BLOOD PRESSURE PATTERN IN HEALTHY NIGERIAN ADOLESCENTS

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ABSTRACT

Background

The rising prevalence of primary hypertension in the paediatric population worldwide presents a worrisome trend, emphasizing the need to determine blood pressure (BP) levels and its correlates in healthy Nigerian adolescents.

Materials and Methods

A cross-sectional study of 1179 students aged 10-17 years (538 males and 641 females) was conducted in Gwagwalada. BP was measured using the mercury sphygmomanometer.

Results

Mean (SD) SBP increased significantly from 96.7 (10.8) mm Hg at 10 years, to 116.8 (11.1) mm Hg at 17 years, $p < 0.01$. Mean (SD) DBP also increased significantly from 62.8 (8.3) mm Hg at 10 years, to 74.5 (10.6) mm Hg at 17 years, $p < 0.01$. SBP and DBP correlated positively and significantly with age, weight, and body mass index, $p < 0.01$. Independent predictors of SBP were age ($\beta = 0.154$, $p < 0.01$), and height ($\beta = 0.281$, $p < 0.05$), and age ($\beta = 0.205$, $p < 0.01$), and weight ($\beta = 0.527$, $p < 0.05$) for DBP. There was no significant relationship between blood pressure, and gender, socio-economic class, and place of residence, $p > 0.05$, respectively. The prevalence of systolic and diastolic hypertension was 8.0 and 6.8 percent, respectively.

Conclusion

The significant correlation of BP with age and body size highlights the need for age and anthropometry based regional BP reference charts.

INTRODUCTION

Hypertension is one of the most common non-communicable diseases in developing countries, and constitutes a major health problem worldwide.[88] It contributes significantly in itself, and as a major risk factor for cardiovascular disease, to the huge global burden of morbidity and mortality from preventable causes.[88] Childhood blood pressure has been described as the strongest of all known predictors of adult blood pressure.[1] And substantial evidence has established that the roots of adult hypertension, extend into adolescence and childhood.[1-7] Thus, in the prevention of adult hypertension and its sequelae, it is crucial, not only to ensure normal blood pressure levels, but also to identify early those children at risk, as well as to expedite effective management of elevated blood pressure levels in children and adolescents.[42]

The recognition of these facts, as well as the rising prevalence of essential hypertension in children and adolescents and the long term health risks,[8-10] have emphasized the need to determine the normal blood pressure distribution and its correlates in the paediatric age group, for early identification and management of those found to have elevated blood pressure levels.[11-14] The success of such preventive strategies in any population, requires in-depth knowledge of the blood pressure distribution and its correlates, for standard epidemiologic definitions of normal and abnormal blood pressure levels, for the target population.[2,42]

Blood pressure is affected by several factors, which include age,[1-12,36-39] gender,[10,19] body size,[13,38,40] race or ethnicity,[9,14,30] socioeconomic status,[29,41] and environment or place of residence.[23,25,28] Over the last few decades, studies on paediatric blood pressure pattern and its correlates have been conducted in different populations.[15-30] A number of these have demonstrated some variation in the levels and trends of blood pressure, from one population to another,[19-22] suggesting possible population differences in responses, to some of the factors that influence blood pressure levels, notably growth and maturation patterns.[19-22]

Numerous studies on blood pressure profiles in Nigerian children, have been conducted in different localities of the country, using different methods.[10,25-29,39,41,50,51] However, a greater proportion of these studies have been in the southern part of the country,[10,26,29,39,41,50,51] with fewer documented studies in the north,[25,27,28] and none involving children living in the Federal Capital Territory (FCT) documented. It is noteworthy that this area has an attendant rapid urbanization rate. This study was therefore, undertaken to describe the blood pressure pattern of apparently healthy adolescents aged 10 to 17 years, residing in Gwagwalada Area Council of the FCT, Nigeria.

SUBJECTS AND METHODS

The study was a prospective, descriptive, and cross-sectional one, carried out in secondary schools in Gwagwalada Area Council, of the Federal Capital Territory of Nigeria (FCT), between January and March, 2012. A multi-stage sampling technique was used to select 1292 subjects for the study. Apparently healthy students aged 10 to 17 years, with informed and written consent from parents/guardians and child, were included in the study.

