

Oscillometric blood pressure profile and anthropometric indices among healthy school children in Ilorin, North-central Nigeria

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ABSTRACT

Context: Oscillometric devices are preferred method for measuring blood pressure (BP) among children. **Aims:** This study measured BP among school-age children using a validated oscillometric device (Omron 705 IT[®]) and correlated the findings with the anthropometric parameters, with a view to determine the predictors of BP. **Settings and Design:** This was a cross-sectional, descriptive study. A multistage stratified random sampling technique was used in the selection of pupils from primary schools in Ilorin, Nigeria. **Subjects and Methods:** Two serial BPs were measured using Omron 705 IT[®] with appropriate cuffs using “the fourth report” guideline and standard methods were used for measurement of anthropometrics. **Statistical Analysis Used:** Data were analyzed using SPSS version 20. **Results:** A total of 1745 primary school-aged children comprising of 873 males and 872 females were recruited. Anthropometric parameters were comparable between males and females. Mean systolic and diastolic BPs were 103.8 ± 11.0 mmHg and 61.3 ± 8.4 mmHg, respectively. Mean systolic BP was lower in males compared with females (102.9 ± 10.6 mmHg vs. 104.7 ± 11.3 mmHg, respectively, $P = 0.001$). Mean diastolic BP in males was lower compared with females (60.7 ± 8.3 mmHg vs. 61.8 ± 8.5 mmHg, $P = 0.009$). Most of the anthropometric parameters correlated with the BPs. Independent predictor of BP was weight, height, and body mass index (BMI), $P < 0.001$. **Conclusions:** There was a weak correlation between the oscillometric BPs and anthropometric parameters with weight, height, and BMI been the independent predictors of BP.

Key words: Anthropometric indices, blood pressure, Nigeria, oscillometric, school children

INTRODUCTION

Blood pressure (BP) is defined as the amount of pressure exerted on the arterial wall as the blood flows through and is routinely measured as a component of vital signs during the evaluation of a child.^[1] Although there are quite a number of Nigerian studies that have documented BP profile among children, these studies were done with mercury sphygmomanometer that is being phased out globally.^[2-6] Among the devices replacing the mercury sphygmomanometer is the oscillometric device.^[7,8]

A recent meta-analysis affirmed the existence of differences between the oscillometric and auscultatory BP measurements among children.^[9] Thus, the global phaseout of mercury sphygmomanometers makes it imperative to reexamine the BP profile using validated oscillometric devices which are preferred among children.^[8] There were very few studies done in Nigeria with oscillometric devices, among adolescents and most were done with devices that have not been validated.^[10,11]

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This study was designed to determine the oscillometric BP profile of primary school children in Ilorin, North-central Nigeria, using a validated oscillometric device (Omron 705 IT)^[12] and correlate the findings with the various anthropometric parameters with a view to determine the predictors of BP.

SUBJECTS AND METHODS

This was a cross-sectional, descriptive school-based study carried out over a 6-month period (December 2014–May 2015) among primary school pupils aged 6–12 years in Ilorin. Ilorin is the capital city of Kwara state, one of the states in North-central Nigeria.^[13] The city had an estimated population of 1,049,168 in 2013 with a typical settlement patterns spanning urban, semi-urban, and rural communities.^[14] Based on the school lists from the State Ministry of Education, there are 659 primary schools (public and private), 145 secondary schools, and 10 tertiary institutions in Ilorin in three local government areas (Ilorin West, Ilorin East, and Ilorin South).^[15] There are 55 public primary and 205 private primary schools in Ilorin West local government areas. Similarly, Ilorin South has 55 public schools and 176 private primary schools whereas Ilorin East has 79 public schools and 89 private schools.^[15] The three local government areas (LGAs) have a combined population of 109,492 primary school children.^[15]

A multistage stratified random sampling technique was used in the selection of pupils from each of the LGAs that make up Ilorin by the following steps. In each of the local government, using the school lists provided by the Kwara State Ministry of Education, the primary schools were stratified into private and public primary schools. Thereafter, the lists were assigned numbers based on the alphabetical order. Based on the proportion of the pupils in the three LGAs and the ratio of public to private primary schools, the table of random numbers was used to select public and private primary schools that formed the sampling units for the study. By this, a total of 20 primary schools were recruited for the study. In each of the selected primary schools, a systematic random sampling technique was used for children recruitments. Thus, a cumulative total of 1745 pupils were recruited for the study.

