Oscillometric Blood Pressure Profile of Adolescent Secondary School Students in Abakaliki Metropolis

Uchechukwu C. Uko1, Fortune A. Ujunwa2, Uzoamaka Vivian Muoneke2, Pius C. Manyike2, Clifford O. Okike4, Bede C. Ibe1,3
1Department of Paediatrics, Federal Teaching Hospital, 2Department of Paediatrics, College of Medicine, Ebonyi State University, Abakaliki, Ebonyi, 3Department of Paediatrics, College of Medicine, University of Nigeria, Nsukka, Enugu, 4Department of Paediatrics, Federal Medical Centre, Asaba, Delta, Nigeria

Abstract

Context: Adolescence is characterized by a tremendous pace in growth, biological, and psychosocial changes. This may translate to rapid increases in anthropometric parameters and indulgence in youth risk behaviors, and these are the risk factors for arterial hypertension (HTN).

Aim: This study aimed to determine the oscillometric blood pressure (BP) profile of apparently healthy secondary school adolescents in Abakaliki metropolis and its relationship with sex and anthropometric variables. Subjects and Methods: This multistage process selected 2401 students among those aged 10–19 years spanning from August 2015 to January 2016. BP was measured using the oscillometric method. Information on modifiable risk factors for HTN was obtained. Anthropometric parameters were measured. Data were analyzed with Student’s t-test, analysis of variance, and correlation analysis. Results: The mean age (years) of the study population was 15.12 ± 2.29. The mean systolic BP (SBP) and diastolic BP (DBP) were 106.72 ± 11.37 mmHg and 63.60 ± 7.34 mmHg, respectively. Females had significantly higher mean DBP but with no significant gender difference in mean SBP. The means of anthropometric parameters were 49.19 ± 10.28 kg, 1.54 ± 0.10 m, and 20.46 ± 2.86 kg/m² for weight, height, and body mass index, respectively, and all showed significant gender differences, with females having higher values except for height. A relatively low rate of indulgence in alcohol use compared to another study in the same region as well as a significant association of alcohol use among those found to have HTN was noted. The prevalence of HTN was 4.6%, which was significantly higher in females. Conclusions: Routine BP monitoring is recommended for adolescents, especially those with prevailing risk factors including a family history of HTN, obesity, and substance and alcohol misuse. Early detection will help in mitigating the effect of these cardiovascular risk factors.

Keywords: Adolescents, blood pressure, hypertension, oscillometric

Résumé

Contexte: L’adolescence est caractérisée par un rythme de croissance considérable, des changements biologiques et psychosociaux. Cela peut se traduire par rapide. l’augmentation des paramètres anthropométriques et l’indulgence dans les comportements à risque des jeunes, et ce sont les facteurs de risque de l’hypertension artérielle (HTN). But: Cette étude visait à déterminer le profil de pression artérielle oscillométrique d’adolescents apparemment sains du secondaire en La métropole d’Abakaliki et ses relations avec le sexe et les variables anthropométriques. Sujets et méthodes: Ce processus en plusieurs étapes sélectionné 2401 étudiants âgés de 10 à 19 ans entre août 2015 et janvier 2016. La mesure de la pression artérielle a été réalisée à l’aide de la méthode oscillométrique. Des informations sur les facteurs de risque modifiables pour HTN ont été obtenues. Les paramètres anthropométriques ont été mesurés. Les données ont été analysées avec la méthode de Student. test t, analyse de variance et analyse de corrélation. Résultats: L’âge moyen (années) de la population à l’étude était de 15,12 ± 2,29. La moyenne systolique BP (SBP) et diastolique BP (DBP) étaient respectivement de 106,72 ± 11,37 mmHg et 63,60 ± 7,34 mmHg. Les femmes avaient une moyenne significativement plus élevée DBP mais sans différence significative entre hommes et femmes dans le SBP moyen. Les moyennes des paramètres anthropométriques étaient de 49,19 ± 10,28 kg, 1,54 ± 0,10 m, et 20,46 ± 2,86 kg / m² pour le poids, la taille et l’indice de masse corporelle, respectivement, et

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Address for correspondence: Dr. Uzoamaka Vivian Muoneke, Department of Paediatrics, College of Medical Sciences, University of Nigeria, Enugu Campus, Nsukka, Enugu State, Nigeria. E-mail: vizym@yahoo.com

