The relationship between basal blood pressure and body mass index in apparently healthy Nigerian adolescent students

***A. Alabi, E. A. Alikor and **O. O. Ogunkunle**

*Departments of Paediatrics and Child Health, University of Port Harcourt, *Braithewaite Memorial Hospital, Port Harcourt and **University College Hospital, Ibadan, Nigeria.*

Correspondence to: Dr Edward A. D. Alikor, Department of Paediatrics and Child Health, University of Port Harcourt, Port Harcourt, Nigeria. (E-mail Achi_Alikor@yahoo.com)

Abstract

Background: In contrast to the situation in developed countries, very few studies have been done on blood pressure (BP) determinants among Nigerian adolescents.

Aim: To evaluate the relationship between basal BP and body mass index (BMI) in a group of healthy Nigerian secondary school students.

Methods: This was a cross-sectional study of 1080 adolescent students selected by a two-stage multi-phase cluster sampling technique. The height, weight and BP of each student were taken using standard methods. Pearson correlation was used to describe the strength of association between variables. Multiple stepwise regressions were conducted to determine the individual or combined contribution(s) of some variables to the variation in BP levels.

Results: Mean BMI for males and females were 17.63 ± 2.54 kg/m^2 and 18.87 ± 1.81 kg/m^2 respectively. Forty six students (4.3%) were overweight. Mean systolic and diastolic BPs were 113.13 ± 11.44 mm Hg and 68.29 ± 8.07 mm Hg respectively. Thirty-five subjects (3.2%) had systolic or diastolic BP above the 95th percentile for age and sex. Twenty-four (68.6%) of these subjects were also found to be overweight. A moderate positive correlation was observed between both systolic and diastolic BP and BMI. Regression analysis showed that weight, height and BMI were predictors of systolic BP. Height and BMI were the only predictors of diastolic BP.

Conclusion: These findings suggest that there is a moderate association between basal BP and BMI.

Recommendation: Control/prevention of the accumulation of excess body fat in adolescence is recommended.

Keywords: Body mass index, Blood pressure, Adolescent, Nigerians

Introduction

Essential hypertension is a major public health problem worldwide [1]. About 11.0% of the Nigerian adult population are hypertensive [2]. In the past two decades, an increase in the understanding of this disease has identified it as a major risk factor for cardiovascular disease [3,4].

Despite the demonstrated efficiency of drug treatment, the associated problems of availability, cost, unpleasant side effects and the need for complete adherence to life-long medication, have made it increasingly clear that the eventual solution to this public health problem is primary prevention [5].

In considering the prevention of essential hypertension, it is important to understand the childhood characteristics that are associated with the development of the disease in adult life. The most reliable childhood predictor of adult blood pressure (BP) level is BP level in childhood[6]. The tendency for children to maintain their BP ranking over time compared with their peers, referred to as the "tracking phenomenon", has been repeatedly demonstrated in various studies of BP in children and adolescents [6-8] . This suggests that, based on BP ranking, there is some potential for identifying children and adolescents who are at risk of becoming hypertensive adults. In view of this finding, preventive strategies are being focused on the factors which determine BP level in childhood and adolescence.

Cross sectional studies of BP in children and adolescents report that current levels of both systolic and diastolic BP correlate significantly with measures of adiposity [6,9]. Evidence from longitudinal studies also reveals that high adult BP levels correlate significantly with an increase in adiposity from childhood to adulthood [6]. Furthermore, there is a moderate risk that excess body fat acquired during childhood will persist into adult life [10]. Most importantly, level of adiposity is subject to environmental and life style modification [3]. Thus, it is generally agreed that strategies to prevent the acquisition of excess body fat during childhood and adolescence should be a major point of focus in the prevention of adult essential hypertension [4,11].

Body mass index (BMI) has been reported to be the most suitable measure for expressing both subcutaneous and total body fat in adolescents [12-15]. It is specific in identifying adolescents with excess body fat[12] and unlike the measure of skin-fold thickness which is limited by considerable intra and inter observer errors [13], BMI is easy to measure and has a high level of reproducibility [13]. However, some limitations in the interpretations of BMI in adolescents have been noted [16].