The inclusion criteria include all primary school pupils of the selected schools who were apparently healthy, aged 6–12 years and were eligible to participate in the study. The following children were excluded from the study: children with known cardiovascular problems such as congenital or acquired heart diseases; children with suspected genetic syndrome such as down syndrome or dysmorphic features; and children with a known endocrine disorder such as diabetes and thyroid diseases.

An electronic weighing scale (Camry®, Model: EB9323H, China) with an accuracy of 100 g was used to measure the weight. A portable stadiometer (Seca® Model: 213, USA) with accuracy of 0.1 cm was used to measure the height.

An inelastic tape measure was used for the measurements of the mid-arm circumference, waist circumference, and hip circumference. Omron 705 IT® was used for the oscillometric method. Omron 705 IT® measures BP at a range between 0 and 229 mmHg, and pulse rate between 40 and 180 beats/min. It was powered by four alkaline batteries ($1.5\text{ V} \times 4 = 6\text{ V}$) and has an accuracy of $\pm 3\text{ mmHg}$. The device was provided with different sizes of cuffs based on the fourth report recommendations.^[16]

Before recruitment, information sheet detailing what the study was all about consent form and study pro forma were given to all the eligible participants for their respective parents/guardians to fill. For each participant, 7 years and above, the assent form was also provided.

The height was measured to nearest 0.1 cm with the stadiometer (each of the pupils had their height measured in the upright position with their shoe removed, hips and shoulder perpendicular to the central axis, heel against footboard, knee together, arms hanging loosely at the sides, and the head in Frankfurt plane).^[17] Arm circumference was measured with the inelastic measuring tape to the nearest 0.1 cm at the midpoint between the acromion and the olecranon processes. This was used for cuff selection. Waist circumference was measured with the inelastic measuring tape to the nearest 0.1 cm in the horizontal plane at the midpoint of the distance between the lowest rib and the superior border of the iliac crest. Hip circumference was measured with inelastic tape over the major trochanters to the nearest 0.1 cm. Subsequently, the waist-to-hip ratio was calculated. Weight was measured to the nearest 0.1 kg with the pupils lightly dressed and shoes removed. The weighing scale was adjusted to zero reading before each measurement. Body mass index (BMI) was calculated as the body weight in kilogram divided by height in meters squared.

BP was measured in a quiet room between 9 am and 12 noon.^[18] The procedure was explained to each of the participants before measurements. The BP was measured on the right arm after the child had sat quietly for at least 5 min. The participants' back was supported; leg uncrossed, feet resting on a firm surface, and right arm supported and was at the heart level. The cuff was applied to a bare right arm, with the lower border approximately 2 cm above the elbow crease and the midline of the bladder over the brachial artery.^[16] Two measurements were taken with at least 1 min interval, and the mean of the two reading was used for the analysis.^[19] Participants, who had just eaten or had physical activity, had their BP measured at least 30 min after the meal or physical activity. Furthermore, children, who cried or appeared frightful during the procedure, were excused and allowed additional 30 min to rest before the BP measurements were taken. However, where a pupil remained uncooperative by crying or appeared frightful

after resting for the 30 min periods, such pupil was excluded from the study

All the measurements were carried out by the investigator and either of two trained research assistants who were medical doctor (postinternship).

Ethical approval

Ethical approval was obtained from the University of Ilorin Teaching Hospital Ethical Review Committee (UITH/CAT/189/17/682) while a written permission was obtained from the Kwara State Ministry of Education. Furthermore, a written informed consent was obtained from the parents or guardians of the participants. For the participants 7 years and above, the assent was also sought for the study.

Data analysis

The information obtained, with a pretested semi-structured questionnaire, were numerically coded and entered into an Excel spreadsheet. This was then exported and analyzed with IBM SPSS statistics for Windows, version 20 (IBM Corp., Armonk, NY, USA). Data were checked for normal distribution. Data were analyzed separately for males and females. The anthropometric parameters were presented as mean with standard deviation, while the BPs were compared using the *t*-test and ANOVA where there were more than two means. The Pearson correlation coefficient was used to assess the relationship between age, anthropometric variables, and BP. Multiple linear regression analysis was used to assess the independent predictors of BP.

RESULTS

A total of 1745 primary school-aged children were studied. There were 873 males and 872 females giving the male-to-female ratio (male: female) of 1:1. The mean age of the males was 8.76 ± 2.0 years, which was not significantly different from that of the females (8.78 ± 1.9 years), $P = 0.838$. There was no significant difference in the anthropometrics parameter between males and females [Table 1].

