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Pattern of Blood Pressure in Apparently Healthy Nigerian Children aged 1-5 years

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Summary

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Background: Hypertension causes significant morbidity and mortality worldwide. As has been reported, the levels of blood pressure (BP) in childhood are the strongest predictors of adult levels. Hitherto, most studies of childhood BP in Nigeria have involved school-age children and adolescents.

Objectives: In order to provide information on BP in younger children, this study was undertaken to determine the pattern and correlates of BP in apparently healthy under-five children in Ibadan.

Design: Cross sectional study

Methods: Using a stratified multi-stage random sampling method, the BPs of 984 apparently healthy Nigerian children (507 males, 477 females) aged one to five years, recruited from day care centres, nurseries and primary schools in Ibadan North Local Government Area of Oyo State, were measured with a standard mercury sphygmomanometer.

Results: The mean (SD) systolic BP, diastolic BP-IV and V increased from 85.3 (7.5) mm Hg, 50.7 (12.9) mmHg and 34.6 (23.0) mmHg, respectively in the 12-23-month age group to 90.7 (9.0) mmHg, 57.2 (10.4) mmHg and 43.5 (18.8) mmHg respectively, in the 48-60-month age group ($p<0.05$). There was no gender difference in BP ($p>0.05$). Blood pressure correlated positively with age ($r=0.2668$, $p=0.000$), weight ($r=0.345$, $p=0.000$) and height ($r=0.370$, $p=0.000$) but negatively with Quetelet Index ($r= -0.084$, $p=0.008$), Ponderal Index ($r= -0.256$, $p=0.000$) and socioeconomic class ($r= -0.099$, $p=0.002$). There was no significant relationship between the children's and parental BPs. The prevalence of systolic and diastolic hypertension, using the epidemiological definition of 'BP ≥95th percentile for the population studied' was 3.2 percent and 1.7 percent, respectively.

Conclusions: Among the under-five children studied, BP correlated positively with age and anthropometry. Gender differences were not demonstrated and no relationship was observed between the children's BP and that of their parents.

Key-words: Blood pressure, under-five children.

Introduction

HYPERTENSION continues to exert a significant influence on the morbidity and mortality of human populations world-wide. It is an important causative factor in the reduction in life expectancy and quality of life. Among all known childhood predictors of adult blood pressure (BP), the level of the BP in childhood is by far the strongest.[1] An understanding of factors determining childhood BP is therefore important in the primordial prevention of adult hypertension. Most studies on BP in Nigerian children have involved school-age children and adolescents.[2-9] We are unaware of any such study involving Nigerian children under the age of five years. In view

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of this, the present study was carried out to determine the pattern and correlates of BP in apparently healthy children aged one to five years.

Patients and Methods

Study design and sampling

This cross-sectional study was carried out in day care centres, as well as nursery and primary schools in Ibadan North Local Government Area (LGA) using a multi-stage random sampling method. There were 112 private schools, 60 public schools and 22 day care centres in the LGA. Of these, 40 private schools, 20 public schools and 15 day care centres were randomly selected, using a table of random numbers. Among the selected schools, classes were stratified according to age, then those eligible were randomly selected. A list of pupils in all the classes was compiled from the school registers and 1200 apparently healthy subjects aged one to five years were also randomly selected, using a table of random numbers.

Data collection

On first contact, having explained the procedure to the parents/guardians and the teachers of the subjects, each parent was given a questionnaire to complete. Children with evidence of cardiovascular, renal or pulmonary disease, endocrine disorders, sickle cell disease and those on drugs known to affect blood pressure such as steroids or propanolol, were identified and excluded from the study. Each subject was given a socio-economic index (SI) score based on the level of education and occupation of both parents or guardians.[10]

At the second contact, each questionnaire was checked for correctness. A physical examination was performed on each subject, with particular emphasis on the respiratory and cardiovascular systems and the abdomen. Temperatures were taken using a clinical mercury-in-glass thermometer (*Terumo, Michigan, USA*).