There were 16 accredited co-educational secondary schools in the area council, with a total population of 24,023 students. Ten schools (6 public, 4 private) were located in the urban areas, and 6 (3 public, 3 private) in the rural areas. Three urban schools (2 public and 1 private) and 2 rural schools (1 public, 1 private), representing 30 percent of schools in the urban and rural areas, respectively,[93] were selected by ballot, with a total number of 9302 students in the sample frame. The sample fraction was then calculated to obtain the number of subjects selected from each school by proportional allocation of the sample size i.e. (number of students in a selected school x calculated sample size) ÷ total number of students in the sample frame. The selected schools were stratified into classes, and subjects were selected from each class using the class registers at the calculated sample interval of 7 (9302 divided by 1292). Students who declined to participate, or failed to meet the inclusion criteria were replaced by the next student on the roll, until recruitment was completed.[94]

DATA COLLECTION

The selected schools were visited during weekdays, between 8 a.m. and 2p.m. At the first contact, the selected subjects were introduced to the investigator and trained assistants, and the objectives of the study were explained to the subjects. Questionnaires requesting information on socio-demographic characteristics, and consent forms were given to each subject to be completed and signed at home by both the subjects and a parent or guardian. Socio-economic class (SEC) was assigned to subjects using the father's occupation and mother's educational level.[95] Questions on the presence of illnesses suggestive of cardiovascular, respiratory, renal and endocrine disorders, as well as drug history were also included. At the second contact, each questionnaire and consent form was checked for proper completion and consent. Subjects with a history of illnesses or use of medication known to affect blood pressure, as well as abnormal urinalysis, were excluded from further participation in the study. A thorough physical examination was performed on each subject by the investigator in a screened area of the room, in the presence of a gender-appropriate chaperone, with emphasis on the cardiovascular and respiratory systems, as well as the abdomen. A clinical mercury-in-glass thermometer was used to measure temperature. Students with abnormal examination findings were also excluded from the study and referred to the Teaching Hospital, for further evaluation.

Anthropometry:

Height in centimeters (cm) was measured using a portable Shorrboard® stadiometer (Shorr Productions, Olney, Maryland). The subject was barefoot, standing erect with the heels, back and occiput against the vertical scale of the stadiometer. The subject's head was positioned to look forward with the lower border of the eye sockets in the same horizontal plane as the external auditory meati. The horizontal board attached to the vertical scale of the stadiometer was then lowered until it touched the subject's head. The scale was then read to the nearest 0.1cm.[96] Weight in kilograms (kg) was measured using a Seca® 878 electronic personal scale, which had an accuracy of 0.05kg. The subjects were weighed standing barefoot, wearing only their school uniforms with emptied pockets, and the weight was read to the nearest 0.1kg. The accuracy of the scale was confirmed daily using standard weights, before weighing of subjects commenced, and repeated at regular intervals.[96] BMI in kg/m^2 was calculated by dividing the weight (kg) by the square of the height (m). Age and gender-specific percentiles for height, weight and BMI were determined using the Centres for Disease Control and Prevention (CDC) clinical growth charts[97] to obtain stature-for-age and weight-for-age percentiles, and BMI-for age percentiles, recommended by the World Health Organization (WHO), for international use.[98] Subjects with BMI percentiles equal to or greater than the 95th percentile for age and gender, were classified as obese.[98]

Blood pressure:

All blood pressure measurements were carried out by the principal investigator in accordance with the recommendations of the Task Force on BP Control in Children,[2] using a standard mercury sphygmomanometer (Accoson Dekamet®, A.C. Cossor & Son Surgical Ltd, Accoson Works, Harlow, Essex), and the open bell of a Littmann® stethoscope. Measurements were carried out between 8 a.m. and 12 noon in a quiet classroom. The subject was seated and had rested for at least five minutes, and the right arm was fully exposed, extended and supported on a horizontal surface, at the level of the heart. An appropriate-sized cuff covering at least two-thirds of the arm without obstructing the antecubital fossa was used. The centre of the cuff bladder was placed over the inner aspect of the arm, with the width covering at least forty percent of the circumference of the arm. The open bell of the stethoscope was placed in the antecubital fossa, over the brachial artery. The cuff was then rapidly inflated to about 20-30 mm Hg above the point of disappearance of the palpable impulse of the artery, and then deflated slowly at a rate of 2 mm Hg per second, while listening for the Korotkoff sounds. The point at which the Korotkoff sounds became audible (K1), was taken as SBP, while the point of disappearance (K5), was taken as DBP. Readings were recorded to the nearest 2 mm Hg. Three readings were taken at a minimum of 1-minute intervals, with the cuff bladder completely deflated between readings, and the average recorded as the blood pressure. The height Z score, and SBP and DBP Z scores and percentiles were generated for each subject from data and equations provided by the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents[2]. Any subject with SBP and or DBP percentile equal to or greater than the 95th percentile, was referred to the Paediatric Outpatient Clinic of the University of Abuja Teaching Hospital for further evaluation. Their blood pressure measurements were repeated twice within a maximum of two weeks, and if elevated values persisted, then he or she was classified as hypertensive and the lowest value recorded used in analysis.[2]