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tous ont montré des différences significatives entre les sexes, avec les femmes ayant des valeurs plus élevées sauf pour la hauteur. Un taux de consommation d’alcool relativement faible par rapport à une autre étude menée dans la même région ainsi qu’une association significative de consommation d’alcool chez les personnes présentant un HTN. La prévalence de HTN était de 4,6%, ce qui était significativement plus élevé chez les femmes. Conclusions: La surveillance systématique de la TA est recommandée chez les adolescents, en particulier ceux à risque prédominant facteurs, y compris des antécédents familiaux de HTN, d’obésité et d’abus de substances et d’alcool. Une détection précoce aidera à atténuer les effets de ces facteurs de risque cardiovasculaires.

Mots-clés: Adolescents, tension artérielle, hypertension, oscillométrie

**INTRODUCTION**

Blood pressure (BP) is the pressure exerted by circulating blood upon the walls of blood vessels. BP normally varies with age, sex, and time of day as well as ethnicity. BP also demonstrates tracking, implying that those that rank at higher ranges of normal are more likely to progress into hypertensive levels in later life. Deviations of BP adversely affect tissue perfusion and could lead to severe disease and death, and may constitute the basis for the investigation of relevant control systems.

Accurate BP measurements should be part of routine physical examination of all children, 3 years or older. The American Academy of Pediatrics recommends routine screening of asymptomatic adolescents and children during preventive care visits, as treatable causes of secondary hypertension (HTN) such as coarctation of the aorta can potentially be identified.

Prevalence data obtained for HTN among adolescents nationally range from 2.5% to 5.4%. HTN in childhood had been considered a risk factor for HTN in early adulthood. Children and adolescents with primary HTN are frequently overweight. Data on healthy adolescents obtained in school health screening programs demonstrate that the prevalence of HTN increases progressively with increasing body mass index (BMI), and HTN is detectable in approximately 30% of overweight children (BMI >95th percentile). Overweight and HTN are also components of metabolic syndrome, a condition of multiple metabolic risk factors for cardiovascular diseases as well as for Type 2 diabetes mellitus.

Our study site is an evolving city initially predominated by farmers; with rapid urbanization and its effects on lifestyle, there may be effect on their BP profile. In addition, the study site has large salt deposits which contaminate the underground water to levels beyond the WHO standard. These underground sources constitute a significant proportion of domestic water source (including for cooking) in the state. Excessive consumption of salt (table salt) is known to raise the BP, however, the effect of other forms of salts is not certain. It is justified then to study the BPs of consumers of such type of water source.

Systemic HTN which is now commonly seen in children is a major cause of morbidity and mortality. Left ventricular hypertrophy is the most common morbidity from HTN, and early detection helps in reversing this complication. In addition, adolescents are usually assumed to be a healthy population, thus are not routinely screened for HTN despite having modifiable risk factors for this condition. Such adolescents may then develop the complications of HTN if the condition had been present for long undetected.

Mercury sphygmomanometer – an auscultatory method – is considered to be the gold standard for indirect arterial pressure measurement in clinical studies. This method has shortcomings that include systematic error, terminal digit preference, and observer prejudice. Errors in measurement caused by these have not been appreciably mitigated by device modifications and operator trainings and re-trainings.

The auscultatory method is also the standard against which other indirect arterial pressure measurement methods are evaluated. Evaluation protocols include the British Hypertension Society (BHS) protocol and the standard set by the United States Association for the Advancement of Medical Instrumentation (AAMI). The BHS protocol requires that devices must achieve at least Grade B (where A denotes greatest and D least agreement with mercury standard) for systolic BP (SBP) and diastolic BP (DBP). The AAMI protocol requires that the test device must not differ from the mercury standard by a mean difference >5 mmHg, or a standard deviation (SD) >8 mmHg. Most validation studies utilize joint criteria drawn from both protocols – the international protocol.

In most of the previous studies done in our environment, BP determinations were done with the auscultatory method. The oscillometric method of BP determination circumvents the earlier highlighted shortcomings of the auscultatory type. In a validation study in children, readings from the clinically validated oscillometric device closely matched sphygmomanometric measurements. However, inaccurate readings may be given in pregnancy and preeclampsia and atherosclerosis by the oscillometric BP monitor. Our measurement device, OMRON M10 IT (Omron Health care Company Ltd., Muko, Kyoto, Japan) was validated according to the international protocol (Grade A in the BHS and passing the AAMI). We thus decided to use this method for this study.