Anthropometry

Heights/ lengths and weights were measured using the techniques described by Tanner *et al*.[11] For subjects $\underline{<}2$ years, height in centimetres (cm) was measured barefoot, the subject standing erect with his heels, back and occiput in contact with the vertical scale of a locally constructed stadiometer. For those < 2 years of age, length in cm was measured in the recumbent position using a locally constructed infantometer. Children < 2 years of age were weighed to the nearest 0.5kg using the Way Master model 1615 infant scale (*Way Master Co. Reading, England*) while those aged $\underline{<}2$ years were weighed using a flat scale (*Hanson, Model 89p, Ireland*). The accuracy of the scale measurement was initially checked with standard weights. This was repeated at regular intervals. Mid upper arm circumference (MAC) was measured in cm using a non-stretchable tape (*Butterfly, China*) at a point half-way between the acromium of the scapula and the olecranon process of the ulna.

Blood pressure measurement

BP measurements were carried out in accordance with the recommendations of the Task Force on BP Control in Children,[12] using a standard mercury sphygmomanometer (*Accoson, London, England*) and the open bell of a Littmann paediatric stethoscope (*USA*). All measurements were taken by the same investigator (AOO) and were obtained in a quiet classroom. Each subject was allowed to rest for five minutes to afford recovery from activity or apprehension. Children were placed in the sitting position, either on an appropriate chair, or (especially if they were under 2 years of age) on their mothers' laps, with the right arm fully exposed, extended and resting on a supportive surface at the level of the heart. The cuff was chosen to cover at least two-thirds of the length of the upper arm without obstructing the antecubital fossa. The centre of the cuff bladder was placed on the inner side of the arm and covered at least, half of the arm circumference. The open bell of the stethoscope was placed in the antecubital fossa over the brachial artery, which had previously been ascertained by palpation. The mercury column of the sphygmomanometer was vertical and the meniscus was level with the eye of the examiner. The cuff was rapidly inflated to occlude the brachial artery to about 20-30 mm Hg above the point where the palpable impulse of the artery disappeared, then deflated slowly at a rate of 2-5 mm Hg per second while listening for the Korotkoff sounds. Systolic BP (SBP) was taken as the appearance of the Korotkoff sounds (phase I), while diastolic BP (DBP)-IV was taken as the point of muffling (phase IV) and DBP-V as the point of disappearance of the Korotkoff sounds (phase V)[12]. Because controversy exists over whether phase IV or phase V should be used for measurement of diastolic pressure in children and current evidence seems to favour the use of phase V[13,14], it was thought prudent to record both. Measurements were read to the nearest 2mm Hg. Three readings were taken at one-minute intervals, the cuff bladder being deflated completely in between readings. The average of the second and third readings was taken as the BP. The blood pressure of one or both parents (depending on who was available) of each subject was determined in the same way. A child was considered to be hypertensive if his/her BP was $\underline{<}$95th percentile for the population studied.[13, 14]

A urine sample was obtained from each child and urinalysis performed on each sample within 30 minutes of collection. Blood samples were also obtained for haemoglobin genotype determination.

Data handling

The Statistical Package for Social Sciences (SPSS) for Windows 11.0 was used to validate and analyse the data obtained. The mean (standard deviation, SD) or median was computed for quantitative variables such as SBP and DBP. The Student's *t* test was used to compare means between anytwo groups. Pearson's correlation coefficient (r) was used to examine the relationship between BP, age and anthropometric measurements. Linear regression analysis was used to examine the relationship between parental BP and children's BP. A p value of <0.05 was considered significant. Ethical approval was obtained from the University of Ibadan/University College Hospital (UCH) Ethical Review Committee.

Results

A total of 1200 children were selected to be enrolled into the study, but 1002 children participated, giving a response rate of 83.5 percent. Incomplete data, abnormal urinalysis and haemoglobin type SS were obtained from 18 children whose data were therefore excluded from further analysis. Of the 984 children with complete data, 507 were males and 477 females (M: F = 1.1:1). Their ages ranged from 12 to 60 months. No statistically significant difference was found in the proportion of boys compared with girls in any of the age groups ($x^2 = 0.17$, df = 3, p = 0.981). Haemoglobin genotype was AA in 758 (77 percent) of the children, it was AS in 169 (17 percent) and AC in 57 (6 percent); 0.02 percent of the children had traces of proteinuria.

Complete data were obtained from 809 mothers and 331 fathers, giving a response rate of 82.2 percent among the mothers and 33.6 percent among fathers. The majority of the children studied were from Social Classes 1 to 4. Only few (2.7 percent) were from Social Class 5.