DATA ANALYSIS

Data was analysed using the Statistical Package for the Social Sciences (SPSS) version 17, and presented in tables and figures. Measures of central tendency (mean, median) and dispersion (standard deviation, range) and percentiles, were computed for height, weight, BMI, SBP, and DBP, by age and gender, as well as prevalence rates for systolic and diastolic hypertension. Differences in means between any two groups were compared using the Student's t-test, while analysis of variance (ANOVA) was used to compare the means between greater than two groups. Pearson's Chi-square (χ^2) was used to compare differences in proportions, and to determine the relationship between blood pressure and gender, SEC and place of residence, respectively. Pearson's correlation coefficient (r) and multiple linear regression analysis were used to determine the relationship between blood pressure and age, height, weight and BMI, respectively. A p value of <0.05 was considered to be of statistical significance.

Ethical approval was obtained from the Health Research Ethics Committee of the University of Abuja Teaching Hospital, Gwagwalada, the F.C.T. Universal Basic Education Board, the F.C.T. Secondary Education Board and the F.C.T.A. Education Secretariat, respectively. Parents or guardians of subjects found to have elevated blood pressure levels, as well as those excluded from participating in the study on account of abnormal physical findings and urinalysis, were notified, and their children or wards referred to the Paediatric Outpatient Clinic of the University of Abuja Teaching Hospital, Gwagwalada, for further management.

RESULTS

GENERAL CHARACTERISTICS OF THE STUDY POPULATION

A total number of 1,292 apparently healthy students were enrolled into the study. 1,179 (91.2%) subjects completed the study, as 113 (8.8%) withdrew before complete anthropometric and blood pressure measurements could be obtained from them.

Table I shows the age, gender, and socio-economic distribution of the subjects studied by place of residence. Mean (SD) age of the subjects was 13.9 (1.9) years (range: 10-17). Subjects aged 10 and 13 years had the least representation (4.4%) and the highest preponderance (15.8%), respectively, in the study population. There were 538 males and 641 females, with a male to female ratio of 0.8:1, and the difference in the proportion of males to females was statistically significant, χ^2 = 8.998, $p < 0.05$. A significantly greater proportion of the subjects resided in the urban areas (59.1%), χ^2 = 39.207, $p < 0.01$, and were from the lower SEC (42.8%), closely followed by the middle (38.1), and distantly by the upper (19.1%), χ^2 = 111.7, $p < 0.01$.

Table I: General characteristics of the study population by place of residence

	Place of residence		
Socio-demographic factors	**Urban n = 697 (59.1) n (%)**	**Rural n = 482 (40.9) n (%)**	**Total N = 1179 (100.0) n (%)**
Age, years			
10	22 (1.9)	29 (2.5)	51 (4.4)
11	65 (5.5)	50 (4.2)	115 (9.7)
12	98 (8.3)	66 (5.6)	164 (13.9)
13	93 (7.9)	93 (7.9)	186 (15.8)
14	105 (8.9)	77 (6.5)	182 (15.4)
15	122 (10.3)	59 (5.0)	181 (15.3)
16	106 (9.0)	67 (5.7)	173 (14.7)
17	86 (7.3)	41 (3.5)	127 (10.8)
Gender			
Male	306 (25.9)	232 (19.7)	538 (45.6)
Female	391 (33.2)	250 (21.2)	641 (54.4)g
Socio-economic class			
Upper	165 (14.0)	60 (5.1)	225 (19.1)
Middle	265 (22.5)	184 (15.6)	449 (38.1)
Lower	267 (22.6)	238 (20.2)	505 (42.8)

Table II shows the age, blood pressure, and anthropometric characteristics of the study population. The males were older and taller when compared to the females, while the females had higher blood pressure, weight, and BMI than the males. However, the differences in means were statistically significant only with respect to weight, $p < 0.05$.