This study, thus, aims to determine the BP profile of adolescents in Abakaliki, its relationship with sex and anthropometric parameters, and the prevalence of HTN among them.
Subjects and Methods

Study area and population

The study was carried out in Abakaliki, the capital city of Ebonyi State in South-Eastern Nigeria. Several minerals are found in commercial quantities across the state including lead, zinc, copper, aluminum, coal, lignite, gypsum, and salt. The study population consisted of secondary school students in Abakaliki metropolis.

Inclusion criteria

1. Apparently healthy adolescent schoolchildren within ages 10–19 years.

Exclusion criteria

1. Children manifesting clinical evidence of cardiovascular and/or renal anomalies (body swelling, palpitation, shortness of breath on mild exertion, oliguria, and pallor).

Ethical approval was obtained from the Research and Ethics Committee of the Federal Teaching Hospital Abakaliki. Permission was also obtained from the Secondary Schools Education Board of Ebonyi State. Parents’ informed consent and respondents’ assent were obtained.

A multistage sampling procedure was used to select the children from the schools to achieve the determined sample size of 2401. All the eight public- and five private-approved schools in the metropolis were sampled. Each contributed proportionately to the sample size. The school registers were used to arrange the children according to age as of the last birthday. The first student in each school was selected by simple random sampling, and an interval width was applied subsequently to consecutively recruit the students. Data pro formas – to obtain relevant histories – were issued to the selected students to take home for completion with their parents. Those who did not return theirs were replaced with the next individuals in the ordered list. Students’ recruitment continued until the required sample size was accomplished.

Data collection

A research team was trained to collect and record data. The students were prepared for BP measurement as outlined in the Fourth Report on the Diagnosis, Evaluation, and Treatment of High BP in Children and Adolescents (Fourth Report);[12] the right arm was preferred for consistency and for comparison to standard BP tables. BP was measured using the oscillometric method, with the OMRON M10-IT digital BP monitor.[26] The device came with a free size cuff that covers for sizes 22 cm to 42 cm,[26] which cover from child cuff to large adult cuff sizes (child – 22 cm, small adult – 26 cm, adult – 34 cm, and large adult – 44 cm).[26] Thigh cuff was not covered however and was not required in this study. The programmed device took three measurements at intervals of 2 min, for each student, and an average of the three readings was displayed. The intervals allowed the arteries to return to the premeasurement state before the next measurement.[27,28] All measurements were done during break periods (11:20 am to 11:50 am) to minimize disruption in school activities.

HTN was determined by categorizing the students into BP percentiles according to the recommendations in the Fourth Report.[12] The BP percentile for each student was determined with an online calculator differently for boys[30] and girls.[30] HTN was defined as average SBP or DBP that is ≥95th percentile for sex, age, and height on at least three separate occasions.[12]

Above 17 years of age, the adult BP categorization which uses the JNC 7 category (Joint National Committee on Prevention, Evaluation, and Treatment of High BP) was employed with BP readings of <120/80 mmHg taken as normal, 120–139/80–89 mmHg as pre-HTN, and ≥140/90 mmHg as HTN. Stage 1 HTN was noted as BP of 140–159/90–99 mmHg, whereas stage 2 was taken as BP of ≥160/≥100 mmHg.[31]

Students with elevated BP on the first measurement had the measurement repeated with a mercury sphygmomanometer. This was repeated two other times with 1-week intervals.

Height was measured using a mobile stadiometer, to the nearest 0.25 cm using standardized methods.[32] Weight was measured with an Omron digital scale HN 289 which is accurate to 0.1 kg. BMI was calculated as weight in kg/(height in meters²) and the unit is in kg/m².[33] BMI ≥95th percentile meets the criterion for obesity, and a BMI between the 85th and 95th percentiles defines overweight, using the Centre for Disease Control classification system.[33] The percentile of BMI for each student was calculated with an online calculator differently for males[34] and females.[35]

Information on the risk factors for HTN was also obtained. Consumption of <8 g and >16 g daily of alcohol was classified as insignificant and significant alcohol intake, respectively.[36] Sixteen grams of alcohol is contained in just one can of beer. Alcohol content of beers in Nigeria ranges from 4.7% to 7.5% per can.[37] Gin has about 40% of alcohol.[38] Smokers were classified as those who smoke any form of tobacco or marijuana either occasionally or daily.

