

# Primary hypertension among a population of Nigerian secondary school adolescents: Prevalence and correlation with anthropometric indices: A cross-sectional study

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## Abstract

**Aim:** To assess the prevalence of primary hypertension and its correlation with anthropometric indices among a population of Nigerian adolescents.

**Materials and Methods:** A cross-sectional study of secondary school adolescents aged 10–19 years in Enugu, Nigeria, using multi-staged sampling method. Anthropometry and blood pressures were measured using standardized instruments. Data analysis was with the Statistical Package for Social Sciences (SPSS) Version 20.0 (Chicago, IL, USA).

**Results:** A total of 2419 adolescents (mean age, 14.80 ± 2.07 years) were included in the study. Prevalence of hypertension was 10.7%. Systolic and diastolic hypertension were observed in 232 (9.6%) and 85 (3.5%) of the participants, respectively. Forty-two of the 137 obese (30.7%) compared to 158 among the 1777 (7.7%) with normal body mass index (BMI) ( $P < 0.001$ ) had systolic hypertension. Waist circumference ( $r = 0.37$ ) and BMI ( $r = 0.37$ ) significantly and positively correlated with systolic hypertension.

**Conclusion:** Obese and overweight adolescents had higher prevalence of primary hypertension than their counterparts with normal BMI.

**Key words:** Adolescents, anthropometry, body mass index, obesity, overweight, prevalence, primary hypertension

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## Introduction

Hypertension is the most common noncommunicable disease and the most prevalent cardiovascular disease risk factor worldwide.<sup>[1]</sup> The risks for cardiovascular disease,

cerebrovascular disease and death increase progressively with each millimeters of mercury increase in blood pressure.<sup>[2]</sup> In 2010 alone, an estimated 9.4 million deaths were attributable to hypertension globally.<sup>[3]</sup> According to the report of the World Health Organization in 2012, more than a third of Africans are hypertensive.<sup>[4]</sup> Many studies on hypertension worldwide have been conducted among the middle-aged and elderly patients.<sup>[5]</sup> Hence, there is the

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general impression that hypertension is exclusive to the older age group.<sup>[5]</sup> However, recent data have shown that the incidence of hypertension among adolescents is increasing.<sup>[6]</sup> Primary hypertension is more common in adolescents than preadolescents; and has multiple risk factors, including obesity and a family history of hypertension.<sup>[7]</sup> Secondary causes of hypertension in children include endocrinopathies, which are rare.<sup>[8]</sup> Other secondary causes, especially renal parenchymal and renovascular diseases are more common in preadolescent children.<sup>[7]</sup> Among adolescents, obesity is a known risk factor for primary hypertension; a fact that is replete in the literature.<sup>[9]</sup> However, significant gaps still exist in the literature regarding the burden of hypertension among adolescents in developing countries such as Nigeria. A recent survey in Lagos, South-West Nigeria, among adolescents in a single secondary school reported systolic hypertension prevalence rates of 16% and 12.1% among obese females and males, respectively.<sup>[10]</sup> This study set out to determine the prevalence of primary hypertension and its correlation with anthropometric indices among secondary school adolescents in a South-East Nigerian city.

## Materials and Methods

### Study setting

The study was conducted in Enugu which is the capital of Enugu State in the South East geopolitical zone of Nigeria. Enugu metropolis comprises three Local Government Areas (Enugu East, Enugu South, and Enugu North) with a total population of about 833, 373.<sup>[11]</sup>

### Study design and population

A cross-sectional study was carried out among secondary school adolescents in Enugu metropolis. Their anthropometry and blood pressures were measured.

### Inclusion and exclusion criteria

Secondary school adolescents aged 10–19 years who assented and whose parents gave written informed consent were included in the study. Subjects with known or suspected chronic illnesses such as Nephrotic syndrome and other forms of chronic kidney disease (CKD), malignancy, bronchial asthma and those on prolonged steroid therapy were excluded from the study. Cushing's disease was also excluded based on history and physical examination. CKD was excluded in the absence of triad of pallor, peripheral edema, and oliguria.