Table II: Age, blood pressure, and anthropometric characteristics of the study population by gender

Characteristic	Male n = 538	Female n = 641	All N = 1179	t	p
Age (years)					
Range	10-17	10-17	10-17		
Mean (SD)	13.9 (1.9)	13.7 (2.0)	13.9 (1.9)	-0.542	0.588
Median	14.0	14.0	14.0		
SBP (mmHg)					
Range	50-150	68-158	50-158		
Mean (SD)	107.3 (13.5)	108.5 (12.5)	107.9 (13.0)	-0.175	0.861
Median	108.0	110.0	110.0		
DBP (mmHg)					
Range	40-108	40-98	40-108		
Mean (SD)	66.9 (11.0)	67.9 (12.5)	67.5 (10.8)	-0.150	0.881
Median	68.0	70.0	68.0		
Height (cm)					
Range	120-190	115-175	115-190		
Mean (SD)	154.2 (11.7)	152.1 (9.2)	153.0 (10.5)	0.128	0.898
Median	154.0	153.0	154.0		
Weight (kg)					
Range	26-79	22-92	22-92		
Mean (SD)	45.9 (10.8)	47.4 (10.3)	46.7 (10.5)	2.419	0.016*
Median	44.5	47.0	46.0		
BMI (kg/m^2)					
Range	12.9-39.6	11.7-43.9	11.7-43.9		
Mean (SD)	19.1 (2.9)	20.4 (3.9)	19.8 (3.6)	-1.647	0.100
Median	18.7	19.9	19.3		

PATTERN OF BLOOD PRESSURE

The mean (SD) blood pressure increased significantly from 96.7 (10.8) mm Hg for SBP and 62.8 (8.3) mm Hg for DBP at 10 years, to 116.8 (11.1) mm Hg and 74.5 (10.6) mm Hg at 17 years, respectively, $p < 0.01$. The mean rate of increase for each year was 2.6 mm Hg for SBP, and 1.5 mm Hg for DBP.

The mean SBP and DBP for age and gender are shown in Figures 3 and 4, respectively. Blood pressure increased with age in both genders, with statistically significant increments limited to the mean SBP of the females, $F = 6.509$, $p < 0.05$. The females had higher mean SBP and DBP values in most age groups. These gender differences were, however, not statistically significant, $p > 0.05$.

In female subjects, mean SBP remained static between 13 and 14 years, a trend which was repeated at the same ages for DBP. Another finding of note was the drop in mean DBP in males between 10 and 11 years, by 6.5 mm Hg with a percentage decline of 5.5%.