Anthropometry

The anthropometric characteristics of the subjects were as shown in Table 1. There was no significant difference between girls and boys in terms of their ages and anthropometric measurements.

Table I

Age and Anthropometric Characteristics of Subjects

Characteristic	*Male* *N=507*	*Female* *N=477*	*All* *N=984*	*T*	*p*	*95% CI*
Age (months)						
Range	12 – 60	12 – 60	12 – 60			
Mean (SD)	35.8 (14.2)	36.1 (14.0)	35.9 (14.1)	-0.281	0.779	-2.02,1.52
Median	36.0	36.0	36.0			
Weight (Kg)						
Range	8 – 32	8 – 25	8 – 32			
Mean (SD)	13.5 (3.2)	13.5 (3.0)	13.5 (3.1)	0.354	0.723	-0.32,0.45
Median	13.5	13.0	13.0			
Height (cm)						
Range	70 – 134	70 – 118	70.0 – 134			
Mean (SD)	91.8 (11.4)	92.3 (10.6)	92.1 (11.0)	-0.766	0.444	-.02,0.01
Median	93.0	93.0	93.0			
Quetelet Index (kg/m²)						
Range	8.6 – 26.	9.9 – 24.2	8.6 – 26.3			
Mean (SD)	16.0 (2.1)	15.7 (2.1)	16.0 (2.1)	1.942	0.052	-0.01,0.52
Median	15.8	15.6	15.7			
Ponderal Index (kg/m³)						
Range	8.4 – 30.9	8.9 – 31.9	8.4 – 31.9			
Mean (SD)	17.8 (3.9)	17.4 (3.9)	17.6 (3.8)	1.837	0.066	-0.03,0.92
Median	17.0	17.0	17.0			
MAC (cm)						
Range	12.0 – 19.0	11.5 – 20.5	11.5 – 20.5			
Mean (SD)	15.2 (1.2)	15.3 (1.3)	15.3 (1.2)	-0.370	0.171	-0.27,0.05
Median	15.0	15.0	15.0			

MAC = Mid-arm Circumference, SD= Standard Deviation, CI=Confidence Interval

Table II

Mean Systolic and Diastolic Blood Pressures (mm Hg) of All Subjects

Age (months)	*N*	*SBP x (SD)*	*DBP IV x (SD)*	*DBP V x (SD)*
12 – 23	236	85.3(7.5)	50.7(12.9)	34.6(23.0)
24 – 35	252	86.6(9.0)	51.9(12.1)	38.5(19.9)
36 – 47	239	88.7(9.1)	54.9(11.3)	41.1(17.3)
48 – 60	257	90.7(9.0)	57.2(10.4)	43.5(18.8)
F statistic	984	18.2	15.5	8.9
P		0.000	0.000	0.000

Pattern of blood pressure in the children

Table II shows the mean BP by age, in all the subjects. The average rate of increase for mean SBP was 1.4 mm Hg/year of life. Similarly, the average rates of increase per year of life for mean DBP-IV and DBP-V were 1.7 mm Hg and 2.3 mm Hg, respectively. Table III compares the mean SBP, DBP-IV and DBP-V between males and females. The differences were not significant ($p > 0.05$) across all age groups except for DBP-V in the 12-23 month age group. Since the differences in BP between the sexes were not significant, the values for both sexes are combined in the remaining figures and tables. Figures 1 to 3 show the derived graphs of mean and 95 percent Confidence Intervals of SBP, DBP-IV and DBP-V, respectively. Thus the expression relating mean SBP,

Table III

Mean BP (mm Hg) by Age and Gender

Age (mons)	*BP*	*Male x (SD)*	*Female x (SD)*	*t*	*P*
12 – 23	SBP	85.1(7.1)	85.5(7.9)	-0.325	0.746
	DBP IV	49.5(12.8)	52.1(13.1)	-1.545	0.124
	DBP V	31.4(23.3)	38.2(22.2)	-2.306	0.022*
24 – 35	SBP	86.6(9.0)	86.5(8.9)	0.135	0.893
	DBP IV	50.7(12.4)	53.2(11.9)	-1.641	0.102
	DBP V	37.1(19.9)	41.1(17.1)	0.036	0.972
36 – 47	SBP	89.5(9.2)	87.9(9.0)	1.282	0.201
	DBP IV	55.4(11.3)	54.4(11.3)	-0.705	482
	DBP V	41.2(17.8)	39.9(19.9)	-1.1220	0.263
48 – 60	SBP	90.6(9.3)	90.7(8.7)	-0.150	0.881
	DBP IV	57.1(9.9)	57.3(10.9)	-0.156	0.876
	DBP V	44.1(18.7)	42.7(18.9)	0.590	0.555