### Determination of sample size

The sample size was calculated from the following formula for cross-sectional studies:

$$N = Z^2 \frac{P(1-P)}{D^2}$$

Where  $Z = 1.96$  i.e., the level of significance.

$P = 0.14$  (reported prevalence (14%) of obesity related hypertension among adolescents in Nigeria from a previous study).<sup>[10]</sup>

$D =$  Degree of accuracy desired; 1.5%.

$$1.96 \times 1.96(0.14)(0.86)/0.0002 = 2312.$$

Using the above formula the minimum sample was 2,312 subjects but 2,419 subjects were enrolled to account for possible attrition.

### Sampling method

A multi-stage random sampling method was used. Three local government areas in Enugu metropolis were sampled. Secondary schools in each local government were stratified into three; boys, girls, and coeducational (mixed) schools. One school was selected from each group by simple random sampling thereby selecting a total of three schools in each local government area. A total of nine schools were therefore selected for this study, representing 10% of the schools in the metropolis. The selected schools were further stratified into junior and senior sections. Equal proportion of the allocated sample to schools was divided among each section. The total number of students in each section constituted the sampling frame in each section. The allotted sample to each section was divided according to the number of classes/streams in each section. The subjects were selected by simple random sampling using a statistical table of random numbers for each class/streams until the allotted number for the specific school was obtained.

Allotted sample of each of the nine schools was calculated as follows:

Sample size allotted to a given school ( $A_m$ ) is equal to:

$$A_m = \frac{\text{Population of target school} \times \text{Calculated sample size}}{\text{Total population of the nine schools}}$$

### Data collection

Data were collected with pretested structured questionnaires. Study-measured adolescent heights and weights were used to calculate body mass index (BMI). Waist circumference was measured at the midpoint between the lowest border of rib cage and the top of the lateral border of the iliac crest during minimal expiration and hip circumference was measured at the greatest horizontal circumference below the iliac crest at the level of the greater trochanter using nonstretchable tape. Waist and hip circumferences were measured to the nearest 0.1 cm. Waist to hip ratio was calculated as follows;

WHR = Waist circumference (centimeters).

Hip circumference (centimeters).

Blood pressure was measured with the subject seated with his or her back supported, feet on the floor, arm supported,

and cubital fossa at heart level after 5 min of rest on both upper arms initially; then on the arm that gave higher blood pressure value. Three readings were measured at 5 min interval with standardized (Accoson®) mercury sphygmomanometer and Littman's stethoscope.<sup>[12]</sup> An appropriate-sized bladder cuff that covers at least two thirds of the length of the upper arm and 80–100% of the circumference of the upper arm was placed in such a way that about 3 cm gap inferiorly still allowed the palpation of the brachial artery.<sup>[13]</sup>

The sphygmomanometer bladder was inflated to 30 mmHg above the palpated systolic blood pressure (SBP) and deflated at a rate of 3 mmHg/s with the first and fifth Korotkoff sounds used as the systolic and diastolic blood pressure (DBP), respectively.<sup>[14]</sup> Three readings were recorded. The averages of the systolic and diastolic readings of the three measurements were taken as the mean systolic and DBP.<sup>[14]</sup>

### Definitions

Positive history of smoking was defined as taking at least a stick of cigarette per day. Alcohol intake was positive if a respondent consumed at least 600 milliliters of alcoholic beverage per week while positive physical activity was defined as at least 30 min of activity in a day. Hypertension was defined as blood pressure reading  $\geq 95^{\text{th}}$  percentile of the blood pressure for the gender, age, and height according to the recommendation by the 2004 National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents.<sup>[13,14]</sup> Two hundred and eleven (8.7%) adolescents aged 18 and 19 years were considered as adults and hypertension among them was classified as average SBP  $\geq 140$  mmHg and average DBP  $\geq 90$  mmHg according to the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.<sup>[15]</sup> Prehypertension was defined as SBP/DBP  $\geq 90^{\text{th}}$  percentile but  $< 95^{\text{th}}$  percentile for adolescents  $< 18$  years. In adolescents older than  $\geq 18$  years, it was defined as SBP and DBP 120–139 and 80–89, respectively. Obesity was defined as BMI  $\geq 95^{\text{th}}$  percentile for age and sex, and overweight defined as BMI  $> 85^{\text{th}}$  percentile but  $> 95^{\text{th}}$  percentile for age and sex.<sup>[16]</sup>