Junk food was defined as food high in calories and low in nutritional content. Examples include potato chips, soft drinks, sausages, meat pie, buns, ice creams, and biscuits. Consumption of junk foods was defined as intake ranging from up to three times a week to more than or equal to once a day.[17]

Social class of the students was determined with the method as outlined by Olusanya.[39] Participants who were found to be hypertensive were referred for further evaluation and treatment.

Data analysis

Data analysis was done with SPSS software version 20 (IBM Corporation, Armonk, New York, USA). Data were presented in the form of tables and figures. The means of anthropometric and BP parameters were compared between the sexes and between public and private school students with Student’s t-test. Analysis of variance was used to compare
the means of anthropometric and BP parameters among the ages. Ninety-five percent confidence limit was used for the BP ranges. Correlation analysis was done between the obtained BP parameters and anthropometric variables.

**Ethics approval and consent to participate**

Ethical approval was obtained from the Research and Ethics Committee of the Federal Teaching Hospital Abakaliki. Permission was also obtained from the Secondary Schools Education Board of Ebonyi State. Parents’ informed consent and respondents’ assent were obtained.

Consent and assent to publish the obtained data were also obtained from the parents and respondents, respectively.

**Results**

**Sociodemographic profile**

The participating respondents were 2401 comprising 1196 (49.81%) males and 1205 (50.19%) females, giving a male: female ratio of 1:1.01. Their age ranged from 10 years to 19 years. The mean age ± SD of the population was 15.12 ± 2.29 years, with males aged 15.12 ± 2.29 years and females aged 15.12 ± 2.29 years ($P = 0.34$). Among the 2401 students, 797 (33.19%), 463 (19.28%), and 1096 (45.65%) belonged to the upper, middle, and lower socioeconomic classes, respectively. Among the students, 392 (16.33%) had a positive family history of HTN defined as HTN in a first-degree relative, in this case either or both parents. Eighty-seven (3.62%) out of the 2401 students consumed significant quantities of alcohol.

**Blood pressure pattern and relationship with age and gender**

The SBP of the study population ranged from 76 mmHg to 161 mmHg and the DBP from 45 mmHg to 105 mmHg. The means ± SD of SBP and DBP of the study population were 106.72 ± 11.37 mmHg and 63.60 ± 7.34 mmHg, respectively. The mean DBP of the study population was statistically significantly higher in the females (65.30 ± 7.32 mmHg) compared to the males (61.90 ± 6.96 mmHg) ($P = 0.00$). There was no statistically significant gender difference in the mean SBP, with SBP of 106.98 ± 10.21 in the females and 106.46 ± 12.43 in the males ($P = 0.27$).

Table 1 shows the distribution of mean SBP ± SD and DBP ± SD of the study population according to age and sex. Females recorded significantly higher SBP ± SD values at 10, 12, 13, and 14 years, whereas males recorded significantly higher values at 17, 18, and 19 years.

For the DBP ± SD of the study population, females recorded significantly higher values in all ages except at 11 years where there was no significant difference.

BP was seen to increase with age as shown in Table 1. Figures 1 and 2 summarily show the variation of the BP parameters with age.

**Table 1: Distribution of mean systolic blood pressure±standard deviation and mean diastolic blood pressure±standard deviation of the study population according to age and sex**