SBP = Systolic BP DBP IV = Diastolic BP IV DBP V = Diastolic BP V

* = significant difference

Table IV

BP Levels (mm Hg) of Subjects by Age and Weight Percentiles

Age	*Weight*	*Systolic BP*			*Diastolic BP IV*			*Diastolic BP V*		
(months)	*Centile*	*5th*	*50th*	*95th*	*5th*	*50th*	*95th*	*5th*	*50th*	*95th*
12-23	5th	68.5	74.0	82.0	22.7	26.0	48.0	0.0	22.0	30.0
	50th	84.0	84.0	92.0	46.0	54.0	58.0	0.0	44.0	48.0
	95th	94.0	99.3	102.0	66.0	62.0	68.0	0.0	52.0	8.0
24-35	5th	90.0	70.0	85.0	30.0	30.0	38.0	0.0	28.2	38.0
	50th	90.0	86.0	90.0	46.0	50.0	62.0	0.0	40.0	59.0
	95th	90.0	100.0	120.0	50.0	60.0	68.0	0.0	50.0	64.0
36-47	5th	98.0	78.0	84.0	32.0	38.0	38.0	10.2	29.1	33.0
	50th	98.0	88.0	98.0	46.0	58.0	62.0	15.3	56.0	62.0
	95th	98.0	100.0	122.0	52.0	72.0	68.0	15.7	60.0	67.0
48-60	5th	76.0	78.0	80.0	34.0	38.0	68.0	10.3	35.0	67.0
	50th	98.0	88.0	96.0	55.0	58.0	68.0	17.3	56.0	68.0
	95th	98.0	109.0	124.0	58.0	71.0	72.0	17.7	69.0	70.0

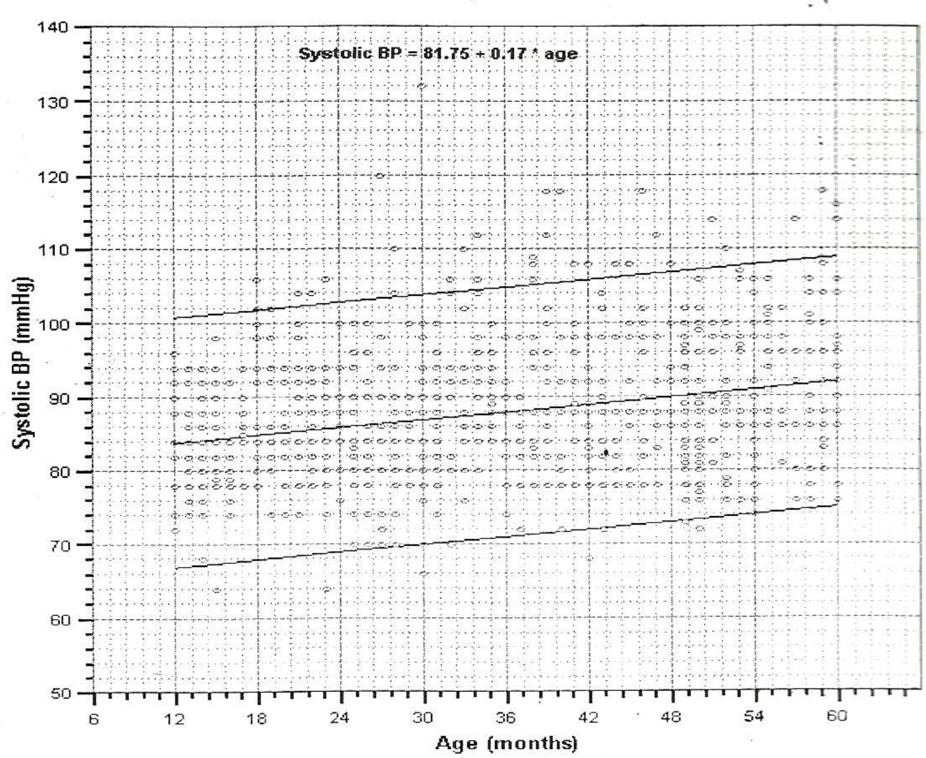

Fig 1. Graph of Mean and 95% Confidence Intervals of Systolic Blood Pressure by Age, for all Subjects