Despite the high prevalence of essential hypertension in the Nigerian adult population, a dearth of information exists concerning BP levels in adolescents, the factors which determine them, and the possible role this information could play in the development of strategies for the control/prevention of adult essential hypertension.

It is for these reasons that this study was conducted with these objectives: (i) to determine the relationship between basal BP and BMI in secondary school students in Port Harcourt and (ii) to compare the strength of the relationship between basal BP and BMI with those between basal BP and age, weight and height.

Materials and Methods

This study was carried out in Obio/Akpor Local Government Area of Rivers State in Nigeria. It is a highly industrialized and mainly urban area, constituting a part of the larger Port Harcourt metropolis; it has a projected population of 328,643 (1991 census) [17].

The indigenes of this area speak Ikwerre. They are predominantly farmers with a large proportion of them engaging in fishing and animal husbandry. Many others are traders. However, the presence of the oil industry and rapid industrialization in this local government area, have attracted an influx of individuals from various walks of life and different Nigerian tribes into the area.

A minimum sample size of 1000 was used for the study. The study was cross-sectional using a two-stage multi-phased cluster sampling technique to select the subjects. In the first stage, 6 schools were selected by random sampling from a list of all the co-educational secondary schools in Obio/Akpor local government area. The selection was done to proportionately reflect the different strata making up the schools viz: socio-economic state of the school and the ownership (government, private, etc.). In the second stage, one arm was randomly selected from each of the 6 classes in each selected school. All students in selected classes who met the study inclusion criteria were recruited into the study. Further details of the sampling technique had previously been published [18].

Apparently healthy secondary school students aged 10-19 years were included in the study. Students with evidence, from questionnaire responses and/or physical examination, of any pathologic state associated with alteration in BP levels, such as renal, cardiovascular or endocrine disease, were excluded from the study. Also excluded were students from whose parents a history of use of drugs known to influence blood pressure levels, such as steroid were obtained.

Informed written consent was obtained from the parents and/or the schools principal. Approval for the study was obtained from the Ethics Committee of the University of Port Harcourt Teaching Hospital.

The students were made familiar with the procedure of blood pressure measurement using the mercury sphygmomanometer in order to reduce any anxiety that could be associated with the measurement later. Each subject was then given a questionnaire to take home, to be completed by his or her parents or guardian. The information obtained included demographic and socio-economic data as well as medical information including family history of hypertension, stroke or sudden death. In subsequent contact with each child, the questionnaires were collected from the subjects, and checked to ensure that they had been correctly completed.

A complete physical examination, with emphasis on the cardiovascular system was carried out on each subject. Heights and weights were then measured according to techniques described by Tanner *et al* [19]. Height in metres (m) was measured without shoes, the subject standing erect with his heels and back in contact with the vertical scale of a locally constructed stadiometer. Weight was measured without shoes, using a Hansen bathroom scale and recorded to the nearest 0.5 kilograms. The accuracy of the scale measurement was initially checked with standard weights. For the purpose of this study, BMI was defined as weight in kilogrammes (kg) divided by the square of height in metres(m^2). Basal BP (i.e. BP measured under resting conditions and after all attempts have been made to reduce the influence of the emotional state of the child on BP) [9] was measured in accordance with the technique described by Moss [20]. To allay apprehension, BP for each subject was measured in the presence of the other subjects in the class. For the purpose of this study, BP equal to or greater than 2 standard deviations above the mean for age and sex was defined as elevated[21]. To also ensure that valid measurements were obtained, the measurement taken by the mercury sphygmomanometer used in this study was initially checked against that of another accurate, well-maintained mercury sphygmomanometer for accuracy and reliability. Only one investigator took all the BP measurements. For each child, the measurement of the BP was done three times and the average systolic and diastolic BP taken. The measurements of height and weight of the subjects were done by a trained assistant.