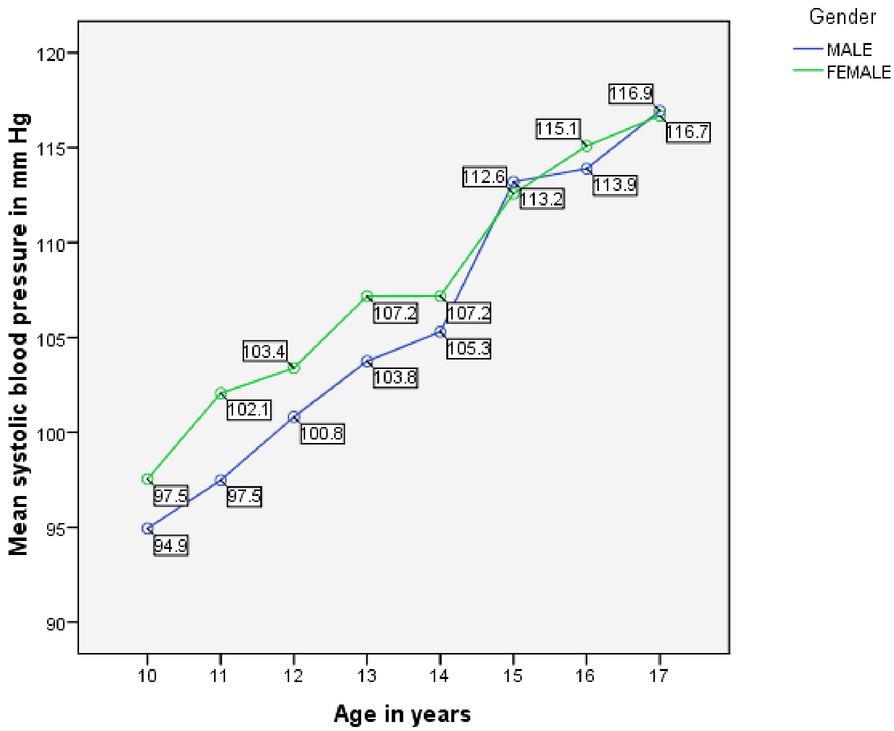

Figure 1: mean systolic blood pressure by age and gender

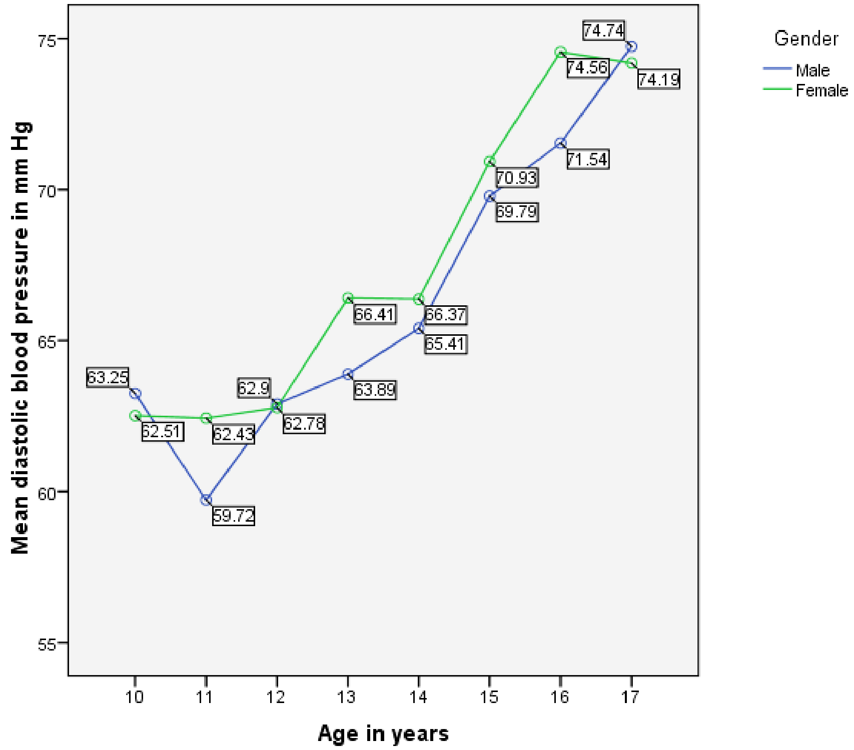

Figure 2: Mean diastolic blood pressure by age and gender

ANTHROPOMETRY

The mean (SD) height, weight, and BMI increased with age in both genders, as shown in Table III. The females were initially taller and heavier, a trend which reversed at 15 and 17 years, respectively, and also had higher mean BMI at all ages. The gender differences in height, weight, and BMI were however not statistically significant, except in the heights of the 12 year olds, and in the BMI at 12, 14, and 15 years. Four point two percent of the subjects had BMI values equal to or above the 95th percentile for age, which categorized them as being obese.

Table III: Mean height (cm), weight (kg), and body mass index (kg/m^2) of subjects by age and gender

Age (years)	Height (cm)		Weight (kg)		BMI (kg/m^2)	
	Male, n=538 Mean (SD)	Female, n=641 Mean (SD)	Male, n=538 Mean (SD)	Female, n=641 Mean (SD)	Male, n=538 Mean (SD)	Female, n=641 Mean (SD)
10	137.8 (5.9)	139.9 (7.3)	32.2 (3.7)	34.6 (6.1)	16.9 (1.4)	17.6 (2.7)
11	142.6 (9.7)	146.1 (9.5)	35.4 (6.3)	40.2 (9.8)	17.3 (1.9)	18.9 (5.2)
12	147.0 (9.3)	148.0 (8.4)*	39.5 (8.3)	41.3 (8.0)	18.2 (3.1)	18.8 (3.1)#
13	150.4 (8.4)	150.9 (7.9)	43.2 (9.2)	46.6 (9.5)	19.1 (3.9)	20.5 (4.2)
14	153.8 (9.1)	155.2 (7.5)	44.5 (8.8)	48.8 (6.5)	18.6 (2.4)	20.3 (2.6)#
15	158.4 (9.8)	155.8 (8.0)	49.7 (9.2)	51.8 (7.9)	19.8 (3.2)	21.4 (3.6)#
16	162.3 (9.3)	155.7 (8.1)	52.8 (8.5)	53.2 (7.7)	19.9 (2.1)	22.0 (3.3)
17	165.1 (7.6)	157.1 (6.1)	56.8 (7.4)	55.3 (11.3)	20.8 (1.8)	22.4 (4.2)