### Follow-up

Identified cases of hypertension were referred to the Adolescent and Pediatric Cardiology Clinic of University of Nigeria Teaching Hospital for further evaluation and management.

### Ethical considerations

Ethical clearance was obtained from the Health Research and Ethics Committee of the University of Nigeria Teaching Hospital Enugu. Approval to conduct the study was also obtained from Enugu State Post Primary School Management Board.

### Data analysis

Data were analyzed with the Statistical Package for Social Sciences (SPSS) version 20.0 (Chicago, IL, USA). The Chi-square was used to test for significant association of categorical variables while Student's *t*-test was used to compare means of continuous outcome variables. Pearson correlation analysis was also done to determine the strength of relationship between anthropometric indices and blood pressure. Logistic regression model was used to test for association of significant risk factors and the outcome variables after univariate analysis. Risk factors included into the model were age, gender, BMI, waist circumference, and waist to hip circumference. The odds ratio and 95% confidence interval of risk factors used in the logistic regression model were calculated. In calculating the odds of developing prehypertension and hypertension between males and females, the female gender was used as the reference group. A  $P < 0.05$  was taken as statistically significant and all reported *P* values were two-sided.

## Results

There were 2419 adolescents included in the study (1242 males and 1177 females). Their ages ranged from 10 to 19 years with a mean age of  $14.80 \pm 2.07$  years.

### Prevalence of primary hypertension

Two hundred and sixty study participants had either systolic or diastolic hypertension, giving an overall hypertension prevalence of 10.7% among the study participants.

**Table 1: Association of elevated blood pressure with gender**

BP	Male n (%)	Female n (%)	Total n (%)	OR	P	95% CI
Systolic						
Normal	1148 (92.4)	961 (81.6)	2030 (83.9)	2.75	<0.0001	2.12–3.55
Prehypertension	53 (4.3)	120 (10.2)	157 (6.5)	0.39	<0.0001	0.28–0.55
Hypertension	41 (3.3)	96 (8.2)	232 (9.6)	0.38	<0.0001	0.26–0.56
Diastolic						
Normal	1089 (87.7)	1052 (89.4)	2141 (88.5)	0.85	0.19	0.66–1.09
Prehypertension	98 (7.9)	95 (8.1)	193 (8.0)	0.98	0.87	0.73–1.31
Hypertension	55 (4.4)	30 (2.5)	85 (3.5)	1.77	0.01	1.13–2.78

BP=Blood pressure; OR=Odds ratio; CI=Confidence interval

**Table 2: Behavioural risk factors for systolic hypertension**

Behaviourial/history	Systolic hypertension				
	Yes n (%)	No n (%)	OR	P	95% CI
Smoking					
Yes	0 (0.0)	1 (0.0)	1121	1.000	0.000–NA
No	157 (100.0)	2261 (100.0)			
Ever smoked					
Yes	1 (0.6)	19 (0.8)	0.757	0.787	0.101–5.690
No	156 (99.4)	2243 (99.2)			
Alcohol					
Yes	33 (21.0)	402 (17.8)	1.231	0.306	0.826–1.835
No	124 (79.0)	1860 (82.2)			
Physical exercise					
Yes	141 (89.8)	1999 (88.4)	1.159	0.586	0.681–1.975
No	16 (10.2)	263 (11.6)			
Parental hypertension					
Yes	35 (22.3)	517 (22.9)	0.968	0.871	0.657–1.428
No	122 (77.7)	1745 (77.1)			
Parental overweight/obesity					
Yes	44 (28.0)	846 (37.4)	0.652	0.019	0.455–0.933
No	113 (72.0)	1416 (62.6)			