Data analysis

The data was analyzed using the Statistical Package for Social Sciences(SPSS) version 11.0 software. Basic observational statistics were obtained. Students' t-test was used to determine the degree of association between two mean values. The level of significance was taken to be $p<0.05$. Pearson correlation was used to describe the strength of association between variables. Multiple stepwise regressions of individual systolic/diastolic BP levels on other measured variables (e.g. height, weight, BMI) were conducted, to determine the individual or combined contribution(s) of these variables to the variation in BP levels. The tolerance level was set at a probability of 0.01. The predictability of the regression equations was evaluated with the analysis of variance (ANOVA) procedure.

Results

The results of 1080 subjects were analyzed. The ages ranged from 10 to 19 years. The mean age was 14.33 ± 2.33 years. There were 550 males and 530 females giving a male: female ratio of 1.04:1.00. The mean male age was 13.95 ±2.29 years while that of females was 14.31±2.30 years (p>0.05). Mean socio-economic index score (Range 1-5) was 2.48 ± 1.22. The mean score for males was 2.40 ± 1.21 while the mean for females was 2.57 ± 1.24 (p>0.05). The mean heights for the males and females were 1.57±0.12 m and 1.56±0.1 m respectively with no statistically significant difference between them. The overall mean weight of females of 45.95 ± 10.45 kg was significantly heavier than that of males of 44.21±11.67 kg (p<0.05).

The BMI showed a gradual increase with age (Table 1). The overall mean BMI was 15.79 ± 1.79 kg/m^2 at 10 years and 20.70 ± 1.71 kg/m^2 at 19 years. The overall mean BMI for males was 17.63 ± 2.54 kg/m^2 while that for females was 18.87 ± 1.81 kg/m^2 (p<0.001). The females were generally more ponderous than the males after 12 years of age.

Systolic BP ranged from a mean of 103.86 ±8.93 mm Hg at 10 years to 122.33± 9.45 mmHg at 19 years, whilst diastolic BP ranged from a mean of 65.86± 7.18 mm Hg at 10 years to 70.50 ± 6.90 mm Hg at 19 years. Tables 2 and 3 show the comparison between the mean systolic and diastolic BP of males and females (by age) respectively. Table 4 shows that, at each age, the correlation between BMI and systolic BP was generally more significant than that observed between BMI and diastolic BP. The strongest correlation between BMI and BP was observed for systolic BP at 17 years in males and 11 years in females.

The correlation matrix of the measured variables is indicated in Table 5. Both systolic and diastolic BP correlated significantly (p<0.001) with age, height, weight and BMI. Systolic and diastolic BP showed a positive correlation with weight i.e. (0.61, p<0.001) and (0.32, p<0.001) respectively. Systolic BP showed a moderate positive correlation with height and BMI. The relationship between BP (systolic and diastolic) and age, although statistically significant (p<0.001) is confounded by the positive correlation (0.68, p< 0.001) also obtained between weight and age i.e. the increase in weight with age could possibly account for the positive correlation between age and BP. Systolic and diastolic blood pressure showed a correlation with BMI (p<0.001).

The results of the multiple and stepwise regression analysis for both systolic and diastolic BP are presented in Tables 6 and 7 respectively. These tables taken together, show that of all the variables studied only weight, height, and BMI were predictors of systolic BP and accounted for 55.3% of the variation in systolic BP. Only height and BMI were predictors of diastolic BP, and together with the other variables, accounted for 31.5% of the variation in diastolic BP. Weight alone accounted for 49.9% of the variation of systolic BP, whereas height accounted for 4.9% and BMI 0.5% of the variation. For the diastolic BP, height and BMI accounted for 29.7% and 1.2% of the variation respectively.