Key: SD – Standard deviation, * - Mean (SD) height of females was significantly higher, $p < 0.05$. # - Mean (SD) BMI of females were significantly, $p < 0.05$

PRESSURE, ANTHROPOMETRY AND SOCIO-DEMOGRAPHIC FACTORS

Table IV shows that blood pressure correlated significantly and positively with age, height, weight, and BMI, that is, the older, taller and heavier the

positive association with age, β 0.154, $p < 0.01$, and height, β 0.281, $p < 0.05$, while DBP had a significant positive association with age, β 0.205, $p < 0.01$, and weight, β 0.527, $p < 0.05$. Age and height are thus, independent predictors of SBP, while age and weight are independent predictors of DBP.

Table IV: Correlation of blood pressure with age, height, weight, and body mass index

Variable	SBP	DBP
Age		
r	0.453	0.402
p	<0.01[#]	<0.01[#]
Height		
r	0.443	0.342
p	< 0.01[#]	< 0.01[#]
Weight		
r	0.558	0.464
p	< 0.01[#]	< 0.01[#]
BMI		
r	0.424	0.332
p	< 0.01[#]	< 0.01[#]

Key: [#] - SBP and DBP correlated positively and significantly with age, height, weight, and BMI, $p < 0.01$.

Table V, on the other hand, reveals no statistically significant association between blood pressure, and gender, SEC, and place of residence, $p > 0.05$.

Table V: Mean blood pressure by gender, socio-economic class, and place of residence

Socio-demographic variable	N = 1179 n	SBP, mm Hg Mean (SD)	DBP, mm Hg Mean (SD)
Gender			
Male	538	107.3 (13.5)	66.9 (11.1)
Female	641	108.5 (12.5)	67.9 (12.5)
χ^2, p		0.619, 0.203	0.019, 0.889
SEC			
Male - Upper	97	108.9 (13.9)	70.1 (9.9)
Middle	199	107.3 (13.2)	67.6 (11.2)
Lower	242	106.2 (13.6)	65.1 (11.0)
χ^2, p		2.377, 0.305	2.758, 0.252
Female - Upper	128	108.5 (12.8)	70.2 (10.6)
Middle	250	108.6 (12.7)	68.4 (10.6)
Lower	263	108.6 (12.3)	67.3 (10.8)
χ^2, p		0.231, 0.891	0.116, 0.994
Residence			
Male - Urban	306	107.9 (13.6)	67.2 (11.0)
Rural	232	107.2 (13.5)	67.9 (11.1)
χ^2, p		0.108, 0.742	0.924, 0.336
Female – Urban	391	108.1 (11.1)	66.8 (10.9)
Rural	250	109.1 (11.6)	70.4 (9.9)
χ^2, p		0.403, 0.526	0.398, 0.528

Key: N – Total number of subjects, n – number of subjects in each subgroup, SBP – Systolic blood pressure, DBP – Diastolic blood pressure, SD – Standard deviation, SEC – Socio-economic class.

PREVALENCE OF HYPERTENSION

The total prevalence for systolic hypertension was 8.0 percent, while that for diastolic blood pressure was 6.8 percent. Three point two percent of the male subjects and 4.8% of the females had systolic hypertension, respectively, while diastolic hypertension was recorded in 3.7% and 3.1% of the males and females, respectively. There were no statistically significant gender differences in the prevalence rates for systolic and diastolic hypertension, respectively, $p < 0.05$.

DISCUSSION

The present study has described normative blood pressure and its correlates, and the prevalence of hypertension, in adolescent school children in Gwagwalada Area Council of the F.C.T.

The mean SBP values obtained in this study were lower than those reported by Nichols and Cadogan[45] in Tobago, Zhong-Qiang *et.al*[43] in China, Awogbemi[10] in Lagos, Hamidu *et.al*[28] as well as Bugaje *et.al*[38] in Zaria, who used similar methods in measuring blood pressure in their respective adolescent populations. They were also lower when compared to reference values established in American children of similar age from the NHBPEP charts.[2] Conversely, mean DBP for the different ages was higher when compared with the American reference values,[2] and the values reported by Awogbemi.[10] However, Nichols and Cadogan,[45] Hamidu *et.al*[28] and Bugaje *et.al*[38] reported higher DBP values in their study populations.