OR=Odds ratio; CI=Confidence interval; NA=Not available

**Table 3: Correlation between blood pressure and anthropometric parameters of the subjects**

Variables	r (P)	
	Systolic BP	Diastolic BP
BMI	0.41 (<0.001)	0.33 (<0.001)
Waist circumference	0.37 (<0.001)	0.29 (<0.001)
Waist to hip ratio	-0.04 (0.088)	-0.08 (0.002)

BMI=Body mass index; BP=Blood pressure; r=Correlation coefficient

**Table 4: Anthropometric predictors of hypertension among adolescents**

Variables	B	OR	P	95% CI
<b>Systolic</b>				
Waist circumference	0.03	1.03	0.003	1.01–1.05
Waist to hip ratio	-4.90	0.01	<0.001	0.0–0.011
BMI (overweight)	-0.95	0.39	0.001	0.22–0.69
BMI (obese)	-0.45	0.64	0.14	0.35–1.16
<b>Diastolic</b>				
Waist circumference	0.07	1.07	0.002	1.03–1.11
Waist to hip ratio	-3.92	0.02	0.035	0.0–0.76
BMI (overweight)	-0.55	0.58	0.25	0.23–1.46
BMI (obese)	-0.42	0.66	0.42	0.24–1.80

B=Regression coefficient; BMI=Body mass index; OR=Odds ratio; CI=Confidence interval

Systolic hypertension was observed in 232 (9.6%) of the participants. Diastolic hypertension was observed in 85 (3.5%) of participants. The prevalence of systolic hypertension among males and females were 3.3% and 8.2%, respectively ( $P < 0.001$ ). Fifty-five (4.4%) males and 30 (2.5%) females had diastolic hypertension ( $P = 0.01$ ) are shown in Table 1. Both systolic and diastolic hypertension

were not significantly associated with gender ( $P = 0.167$  and  $P = 0.870$ , respectively).

### Obesity and overweight-related hypertension

Forty-two of the 137 obese adolescents (30.7%) had systolic hypertension. Twelve of 41 obese males (29.3%) and 30 of 96 obese females (31.3%) had systolic hypertension, respectively ( $P = 0.866$ ). Systolic hypertension was present in 31 of 173 overweight adolescents (17.9%). Systolic hypertension was significantly higher among obese than overweight adolescents ( $P = 0.019$ ). Prehypertension was present in 20 of 173 overweight (11.6%) and 9 of 137 (6.6%) obese adolescents ( $P = 0.17$ ). Among the 2109 subjects with normal BMI, systolic hypertension was observed in only 159 subjects (7.5%). The prevalence of diastolic hypertension among normal, obese, and overweight subjects were 3.1%, 8.8%, and 4.6%, respectively. The relationship between behavioral risk factors and systolic hypertension is shown in Table 2.

### Correlation of anthropometric variables and blood pressure

Waist circumference ( $r = 0.37$ ,  $P < 0.001$ ) and BMI ( $r = 0.46$ ,  $P < 0.001$ ) had significant positive correlation with systolic. Similarly, there was significant positive correlation between waist circumference ( $r = 0.29$ ,  $P < 0.001$ ) and BMI ( $r = 0.33$ ,  $P < 0.001$ ) and DBP, are shown in Table 3. Waist to hip ratio had a significant but weak negative correlation with DBP ( $r = -0.08$ ,  $P = 0.002$ ) and weak negative correlation with SBP which was not statistically significant ( $r = -0.04$ ,  $P = 0.088$ ). Logistic regression analysis showed that waist circumference ( $P = 0.003$ ), waist

to hip ratio ( $P < 0.001$ ), and being overweight ( $P = 0.001$ ) significantly correlated with systolic hypertension [Table 4]. Waist circumference ( $P = 0.002$ ) and waist to hip ratio ( $P = 0.035$ ) significantly correlated with diastolic hypertension. However, multiple regression analysis showed only BMI to be a significant predictor of hypertension.