Table 1. Mean BMI (kg/m^2) at various ages by sex

Age	Males			Females		
(Years)	No	Mean BMI	± 1SD	No	Mean BMI	±1SD
10	28	15.78	±1.97	44	15.79	±1.69
11	74	16.08	±1.88	38	15.37	±1.41
12	66	16.52	±2.00	43	16.49	±3.59
13	66	16.83	±2.34	62	19.98	±3.16
14	96	17.11	±2.17	82	19.00	±2.40
15	67	18.42	±2.23	74	19.28	±2.25
16	63	18.64	±1.94	81	19.94	±2.61
17	62	20.21	±2.58	68	20.25	±3.10
18	16	19.59	±1.32	26	21.05	±2.52
19	12	20.49	±1.59	12	20.92	±1.87
All Ages	**550**	**17.63**	**±2.54**	**530**	**18.87**	**±1.81**

Table 2. Mean systolic BP (mmHg) at various ages by sex

Age (years)	Male No	Male Mean±1SD	Female No	Female Mean±1SD
10	28	102.57±10.71	44	104.68±7.60
11	74	104.41±8.83	38	103.26±9.00
12	66	108.79±13.74	43	109.49±12.01
13	66	108.18±9.91	62	112.68±10.64
14	96	110.91±9.51	82	118.11±10.08
15	67	115.27±9.40	74	119.15±9.30
16	63	116.32±8.06	81	119.44±8.16
17	62	119.42±10.24	68	115.47±12.02
18	16	123.5±11.86	26	115±7.98
19	12	112.67±8.33	12	122±10.82
All ages	**550**	**111.76±11.49**	**530**	**114.54±11.22**

SD - Standard Deviation

Table 3. Mean diastolic BP (mmHg) at various ages by sex

Age (years)	Male No	Male Mean±1SD	Female No	Female Mean±1SD
10	28	66.71±8.87	44	65.32±5.93
11	74	64.3±6.92	38	63.79±8.31
12	66	65.55±8.92	43	66.35±8.09
13	66	66.47±7.61	62	70.29±5.98
14	96	68.2±9.37	82	70.1±8.61
15	67	67.9±7.08	74	70.97±7.47
16	63	70.49±7.41	81	69.69±7.50
17	62	70.13±7.90	68	70.5±8.64
18	16	69.25±9.70	26	68.69±5.53
19	12	71.17±7.59	12	69.83±6.39
All ages	**550**	**67.61±8.24**	**530**	**69±7.83**

Table 4. Correlation between BP and BMI at each age by sex

Age in years	Male systolic BP	Male diastolic BP	Female systolic BP	Female diastolic BP
10	0.71**	0.44*	0.71**	0.40*
11	0.79**	0.14	0.78**	0.32
12	0.38**	0.12	0.64**	0.16
13	0.84**	0.34*	0.10	0.08
14	0.77**	0.26*	0.73**	0.18
15	0.79**	0.04	0.73**	0.18
16	0.68**	0.11	0.57**	0-.02
17	0.54**	0.29*	0.77**	0.46**
18	0.54	0.13	0.41	0-.01
19	0.31	0.46	0.66*	0-.08
All ages	**0.74****	**0.28****	**0.32****	**0.14****

**p<0.001, *p<0.01

Table 5. Correlation matrix between variables

	Age	Height	Weight	Body Mass Index	Systolic BP	Diastolic BP
Systolic BP	0.44**	0.43**	0.61**	0.41**	1.00	0.42**
Diastolic BP	0.22**	0.23**	0.32**	0.28**	0.42**	1.00
Body Mass Index	0.29**	-0.16	0.45*	1.00	0.41**	0.28**
Age	**1.00**	**0.60****	**0.68***	**0.29****	**0.44****	**0.22****

**p<0.001, *p<0.01

Table 6. Relationship between systolic BP and other variables using multiple regression

Variable	Regression Coefficient	p
Systolic BP		
Constant	136.85	-
Weight	55.9	<0.001*
Height	1.17	<0.001*
BMI	0.22	<0.002*
Age	-0.19	>0.05
Diastolic BP		
Constant	56.9	-
Height	0.85	<0.001*
BMI	0.21	<0.001*
Weight	0.07	>0.05
Age	0.03	>0.05

Multiple correlation coefficient (r^2) is 0.552 (Systolic BP) Multiple correlation coefficient (r^2) is 0.315 (Diastolic BP), * = Significant.