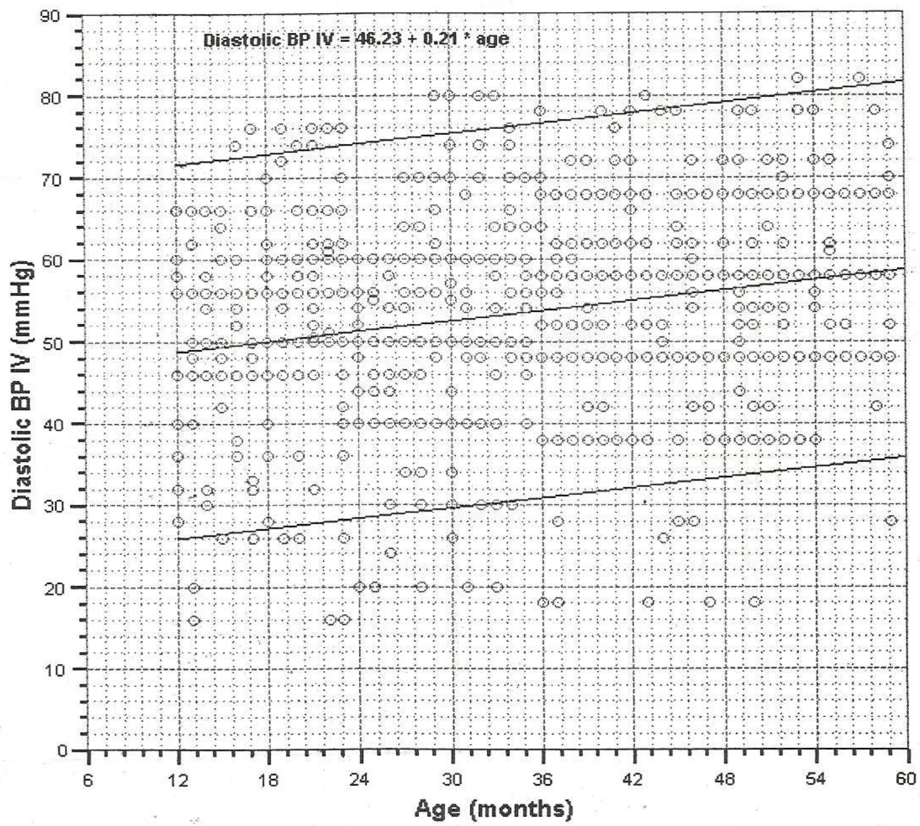

Fig. 2. *Graph of Mean and 95% Confidence Intervals of Diastolic Blood Pressure IV by Age, for all Subjects*

