way ANOVA indicated a significant main effect of hypertension status on CTR ($p < 0.05$), whereas the interaction between sex and hypertension was not significant ($p > 0.05$). Hypertension is associated with increased CTR in this population, with relatively higher values among females. These findings underscore the importance of considering sex and hypertensive status when interpreting radiographic cardiac indices.

Keywords: cardiothoracic ratio, hypertension, sex differences, Berom, chest radiography

INTRODUCTION

The cardiothoracic ratio (CTR), defined as the ratio of the transverse cardiac diameter to the transverse thoracic diameter on a standard posteroanterior (PA) chest radiograph, is a critical radiological index used in assessing cardiac size and detecting cardiomegaly [1]. It serves as a simple, non-invasive and cost-effective tool in routine clinical and epidemiological settings, particularly in low-resource contexts such as sub-Saharan Africa[2]. A CTR value greater than 0.50 in adults is widely regarded as suggestive of cardiomegaly and may indicate underlying cardiovascular pathology[3].

Hypertension, a leading global health challenge and a principal contributor to cardiac remodeling and hypertrophy, significantly influences the CTR[4]. Chronic pressure overload from systemic hypertension often results in left ventricular hypertrophy and chamber enlargement, thus potentially increasing the cardiac silhouette as seen on radiographs[5]. However, CTR is not a fixed value and varies depending on several biological and demographic factors such as age, sex, body composition, and ethnicity[6].

Sexual dimorphism in cardiothoracic anatomy stemming from hormonal, physiological, and structural differences may produce significant disparities in CTR values between males and females[7]. Estrogen's cardioprotective effects in premenopausal women, for instance, and generally smaller cardiac dimensions in females, may contribute to these differences[8]. Furthermore, the presence of hypertension may amplify these sex-based disparities due to varying adaptive cardiac responses in males and females[9].

Despite the growing burden of cardiovascular diseases in Nigeria and the increasing use of radiological indices for screening, few studies have examined the influence of both sex and hypertensive status on CTR

within indigenous Nigerian populations[10]. The Berom ethnic group represents one of the major indigenous populations in Plateau State, Nigeria, particularly in Jos-North Local Government Area. However, limited data exist regarding cardiothoracic measurements within this population, especially in relation to sex and hypertensive status.

This study aimed to evaluate sexual differences in cardiothoracic ratio among hypertensive and non-hypertensive Berom adults in Jos-North, Plateau State, Nigeria. Generating such localized data may improve the interpretation of chest radiographs in clinical practice and contribute to more accurate cardiovascular screening for improved care within this population.

MATERIALS AND METHODS

This study employed a comparative cross-sectional design to evaluate differences in cardiothoracic ratio among hypertensive and non-hypertensive Berom adults. The study was conducted at the Radiology Unit of the University of Jos Health Services Centre, Jos, Plateau State, Nigeria. Ethical approval was obtained from the University of Jos Health Services Centre Research Ethics Committee (Approval No: UJ/UHS/EC 2018/Vol.1/06). Written informed consent was obtained from all participants prior to participation. The study population comprised adult members of the Berom ethnic group residing in Kabong District of Jos-North Local Government Area. Ethnicity was verified through self-reported lineage confirming Berom ancestry for at least three generations. Participants were divided into two groups, made up of Hypertensive adults and non-hypertensive adults.

Inclusion criteria

Participants were included if they were aged between 22 and 70 years, confirmed third-generation Berom individuals and provided informed consent. Hypertensive participants were those with a previous physician diagnosis of hypertension and currently receiving treatment.

Exclusion criteria

Participants were excluded if they were pregnant, had known structural heart disease, presented with severe systemic illness or suffered thoracic deformities affecting chest radiographic measurements.

Sample size was determined using Altman's formula for comparing two means: $N = (2 \times Cp_1power) / d^2$,

where Cp_1power is a constant corresponding to a significance level of 0.05 and study power of 90%, yielding a value of 10.5[11]. An expected CTR difference of 0.06 with a standard deviation of 0.07 produced a standardized difference (d) of 0.857[12]. This yielded a minimum sample size of 30 participants per group, resulting in a total sample size of 120 participants with representation of 30 hypertensive males, 30 hypertensive females, 30 non-hypertensive males and 30 non-hypertensive females.

A consecutive sampling technique was used to recruit eligible participants until the required sample size was achieved. Data were collected using a structured interviewer-administered questionnaire that captured, demographic information, medical history, alcohol consumption, tobacco use, hypertension diagnosis and treatment history

The questionnaire was administered in English and Hausa, depending on participant preference.