| Age (years) | Male SBP (mmHg) | Female SBP (mmHg) | t     | $P$ | Male DBP (mmHg) | Female DBP (mmHg) | t     | $P$ |
|------------|----------------|-------------------|-------|-----|----------------|-------------------|-------|-----|
| 10         | 94.10±7.67     | 99.38±9.78        | −2.29 | 0.00*| 58.34±5.77     | 65.90±8.13        | −4.08 | 0.00*|
| 11         | 97.29±8.68     | 96.04±9.39        | 0.70  | 0.48 | 61.12±7.86     | 60.63±7.26        | 0.32  | 0.75 |
| 12         | 95.76±9.81     | 104.36±10.44      | −6.28 | 0.00*| 59.88±6.54     | 64.31±8.10        | −4.45 | 0.00*|
| 13         | 97.63±10.26    | 103.44±9.82       | −4.27 | 0.00*| 59.81±5.97     | 63.76±6.25        | −4.78 | 0.00*|
| 14         | 102.86±11.00   | 106.60±9.33       | −3.06 | 0.00*| 61.61±7.24     | 64.69±7.55        | −3.47 | 0.00*|
| 15         | 106.92±10.76   | 108.14±8.49       | −1.31 | 0.19 | 61.94±6.80     | 65.37±6.86        | −5.24 | 0.00*|
| 16         | 109.35±10.09   | 107.80±10.46      | 1.47  | 0.14 | 61.81±6.34     | 65.84±7.40        | −5.70 | 0.00*|
| 17         | 113.48±10.40   | 110.33±10.19      | 2.71  | 0.01*| 63.80±7.62     | 66.97±7.51        | −3.71 | 0.00*|
| 18         | 113.83±10.93   | 110.18±8.99       | 2.79  | 0.01*| 63.68±5.70     | 66.16±6.52        | −3.07 | 0.00*|
| 19         | 116.91±11.23   | 109.52±9.91       | 4.49  | 0.00*| 63.61±8.17     | 66.58±7.08        | −2.50 | 0.01*|

*Statistically significant $P$ values at 0.05 level of significance. SBP: Systolic blood pressure, DBP: Diastolic blood pressure

**Figure 1:** Graph of the variation of mean systolic, diastolic, and mean arterial pressures with age for males

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weight ± SD, and mean BMI ± SD of males and females. The mean height of males (1.56 ± 0.11 m) was found to be statistically significantly higher compared to that of females (1.53 ± 0.07 m) \( (P = 0.00) \), whereas the mean weight (49.92 ± 9.19 kg) and BMI (21.19 ± 2.92 kg/m\(^2\)) of females were found to be statistically significantly higher compared to that of males (48.46 ± 11.22 kg and 19.74 ± 2.60 kg/m\(^2\), respectively) \( (P = 0.00 \) for both).

The anthropometric variables were also found to increase with age and correlated positively with SBP and DBP [Tables 3 and 4].

### Prevalence of hypertension

Among the students, 110 were found to have HTN, giving a prevalence of 4.6%; females constituted 65 (5.4%), whereas males constituted 45 (3.8%), and the female proportion was statistically significantly higher \( (P < 0.01) \). The proportions of students with HTN, pre-HTN and normal BP. Data from this study were compared with the BP data from the Fourth Report to determine cutoffs as the Fourth Report was obtained across different races and ethnic groups.\(^{[39]}\)

### Risk factors

Among the entire study population, 162 (6.8%) were overweight, whereas 31 (1.3%) had obesity. The prevalence of HTN among the overweight was 4.32%. Normal BP readings were found in 25 (80.65%) of the obese, whereas HTN occurred in two students (6.45%). Overweight and obesity did not significantly affect the prevalence of HTN in this study.

Table 5 summarizes the relationships of other risk factors and HTN. The table shows that only alcohol use by the students and their fathers and being in the higher socioeconomic class posed significant risks for the development of HTN.

### Discussion

The study showed that the mean SBP ± SD and DBP ± SD of the population of 106.72 ± 11.371 mmHg and 63.60 ± 7.34 mmHg, respectively, obtained by oscillometric method were comparable to the findings obtained by Ayoola\(^{[10]}\) in Ibadan and Okpokowuruk \textit{et al}.\(^{[39]}\) in Uyo (whose results were slightly

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**Table 2: Mean anthropometric characteristics of the study population**

| Variables | Male | Female | Minimum | Maximum | \( t \)-test | \( P \) |
|-----------|------|--------|---------|---------|-------------|-------|
| Age (years) | 15.12±2.29 | 15.12±2.29 | 10 | 19 | 0.03 | 0.97 |
| Weight (kg) | 48.46±11.22 | 49.92±9.19 | 23.00 | 103.3 | −3.48 | 0.00* |
| Height (m) | 1.56±0.11 | 1.53±0.07 | 1.24 | 1.90 | 6.70 | 0.00* |
| BMI (kg/m\(^2\)) | 19.74±2.60 | 21.19±2.92 | 13.23 | 42.57 | −12.90 | 0.00* |