The variations in blood pressure levels observed between the study population and other adolescent populations, was not an isolated finding, as several workers have documented variations in blood pressure levels amongst different populations.[19-22] Differences in methodology may account for these inter-population variations,[99] which include the degree of accuracy in reporting SBP and DBP,[15] the use of DBP IV or DBP V which may vary by as much as 5-10 mm Hg,[100] and the number of readings taken for each subject with 3 readings per visit on 3 occasions giving better accuracy,[71]. However, other postulations have also been advanced to explain this occurrence.

Differences in the impact of growth and maturational factors on blood pressure from one population to another, is one of such postulations.[19-22] With the onset of puberty, and the accompanying rapid physical growth and marked hormonal changes, these differences tend to be exaggerated.[19-22] This is due to the fact that the ages at which pubertal growth spurts occur, when maximum changes impacting on blood pressure levels are recorded, vary from population to population. And as puberty is completed, the influence of these factors on blood pressure, weakens.[42]Environmental factors such the degree of urbanization and industrialization, with the attendant lifestyle changes in diet and physical activity, could also account for the observed variations in blood pressure levels in the different populations.[45] These factors influence maturation patterns, as well as body size, which impact strongly on blood pressure.[99]

The considerable influence body size exerts on blood pressure is well documented,[2,8,21] and taller, heavier individuals tend to have higher blood pressure levels.[2] The subjects in this study were shorter and lighter than those studied by Nichols and Cadogan,[45] which could account for the lower systolic and diastolic values obtained in them. This is corroborated by the finding that height and weight are independent predictors of SBP and DBP, respectively, in the study population. However, differences in body size alone could not account for the variations observed, when the lower blood pressure values obtained in the taller and heavier subjects of this study, were compared to the higher values obtained in shorter lighter subjects by Hamidu *et al*[28] and Bugaje *et al.*[38] These differences suggest that, in some populations, the influence of body size on blood pressure in relation to other factors such as age, and genetics, may have been overstated.[28]

In the present study, blood pressure increased significantly with age, which is consistent with other reports.[1,2,8] Furthermore, the rate of increase is comparable to values reported in Tobagonian[45] and Punjabi[46] adolescents (1.7 to 2.6 mm Hg per year, and 1 to 3 mm Hg per year, respectively). The rise in SBP and DBP with age was quite steep, especially between the ages of 14 and 17 years, and may be due to hormonal changes and rapid increases in body size occurring during the pubertal growth spurts.[19-22]

Highly significant positive correlations between both SBP and DBP, and age, height, weight, and BMI, were observed in this study, emphasizing the strong relationship between blood pressure, age, and anthropometry.[2,8,21] Increase in any of these variables results in a concomitant significant increase in blood pressure. Multiple linear regression analysis further established age and height as independent predictors of SBP, and age and weight for DBP, in the study population. Therefore, the older, taller and heavier an individual is, the higher the blood pressure. Agyemang *et al*,[23] Adams-Campbell *et* al,[39] and Nichols and Cadogan,[45] found age and BMI to be independent predictors of SBP and DBP, while Bugaje *et al*[38] found weight to be the best predictor of both SBP and DBP. This predictive effect of age, and anthropometry, form the basis for the development of current blood pressure reference values that take into cognizance the height, age, and gender of a child, to ensure appropriate classification of the blood pressure.

Interestingly, a decline in the mean DBP of males aged 11 years was observed. This divergence from the normal pattern could be a function of methodology, which was impressed on the change from child to adult cuff between ages 10 and 11. Studies have described a less well-known cuff size phenomenon, which is due to the relation of arm circumference to blood pressure level.[101] Data obtained from these studies demonstrate that the blood pressure differences between cuffs are largely independent of arm circumference.[101] Thus, at the point where one changes from one cuff size to another to accommodate increasing arm circumference, there is a *step* function, which is demonstrated by a drop in blood pressure when the larger cuff is used.[101] This drop could be significant enough to give noticeably lower values in the affected age group, as seen with the DBP of the 11 year old males. Thus, in an effort to reduce such errors, some workers have suggested the use of a single cuff size when conducting studies on body size and blood pressure levels.[101]

The present study reported no significant gender differences in SBP or DBP. This finding is consistent with some other reports,[28,39,40] but contrasts with others which have reported either significantly higher values in adolescent males,[25,34] or in females.[10,38,41] Differences in body size between genders have been advanced as possible reasons for gender differences in blood pressure levels, with the taller or heavier gender having higher values.[27,30] However, in the present study, the females were significantly heavier, but there were no significant gender differences in blood pressure. This may be due to interplay of other factors such as hormonal changes, genetics, and environmental factors, on blood pressure, which were not controlled for.