## Discussion

The overall prevalence of hypertension observed in this study was 10.7%, which was high compared to 5.4% reported in an earlier study among secondary school adolescents in the same city.<sup>[17]</sup> In that earlier study, prevalence of obesity among their study participants (1.9%) was lower than the prevalence 5.7% (137/2419) in this present study.<sup>[17]</sup> Obesity appeared to be the force driving the prevalence of hypertension upwards within this population. Furthermore, the prevalence of hypertension in this study was higher than 7.2% observed by Mijinyawa *et al.*<sup>[18]</sup> in Kano, Northern Nigeria, and 6% by Oduwole *et al.*<sup>[10]</sup> in Lagos, South-West Nigeria. However, our prevalence rates of both prehypertension and hypertension were lower than figures previously reported by Ejike *et al.*<sup>[19]</sup> in Lokoja, North-central Nigeria. These disparities could be explained by differences in methodology. The study by Ejike *et al.*<sup>[19]</sup> recorded point hypertension and prehypertension. The authors also utilized oscillometric device for blood pressure measurements. Oscillometric method of measurement is not as reliable as the auscultatory method.<sup>[13]</sup> Nonetheless, hypertension and prehypertension are emerging noncommunicable public health challenge among adolescents.

There were more females than males with both systolic prehypertension (10.2% vs. 4.3%) and hypertension (8.2% vs. 3.3%) in this study. This finding was corroborated by Oduwole *et al.*<sup>[10]</sup> among their obese adolescents. In that study, females had higher rates of systolic prehypertension (10% vs. 9.1%) and hypertension (16% vs. 12.1%) than males. A possible explanation for this observation is the higher rates of obesity among female than male adolescents.

Systolic hypertension was 4 times higher among obese than normal weight adolescents (30.7% vs. 7.5%). Adolescents who reported positive family history of obesity and overweight were also more likely to be hypertensive. Oduwole *et al.*<sup>[10]</sup> also documented a significantly higher prevalence of systolic hypertension among obese adolescents than among adolescents with normal BMI. The association between BMI and blood pressure has been attributed to various interacting complex systems that have been observed in obese children. These include over-activity of the renin-angiotensin and sympathetic nervous systems, insulin resistance, abnormalities in vascular structure and function.<sup>[20-23]</sup> The high prevalence of obesity and increased

risk of hypertension associated with obesity underscore the need to incorporate obesity assessment, prevention, and control measures in routine adolescent health-care programs.

In this study, BMI and waist circumference showed significant positive correlation with both systolic and DBP. This relationship was also reported by Pio da and Rosa<sup>[24]</sup> among Brazilian children and adolescents. The study by Burgos *et al.*<sup>[25]</sup> showed similar findings with BMI and waist circumference having significant positive relationship with hypertension. Waist circumference and waist to hip ratio were better predictors of systolic and diastolic hypertension than BMI in this study. This agrees with previous findings by Savva *et al.*<sup>[26]</sup> that waist circumference and waist to hip ratio are better predictors of cardiovascular disease risk factors in children than BMI. Pio da and Rosa,<sup>[24]</sup> however, reported that both BMI and waist circumference predicted systolic and DBP singly and in combination.

A limitation of our study was inability to assess some important risk factors for hypertension in adolescents such as Type 2 diabetes or a high fasting blood glucose level, high cholesterol, and triglycerides. Another limitation was on blood pressures measurement using cuff size that covers 2/3 of the arm length instead of 40–50% of the mid-arm circumference since the later method gives a more accurate measurement. In addition, our study is a survey with cluster data, and analyses should ideally use approaches that account for this type of study design.

## Conclusion

Hypertension was common among the adolescents in this study. Waist circumference and waist to hip ratio were significant predictors of both systolic and diastolic hypertension while BMI significantly predicted only the SBP. Strategies that will ensure normal anthropometric parameters among these adolescents need to be promoted.

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## Conflicts of interest

There are no conflicts of interest.

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