*Statistically significant \( P \) values at 0.05 level of significance. BMI=Body mass index

**Table 3: Age distribution of anthropometric variables for males and females**

| Age (years) | Weight (kg)±SD | Height (m)±SD | BMI (kg/m\(^2\))±SD |
|-------------|----------------|---------------|----------------------|
| Males | Females | Males | Females | Males | Females |
| 10 | 33.12±4.30 | 36.5±5.78 | 1.39±7.33 | 1.43±7.56 | 17.00±1.28 | 17.59±1.60 |
| 11 | 35.85±7.38 | 39.12±8.15 | 1.39±7.38 | 1.45±8.34 | 18.49±2.61 | 18.52±2.56 |
| 12 | 36.52±5.33 | 41.61±9.22 | 1.43±6.95 | 1.48±7.86 | 17.77±1.68 | 18.94±2.95 |
| 13 | 38.46±6.73 | 44.93±6.27 | 1.46±7.91 | 1.50±6.34 | 17.93±1.67 | 19.85±2.15 |
| 14 | 43.64±7.70 | 49.48±9.04 | 1.52±8.07 | 1.54±6.24 | 18.73±2.03 | 20.89±3.02 |
| 15 | 48.51±8.05 | 51.58±7.06 | 1.57±7.61 | 1.55±5.85 | 18.60±2.17 | 21.58±2.57 |
| 16 | 52.02±8.72 | 52.35±6.94 | 1.60±7.61 | 1.55±6.22 | 20.23±2.49 | 21.80±2.43 |
| 17 | 56.34±7.26 | 54.17±6.73 | 1.64±6.09 | 1.56±5.86 | 20.98±2.09 | 22.38±2.32 |
| 18 | 58.87±8.17 | 55.84±8.01 | 1.65±7.84 | 1.56±11.1 | 21.72±2.57 | 22.81±2.92 |
| 19 | 60.99±7.86 | 53.61±8.80 | 1.66±7.05 | 1.54±6.37 | 22.22±2.20 | 22.43±2.51 |
| Mean | 46.43±7.15 | 47.88±7.60 | 1.53±7.38 | 1.52±6.68 | 19.37±2.08 | 20.68±2.50 |

\( F \) (ANOVA) 0.22 18.16 2.51 7.87 0.99 15.26

ANOVA: Analysis of variance, SD=Standard deviation, BMI=Body mass index
lower than that of the present study), even though both used the auscultatory method. Figures obtained from other researchers who used the auscultatory method appeared to be higher than those obtained from our study. The DBP obtained in our study, however, appeared lower than the values obtained from the other studies from the East (Enugu and Port Harcourt). The difference may be due to environmental and social factors at play. Different populations may be exposed to different degrees of factors that modify BP. For example, it has been suggested that the hardness in the Abakaliki water could have a significant effect in reducing the BP as well as other cardiovascular risks. This slight reduction in DBP may also play a role in the methodology. A study from Lagos which used the oscillometric device also showed a slight reduction in DBP. Hence, this device which eliminated the shortcomings of the auscultatory method may have accounted for this.

In this study, the SBP and DBP correlated positively with age. This is comparable to other findings. This is because the studied anthropometric variables increase with age, and due to hormonal influences. This has been documented by previous authors. It has also been postulated that it may have to do with the standing height and the need for the heart to generate enough pressure to perfuse the brain at the standing height. Thus, as the height increases, so does the BP though there is a ceiling to this effect; thus, the normal BP does not

### Table 4: Correlations of blood pressure with anthropometric parameters

|              | SBP mean | DBP mean |
|--------------|----------|----------|
| Weight (kg)  | Pearson’s correlation 0.54 | 0.22 |
|              | $P$       | 0.00     | 0.00     |
| Height (m)   | Pearson’s correlation 0.49 | 0.14 |
|              | $P$       | 0.00     | 0.00     |
| BMI (kg/m²)  | Pearson’s correlation 0.40 | 0.22 |
|              | $P$       | 0.00     | 0.00     |

*Statistically significant $P$ values at 0.05 level of significance. SBP=Systolic blood pressure, DBP=Diastolic blood pressure, BMI=Body mass index