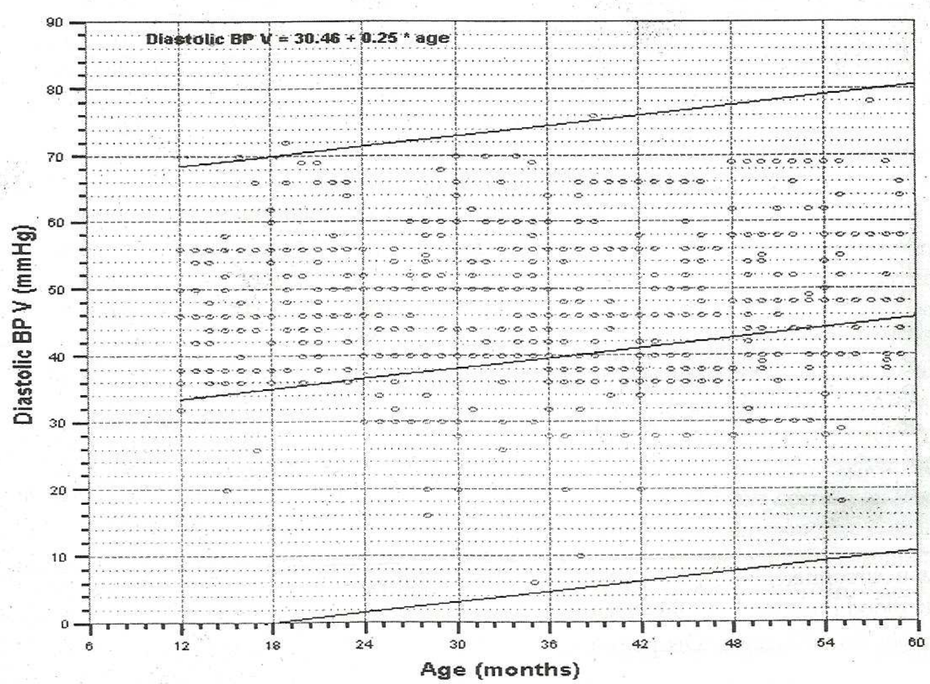

Fig. 3: *Graph of Mean and 95% Confidence Intervals of Diastolic Blood Pressure V by Age, for all Subjects*

Table V

BP Levels (mm Hg) of Subjects by Age and Height Percentile

Age	*Height*	*Systolic BP*			*Diastolic BP IV*			*Diastolic BP V*		
(months)	*Centile*	*5th*	*50th*	*95th*	*5th*	*50th*	*95th*	*5th*	*50th*	*95th*
12-23	5th	69.3	76.0	81.5	22.0	27.0	47.5	0.0	21.0	30.9
	50th	83.1	85.0	90.0	44.0	53.0	57.0	0.0	44.5	48.4
	95th	95.0	100.3	101.0	62.0	65.0	68.0	0.0	51.3	68.8
24-35	5th	89.0	71.0	86.0	31.0	32.3	36.5	0.0	29.3	37.9
	50th	90.0	90.0	91.0	47.0	51.5	61.0	0.0	41.0	58.9
	95th	92.0	99.0	120.0	51.0	61.0	68.0	0.0	52.0	65.1
36-47	5th	96.0	77.5	86.0	32.0	37.0	37.3	9.2	28.4	34.0
	50th	97.5	98.0	99.0	44.0	57.0	62.0	14.4	57.0	63.0
	95th	99.2	100.0	122.0	53.0	71.0	68.0	15.9	62.0	68.2
48-60	5th	75.5	76.0	82.0	35.0	37.0	56.0	11.3	34.9	66.9
	50th	99.5	88.0	97.0	57.0	58.0	64.0	18.1	57.2	67.8
	95th	100.0	107.0	122.0	59.5	70.0	71.0	18.9	70.0	71.0

Table VI

Correlation of BP with Age and Anthropometry

Variable		*Weight*	*Height*	*MAC*	*QI*	*PI*	*SBP*	*DBP IV*	*DBP V*
Age	R	0.729	0.831	0.276	-0.253	-0.632	0.268	0.246	0.177
	P	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Social Class	R	-0.033	-0.016	-0.188	-0.026	-0.008	-0.099	-0.132-	0.019
	P	0.306	0.626	0.000	0.422	0.805	0.002	0.000	0.548
Weight	R	1	0.838	0.533	0.167	-0.380	0.345	0.330	0.251
	P		0.000	0.000	0.000	0.000	0.000	0.000	0.000
Height	R		1	0.416	-0.383	-0.809	0.370	0.355	0.232
	P			0.000	0.000	0.000	0.000	0.000	0.000
MAC	R			1	0.158	-0.139	0.224	0.209	0.069
	P				0.000	0.000	0.000	0.000	0.033
QI	R				1	0.840	-0.084	-0.077	0.002
	P					0.000	0.008	0.016	0.948
PI	R					1	-0.256	-0.252	-0.141
	P						0.000	0.000	0.000
SBP	R						1	0.520	0.336
	P							0.000	0.000
DBP IV	R							1	0.709
P									0.000

MAC – Mid-arm circumference; QI – Quetelet Index; PI – Ponderal Index
SBP – Systolic Blood Pressure; DBP IV – Diastolic Blood Pressure Muffling;
DBP V—Diastolic Blood Pressure Disappearance

DBP-IV and DBP-V and the ages studied are: $81.75 + 0.17x$, $46.23 + 0.21x$, and $30.46 + 0.25x$ respectively, where x = age in months. Table IV shows the BP levels of all subjects by age and weight centiles, while Table V shows the BP levels of all subjects by age and height centiles.