There was no statistically significant relationship between blood pressure and socio-economic class, as socio-economic status was not found to influence blood pressure levels in the study population. This differs from reports by Akinkugbe *et.al*,[41] who found that adolescents from the lower socio-economic class had significantly higher DBP. Ogunkunle *et.al*[29] also reported a significant negative correlation between blood pressure and socio-economic class, in children aged 1 to 5 years in Ibadan. These findings imply that the lower the socio-economic status, the higher the blood pressure, which may place such children at risk of developing hypertension later in life. This is further supported by the documented association of poverty and adverse early life conditions with increased risks for early onset of cardiovascular disease.[74]

On the contrary, Akor *et.al*[72] reported significantly higher SBP in 6 to 12 year old children attending private schools in Jos, who were from the upper and middle socio-economic classes, which they attributed to differences in environment, diet and lifestyle between the upper and lower classes. Thus, in their population, the more affluent children would be at higher risk for the development of elevated blood pressure.

Mean SBP and DBP did not differ significantly between subjects from rural or urban areas of Gwagwalada Area Council. These findings were consistent with findings from Calabar,[75] and may indicate a balance in lifestyle by the preservation of traditional ways of life, and the adoption of modern healthy practices, respectively, by the urban and rural populace, which impact positively on blood pressure.

In contrast, findings from Kogi State,[25] were of significantly higher systolic and diastolic values in urban and rural adolescents, respectively. These findings were attributed to the effects of urbanization and the attendant changes such as consumption of high calorie diet, and sedentary lifestyle, which was not limited to urban dwellers, but had encroached on the rural populace who might be mimicking urban ways of life.[25] The higher DBP in the rural subjects, may also be related to the fact that majority of the rural populace were from the lower socio-economic class, in whom the effects of adverse early life conditions on blood pressure levels, have been described.[74]

The prevalence rate of 8.0% for systolic hypertension obtained from this study was similar to the 7.8% reported by Awogbemi[10] in Lagos, while the 6.8% obtained for diastolic hypertension was higher than the 5.3 percent reported in the same study, using the same criteria of SBP and/ or DBP values at/ or above the 95th percentile for age and gender for the population.[2] Lower figures were reported by Bugaje *et al*[38] in Zaria (2.46 and 1.52 percent for systolic and diastolic hypertension, respectively), despite the non-exclusion of renal causes of hypertension by urinalysis, although hypertension was defined as blood pressure values above 2 standard deviations of the mean.

Other Nigerian studies[26,102,103] have also reported lower prevalence rates, ranging from 5.0 to 5.6 percent, using different methods of blood pressure measurement, and different criteria to define hypertension, such as values above 2 standard deviations of the mean, or the use of arbitrary values as cut-off values. The higher prevalence rates reported in the present study could be reflective of lifestyle changes that have occurred over the years.

The prevalence rates obtained in the present study are indicative of the fact that adolescent hypertension is not an uncommon finding in our population. They are comparable with, or even higher than rates obtained in other parts of the world, in developed and developing nations,[9,43-46] using similar criteria, although oscillometric devices which give values 4 to 5 mm Hg lower than values obtained by auscultation,[104] were used in one of these studies.[9]

In conclusion, blood pressure correlated significantly and positively with age and anthropometry, with age and height, and age and weight found to be independent predictors of SBP and DBP, respectively, amongst adolescent students in Gwagwalada. There were no significant gender differences in systolic and diastolic blood pressure, nor any significant relationship between blood pressure and socio-economic status, and place of residence. The prevalence of systolic hypertension was 8.0 percent, and 6.8 percent for diastolic hypertension. Thus, it is recommended that routine measurement of blood pressure in adolescents should be encouraged, both at clinic visits and as part of the School Health Programme, for early identification of those with and at risk of hypertension. A coordinated and standardized multi-centre study could also be carried out for the development of a national database for normative blood pressure reference values.

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