### Table 5: Relationship between high blood pressure and other risk factors

| Risk factors                  | Hypertensives (%) | Nonhypertensives (%) | Total | $P$   |
|-------------------------------|-------------------|----------------------|-------|-------|
| Eating habit                  |                   |                      |       |       |
| Eats heavily                  | 15 (4.3)          | 332 (95.7)           | 347   | 0.38  |
| Eats moderately               | 52 (2.9)          | 1737 (97.1)          | 1789  |       |
| Eats scantily                 | 8 (3.0)           | 257 (97.0)           | 265   |       |
| Consumption of junk food      |                   |                      |       |       |
| Yes                           | 38 (3.4)          | 1093 (96.6)          | 1131  | 0.53  |
| No                            | 37 (2.9)          | 1233 (97.1)          | 1270  |       |
| Alcohol use                   |                   |                      |       |       |
| Yes                           | 11 (12.6)         | 76 (87.4)            | 87    | 0.00* |
| No                            | 64 (2.8)          | 2250 (97.2)          | 2314  |       |
| Cigarette smoking             |                   |                      |       |       |
| Yes                           | 0 (0)             | 14 (100)             | 14    | 0.50  |
| No                            | 75 (3.1)          | 2312 (96.9)          | 2387  |       |
| Family history of HTN         |                   |                      |       |       |
| Yes                           | 18 (4.6)          | 374 (95.4)           | 392   | 0.07  |
| No                            | 57 (2.8)          | 1952 (97.2)          | 2009  |       |
| Does father smoke cigarette? |                   |                      |       |       |
| Yes                           | 5 (4.3)           | 112 (95.7)           | 117   | 0.46  |
| No                            | 70 (3.1)          | 2214 (96.9)          | 2284  |       |
| Does father take alcohol?     |                   |                      |       |       |
| Yes                           | 28 (5.1)          | 524 (94.9)           | 552   | 0.00* |
| No                            | 47 (2.5)          | 1802 (97.5)          | 1849  |       |
| Does mother smoke cigarette? |                   |                      |       |       |
| Yes                           | 0 (0)             | 14 (100)             | 14    | 0.50  |
| No                            | 75 (3.1)          | 2312 (96.9)          | 2387  |       |
| Does mother take alcohol?     |                   |                      |       |       |
| Yes                           | 2 (2.0)           | 97 (98.0)            | 99    | 0.52  |
| No                            | 73 (3.2)          | 2229 (96.8)          | 2302  |       |
| Socioeconomic status          |                   |                      |       |       |
| Higher socioeconomic class    | 16 (2.0)          | 781 (98.0)           | 797   | 0.05  |
| Middle socioeconomic class    | 14 (3.0)          | 449 (97.0)           | 463   |       |
| Lower socioeconomic class     | 45 (3.9)          | 1096 (96.1)          | 1141  |       |

*Statistically significant $P$ values at 0.05 level of significance. HTN=Hypertension
increase above 120/80 mmHg. As height cannot be reduced for an individual, weight reduction becomes then the available option for BP control.

Rapid increases in BP were noted at the time of puberty. This is in agreement with other studies.\textsuperscript{[11,15]} This could be explained by the hormonal changes referred to above which involve the surges of gonadal hormones including testosterone and estrogen primarily and also other hormones which are mainly steroid hormones. It is postulated that these hormones could have important transcriptional effects on maturing organ systems such as kidney and vasculature with lasting consequences for BP.\textsuperscript{[13]} This highlights the influence of hormones in achieving final adult BP levels.

The rapid increases in BP occurred at ages 13, 14, 16, and 17 years in males; similar occurrence was noticed in females at ages 11, 12, 16, and 17 years. The later increases reflect the period of growth spurt during the end of adolescence. The earlier increases reflect the growth spurt at the onset of hormonal changes that occur at the onset of puberty. Similarly, another study\textsuperscript{[15]} showed that BP increased more rapidly during puberty. In addition to increases in body size, this increase in BP was also attributed to a surge in the gonadal hormones including testosterone, estrogen, growth hormone, and cortisol, with a dominating testosterone effect manifesting as higher BP in males; the effects of these gonadal hormones on BP cited by Shankar et al.\textsuperscript{[17]} were similar to those of other studies.\textsuperscript{[14,7-50]} The pubertal increase in BP occurred earlier in the females, as observed from other studies.\textsuperscript{[10,11,15]} This may be because puberty occurs earlier in females\textsuperscript{[22]} and also due to the consequences of sex-related hormonal activities; estrogen, the early predominant sex hormone in females has been demonstrated to increase the peripheral expression of angiotensinogen,\textsuperscript{[19]} as well as to increase the endothelial expression of sodium channels.\textsuperscript{[32]} These are directly involved in BP elevation.