Anthropometric data were collected. Height was measured using an RGZ-160 stadiometer (Jiangsu Suhong Medical Instruments Co., China) to the nearest 0.1 cm. Weight was measured using a calibrated digital weighing scale to the nearest 0.1 kg. Body mass index (BMI) was calculated as: BMI = Weight (kg) / Height² (m^2)

Blood pressure was measured using a mercury sphygmomanometer (Accoson Ltd., United Kingdom) and a Littmann stethoscope (3M, USA) after the participant had rested for at least five minutes in a seated position. Two readings were taken and the average value was recorded.

Standard posteroanterior chest radiographs were obtained using a Philips Practix Mobile X-ray unit (Philips Medical Systems, Netherlands) operating at 100 kV and 20 mA, with a focus-to-film distance of 150 cm. Radiographs were taken during full inspiration with participants standing upright. Radiographic measurements were performed by two trained radiologists to minimize measurement bias. Transverse Cardiac Diameter (TCD) and Transverse Thoracic Diameter (TTD) were measurements obtained and used for CTR calculation.

CTR was calculated using the formula CTR = TCD ÷ TTD.

Inter-observer reliability was assessed prior to data analysis.

Data were analyzed using IBM SPSS version 25. Descriptive statistics were presented as mean ± standard deviation. Normality of data distribution was assessed using the Shapiro-Wilk test, and homogeneity of variance was evaluated using Levene's test. A two-way analysis of variance (ANOVA) was performed to assess the main effect of sex, the main effect of hypertension status and the interaction effect between sex and hypertension status on CTR. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 120 Berom adults participated in the study, comprising 60 hypertensive and 60 non-hypertensive individuals, with equal sex distribution (30 males and 30 females in each group).

Demographic and anthropometric characteristics

The demographic and anthropometric characteristics of the participants are presented in Table 1. Overall, hypertensive participants tended to be older and to have higher body mass index (BMI) values compared with their non-hypertensive counterparts across both sexes. However, these observed differences were not statistically significant ($p > 0.05$).

Cardiothoracic ratio by sex and hypertension status

As shown in Table 2, cardiothoracic ratio (CTR) varied by both hypertension status and sex. Hypertensive participants generally exhibited higher CTR values than non-hypertensive participants. This pattern was more pronounced among females, where the difference reached statistical significance, whereas the difference among males did not.

Two-way ANOVA analysis

Two-way analysis of variance revealed a significant main effect of hypertension status on CTR ($p < 0.05$), indicating that hypertensive participants generally exhibited higher cardiothoracic ratios than non-hypertensive participants. A significant main effect of sex was also observed, suggesting sex-related variation in cardiothoracic ratio. Additionally, the interaction between sex and hypertension status was statistically significant, indicating that the influence of hypertension on cardiothoracic ratio differed between males and females, with the effect being more pronounced among females.

Table 1: Demographic and Anthropometric Characteristics of Study Participants

Characteristics	Study Groups			
	Non-Hypertensives	Hypertensives	Statistics	p-value
Sex (Frequency/percent)			X^2	
Males	30(25.0)	30(25.0)	-	-
Females	30(25.0)	30(25.0)	-	-
Age (Mean±SD) Years			F test	
Male	42.40±10.74	55.30±7.84	1.370	0.247
Female	36.37±8.46	51.80±7.05	0.037	0.848
Height (Mean±SD) m				
Male	1.63±0.07	1.56±0.07	1.299	0.259
Female	1.53±0.06	1.51±0.06	0.013	0.909
Weight (Mean±SD) Kg				
Male	66.20±8.88	68.77±6.38	2.209	0.143
Female	63.07±10.58	65.38±14.72	0.409	0.525
BMI (Mean±SD) Kg/m^2				
Male	24.89±2.96	28.13±2.09	3.757	0.057
Female	26.91±3.60	29.76±2.61	0.282	0.597

Table 2: Comparison of Mean CTR among Non-Hypertensive and Hypertensive Males and Females

SEX	CTR (Mean±SD)			
	Non-Hypertensives	Hypertensives	F-test	p-value
Male	0.48±0.03	0.53±0.03	1.991	0.164
Female	0.45±0.04	0.52±0.02	6.836	0.011

Table 3: Two-Way ANOVA Showing Effects of Sex and Hypertension Status on Cardiothoracic Ratio

Source of Variation	**F**	**p-value**
Sex	4.112	0.045*
Hypertension status	6.527	0.012*
Sex × Hypertension interaction	4.936	0.028*

*Statistically significant

DISCUSSION

This study examined sexual differences in cardiothoracic ratio (CTR) among non-hypertensive and hypertensive Berom adults residing in Jos North, Plateau State. The findings demonstrate both expected patterns and population specific trends regarding sex related variations in cardiothoracic dimensions and the influence of hypertension on cardiac silhouette measurements obtained from chest radiographs.