Relationship between blood pressure, age, anthropometry and social class

Table VI shows the correlation of the BP of all children with age, anthropometry and social class. There were statistically significant correlations between SBP, DBP-IV and all anthropometric parameters as well as with age. DBP-V similarly correlated with all parameters except for QI. Socioeconomic class showed significant correlation with DBP IV, but not with SBP.

demonstrated in this study. SBP values obtained in this study are in close agreement with those reported by the 1987 National Institutes of Health (NIH) Task Force[12] which were derived from three independent studies using ultrasonic devices. The findings of the present study are also comparable with observations by Park and Menard[15] in American children aged two weeks to five years using an automated oscillometric device. Park *et al*[16] have however, shown that values obtained by the oscillometric method are higher than those obtained by the auscultatory method, advocating that caution be exercised in diagnosing hypertension based on oscillometric methods.

Opinions on the relationship between gender and BP in older children are divergent, with some workers reporting higher levels in males,[7,17] others, higher levels in femalesl,[9,18,19] yet others, no difference.[20-25] The present study found no gender-related differences in BP in the age group studied (except in the 12-23 month age group) which is similar to the observations of Park and Menard.[15] The reason for the gender difference noted in the 12-23 month age group is unclear. Since there was no significant gender difference observed overall, the derived graphs and formulae obtained may be used as a guide to determining normal blood pressure in Nigerian children aged one to five years, regardless of gender. The present data also supports earlier reports[20, 26] showing that BP values correlate with weight and age. In the present study, both weight and height correlated with BP slightly better than age did, while QI and PI correlated negatively with BP, though weakly, suggesting that these parameters might not be crucial in the determination of BP levels in children in this age group. A negative correlation was also found between BP and socioeconomic class in the present study. This is similar to the observations by Akinkugbe *et al* among teenagers in Ibadan. Although previous workers[27 -30] have demonstrated a significant relationship between the BP of parents and that of their children, even in children as young as two months of age, no such relationship was shown in the present study.

Table VII

Strength of Familial Relationship expressed by Regression Coefficient

	Mother		*Father*	
	Systolic BP	*Diastolic BP*	*Systolic BP*	*Diastolic BP*
Regression Coefficient, R	0.025	0.010	0.091	0.024
F-ratio	0.511	0.079	2.730	0.180
P	0.475	0.779	0.099	0.672

Relationship between blood pressures of the children and their parents

Table VII shows that using regression coefficient, the relationships between the children's BPs and those of their parents were not significant.

Prevalence of high blood pressure

Using the epidemiological definition of 'BP $\leq$95th percentile for the population studied', 31 (3.2 percent) had high SBP and 17 (1.7 percent), high DBP. Sixty two (7 percent) of the mothers and 56 (16 percent) of the fathers admitted to knowing that they were hypertensive; the present study only identified high BP in 23 (2 percent) of the mothers and eight (2 percent) of the fathers.

Discussion

This study has sought to establish the normal BP levels of apparently healthy Nigerian children aged one to five years in a classroom setting, using the standard mercury sphygmomanometer. This instrument was chosen for use in this study because of its widespread general usage especially in developing countries like Nigeria, its reliability and accuracy, and the fact that it does not require recalibration.[12]

Progressive increase in BP with age that has been documented in older Nigerian children[2-9] was also

Studies of high BP usually focus more on the adult African than the paediatric population. A major reason for this is that it is difficult to define what paediatric high BP is. Most workers have used either the epidemiological definition of BP, which is two or more standard deviations above the mean for age[28] or values above 95th percentile for age.[16] Using the first definition, the reported prevalence is between 4 percent and 5.8 percent.[3,5,19] Obika *et al*[4] used an arbitrary figure of $^{130}/_{80}$ mm Hg and above, as high BP for children aged 1-14 years. In the present study, the value for high BP used was the epidemiological one.[13] High SBP was found among 3.2 percent of the study population while 1.7 percent had high DBP. Apart from the difference in definition used for high BP in the various studies, the differences in prevalence may also be due to the fact that other workers studied children who were older than five years.

In conclusion, findings from this study suggest that in children aged one to five years in Ibadan, BP correlates significantly and positively with age and anthropometry as is the case in older children. Gender differences in BP were not demonstrated in this age group, neither was anyrelationship observed between the children's BP and that of their parents. Nevertheless, it is recommended that BP measurement be performed routinely as part of the physical examination in all children so as to detect and address abnormalities as early as possible.

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