The significantly higher BMI among females in this study may have an additional role. The implication of this sexual dimorphism in BP profile during puberty is that children who have more exuberant hormonal activities may have higher BPs than their peers and thus more likely to become hypertensive due to the phenomenon of BP tracking.\textsuperscript{[22]} This was evidenced in the higher BPs and prevalence of HTN recorded among the females in this study. Similar findings were obtained in other studies using the auscultatory method.\textsuperscript{[10,11]}

The prevalence of HTN in the study population was 4.6% (male and female prevalence were 3.8% and 5.4%, respectively). This prevalence is higher than the values obtained in several other studies\textsuperscript{[8-10]} but lower than that obtained in another study,\textsuperscript{[11]} all in the adolescent age group. The differences in prevalence among the different studies reported may be due to varying methodology, different criteria for the diagnosis of HTN, regional differences, as well as due to the methods of extraction of the hypertensive individuals from the obtained data. Extraction of those considered to be hypertensive from the obtained data by applying ranges to grouped ages or by applying a single cutoff value to all data may omit some hypertensive individuals, as against using the percentile for each individual represented in the data set. However, the prevalence is within the range observed nationally for adolescents which ranged from 2.5% to 5.4%.\textsuperscript{[8-11]} The gender difference obtained is also similar to that of previous studies.\textsuperscript{[8,11]}

The greater percentage of stage I HTN and pre-HTN among the adolescents buttresses the importance of lifestyle modification and avoidance of risk factors such as alcohol intake, physical inactivity, and smoking. In this study, only significant alcohol intake was found to affect the BP of the respondents; similar findings were obtained in another study\textsuperscript{[22]} but was at variance with findings in other studies.\textsuperscript{[11,53,54]} Alcohol intake was found to be relatively low with a prevalence of 3.6% compared to the study by Ujunwa et al.\textsuperscript{[11]} who recorded 38.4%.

Family history of HTN was found in this study to be independent of BP profile. Other studies,\textsuperscript{[49,54]} however, found the contrary. Essential HTN is known to have genetic predisposition.\textsuperscript{[3]} The contrast may be due to the following: HTN is largely asymptomatic; thus, many sufferers are unaware of their status because people in this population do not routinely check their BP. In addition, the people are commonly in denial of chronic health conditions including HTN. These may reduce the numbers that get to health records. All these imply that the true data on family history may not be representative. Thus, proper health education should be encouraged in order to create this awareness.

The prevalence of obesity in this study was 1.3% and the obesity-related HTN was 10%. This prevalence is higher than the value of 0.3% in Ile-Ife,\textsuperscript{[27]} but comparable with 1.9% in Enugu\textsuperscript{[11]} and much less than 12% obtained in a Caribbean population.\textsuperscript{[47]} The differences may reflect differences in genetic, cultural, and physical activities and socioeconomic status. In this study, however, obesity was not shown to be significantly related to HTN. This contradicts the findings of several other authors.\textsuperscript{[11,28]} This may imply that the cultivation of urbanized lifestyle in this emerging city has not advanced to extensive levels; this existing extent, however, is still worrisome for a developing economy that is still battling with basic health issues including communicable diseases. Hence, there is a need to start interventional mechanism to curb it through effective counseling and health education.

Our study was limited by unavailability of biochemical profile of some of the respondents who were excluded on account of a history of chronic diseases and the absence of established BP reference values in Nigeria. This study relied on the standards made out in the Fourth Report to define cutoffs. This may cause misclassification of BPs as there may be important differences in BP profiles for different ages, gender, and anthropometric parameters between the Nigerian adolescent population and the populations used to generate the data in the fourth report.
Conclusions
BP measurement should be made to be part of routine physical examination in all secondary schoolchildren, especially the adolescents among them. Self-monitoring of BP should be encouraged particularly in those with attendant risk factors. Adequate health education and routine BP monitoring should be incorporated into the school health program.

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Conflicts of interest
There are no conflicts of interest.

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