Table 7. Stepwise regression analysis for systolic & diastolic BP showing changes in multiple regression coefficient of determination (R^2) with addition of different variables

Stages of analysis	R^2	R^2 change	F	p
Systolic BP				
Weight	0.499	0.499	1074.89	<0.001
Weight + Height	0.548	0.049	654.96	<0.001
Weight + Height + BMI	0.553	0.005	443.72	<0.001
Diastolic BP				
Height	0.297	0.297	116.08	<0.001
Height + BMI	0.309	0.012	31.80	<0.001

Discussion

The positive association between BP and BMI which has been previously documented in several cross sectional studies [6,9,20,21] of BP in adolescents was also observed in the present study. Individuals having higher BMI values were also generally found to rank high in BP levels.

In this study, a significant linear relationship was observed between BMI and both systolic and diastolic BP, i.e 0.41, $P<0.001$ and 0.28, $P<0.001$ respectively. This is in agreement with the findings reported by Balogun *et al* [22] and Akinkugbe *et al* [23] in Nigerian children. It is also similar to the findings by Clarke *et al* [15] in American children but at variance with findings by Blackson *et al* [24] in Ghanaian children aged 5-12 years and Antia-Obong *et al* [25] in Nigerian children aged 6-14 years. The reported poor correlation between BMI and BP in their studies [24,25] could possibly be explained by the younger age of the subjects involved in the studies. This gives credence to the observation by Lauer *et al* [6] that correlation between BMI and BP is stronger in adolescence than childhood.

In this study 55.3% of the variation in systolic BP was explained by all the independent variables in the regression analysis. This figure is higher than the 27.3% and 49% reported by Balogun *et al* [22] and Adams-Campbell *et al* [26] respectively in Nigerian children. It is also higher than the 39% reported by Voors *et al* [9] in American children. However, direct comparison between these multiple regression analysis is difficult because of the varying predictor variables measured in the different studies.

Although multiple regression analysis showed that of all the variables, weight and height were responsible for most of the variations in systolic BP, BMI also added a significant influence on systolic BP after height and weight were in the model. This finding agrees with the observation of Voors *et al* [9], but is at variance with the findings of Balogun *et al* [22] who reported that only weight and BMI exerted a significant variation in the level of systolic BP. As regards diastolic BP, 31.5% of the variation was explained by all the measured variables, Voors *et al* [9] also reported a similar figure of 31% in variance of diastolic BP on multiple regression analysis. In agreement with Voors *et al* [9], this study has also shown that height and BMI were the only variables that account for a significant variation in the level of diastolic BP. Contrary to the findings by Andy *et al* [27] age was not a reliable predictor of BP in this study; rather, our findings agree with those of Voors *et al* [9] and Balogun *et al* [22] who reported no association between age and BP after controlling for weight, height and BMI. A possible explanation for this inconsistency in findings could be the fact that the study by Andy *et al* [27] included more children in the first decade of life. This study is limited by the fact that it is a cross-sectional study. A longitudinal study would have allowed observation of the actual progression of individual BP in relation to BMI.

Conclusion

Our study shows that BMI correlates moderately with current levels of both systolic and diastolic BP of Nigerian children in the second decade of life. Weight, height and BMI (in descending order of influence) are predictors of systolic BP whilst height and BMI are predictors of diastolic BP in these children. Age is not a reliable independent predictor of BP. It is recommended that health education should be given to Nigerian adolescents on control of weight as a means of controlling present BP levels and possibly preventing essential hypertension in adult life. A longitudinal study to investigate changes in adiposity with time, its effect on BP level, and the tracking of BP levels from childhood into adult life in Nigerian children is also recommended.

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