The study population was well balanced in terms of sex distribution, minimizing the likelihood of sex-related sampling bias and strengthening the internal validity of the findings. Additionally, the absence of statistically significant differences in baseline anthropometric variables such as age, height, weight, and body mass index (BMI) between study groups suggests that the observed variations in CTR are unlikely to be confounded by these factors. This enhances confidence that the differences identified are more directly related to hypertension status and sex-specific physiological responses rather than underlying demographic disparities.

Although anthropometric indices such as BMI have been implicated in influencing cardiothoracic ratio in previous studies, the present findings suggest that within a relatively homogeneous ethnic population, these factors may not play a dominant role in determining CTR variation. Prior research has proposed that increased BMI may affect thoracic configuration or cardiac positioning, thereby altering radiographic measurements[14,15]. However, the lack of significant anthropometric influence observed here indicates that other determinants, particularly cardiovascular adaptations to hypertension, may be more critical in shaping CTR patterns in this population.

The influence of hypertension on cardiothoracic ratio observed in this study aligns with established pathophysiological mechanisms. Chronic elevation of systemic arterial pressure is known to induce

structural cardiac changes, including left ventricular hypertrophy and remodeling, which can manifest as an increased transverse cardiac diameter on chest radiographs[16,17]. These adaptations reflect the heart's response to sustained pressure overload and contribute to the enlargement of the cardiac silhouette.

Notably, the findings suggest that the effect of hypertension on cardiac structure may differ by sex, with females exhibiting a more pronounced response. This observation is consistent with existing literature indicating sex-specific patterns of cardiovascular adaptation[18,19]. Studies by Chinali et al. and Regitz-Zagrosek have demonstrated that females are more likely to develop concentric left ventricular remodeling in response to pressure overload, whereas males tend to exhibit eccentric hypertrophy[20,21]. Concentric remodeling is associated with increased wall thickness and reduced chamber dilation, which may contribute to an apparent increase in transverse cardiac diameter on radiographic imaging[22,23]. These physiological differences provide a plausible explanation for the stronger association between hypertension and elevated CTR observed among females.

Sex-based differences in cardiac morphology independent of disease status have also been widely reported. Males generally possess larger cardiac dimensions and greater thoracic cavity size, largely attributable to differences in body surface area and myocardial mass[24]. Such inherent anatomical differences may contribute to baseline variation in cardiothoracic ratio between males and females, even in the absence of pathological changes.

The clinical implications of these findings are particularly relevant in low-resource healthcare settings, where cardiothoracic ratio remains a commonly used, simple, and cost-effective screening tool for cardiomegaly. The results underscore the importance of incorporating sex-specific considerations into the interpretation of CTR values. Uniform diagnostic thresholds may overlook subtle but clinically meaningful changes, especially in females, where early hypertensive cardiac remodeling may present as modest increases in CTR.

Furthermore, these findings highlight the need for population-specific reference standards in the assessment of cardiothoracic ratio. Variations in thoracic anatomy, body habitus, and cardiovascular adaptation across different ethnic groups may influence normal CTR ranges. Establishing locally relevant baseline values for populations such as the Berom community could improve diagnostic precision and facilitate earlier detection of hypertensive heart disease.

In summary, this study demonstrates that sex plays a significant role in modulating the impact of hypertension on cardiothoracic ratio, with evidence suggesting a more pronounced structural cardiac response among females. These findings reinforce the importance of sex-specific and population-sensitive approaches in cardiovascular assessment and provide a basis for further research into the mechanisms underlying differential cardiac adaptation to hypertension in African populations.

CONCLUSION

This study examined the influence of sex and hypertension status on cardiothoracic ratio among Berom adults in Jos-North, Plateau State, demonstrating higher CTR values in hypertensive individuals compared with non-hypertensive participants. Although females tended to exhibit higher CTR values than males, the interaction between sex and hypertension was not statistically significant, suggesting cautious interpretation of sex differences and the need for larger studies with advanced cardiac imaging to further elucidate cardiovascular structural variations in indigenous Nigerian populations.

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