Of all the study participants, the mean systolic BP was 103.8 ± 11.0 mmHg. In males, the mean systolic BP was 102.9 ± 10.6 mmHg, which was significantly lower than the value of 104.7 ± 11.3 mmHg in females, $P = 0.001$. The mean systolic BP increased from 102.8 ± 11.1 mmHg at age 6 years to 105.9 ± 12.1 mmHg at age 12 years, ($F = 3.567$, $r = 0.08$; $P = 0.002$). Further details are shown in Figure 1. In all the study participants, the mean diastolic BP was 61.3 ± 8.4 mmHg. The mean diastolic BP in males (60.7 ± 8.3 mmHg) was significantly lower than the corresponding value of 61.8 ± 8.5 mmHg in females, $P = 0.009$. There was no significant increase in the mean diastolic BP with age ($F = 1.419$; $r = -0.02$; $P = 0.201$). Further details are shown in Figure 2.

Table 1: Anthropometric parameters of the study participants

Variable	Male (n=873)	Female (n=872)	t	P
Weight (kg)				
Range	16.0–78.7	15.4–84.0	-1.300	0.194
Mean±SD	26.3±6.3	26.7±7.7		
Height (cm)				
Range	104.1–164.0	101.6–164.4	-1.702	0.089
Mean±SD	129.5±10.7	130.4±11.5		
WC (cm)				
Range	42.0–90.0	28.0–98.5	-1.633	0.103
Mean±SD	57.6±5.2	58.0±6.6		
HC (cm)				
Range	44.0–106.0	32.0–107.0	-0.895	0.371
Mean±SD	63.6±6.6	63.9±7.9		
WHR				
Range	0.63–1.50	0.62–1.13	-1.010	0.313
Mean±SD	0.91±0.06	0.91±0.05		
BMI (kg/m ²)				
Range	9.1–29.7	9.4–43.1	-0.183	0.855
Mean±SD	15.48±1.6	15.46±2.4		

WC: Waist circumference, HC: Hip circumference, BMI: Body mass index, WHR: Waist-to-hip ratio, SD: Standard deviation

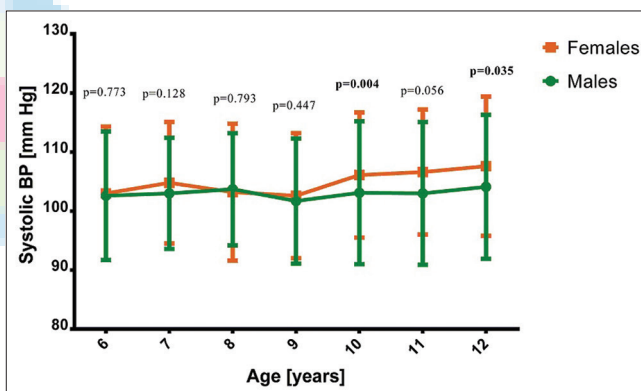


Figure 1: Systolic blood pressure distribution

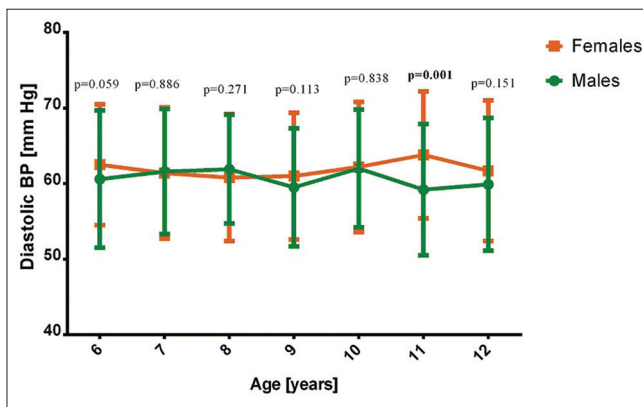
The overall systolic BP correlated with age ($r = 0.0772$ and $P = 0.001$). The systolic BP in males correlated positively with all anthropometric parameters except WHR as shown in Table 2. Similarly, in females, the systolic BP weakly correlated directly with all anthropometric parameters except WHR as shown in Table 2. There was no correlation between overall diastolic BP and age ($P = 0.543$). The diastolic BP in males correlated with BMI, waist, and hip circumferences ($r = 0.11$; 0.08 ; and 0.08 , respectively) as shown in Table 2. In females, it correlated positively with weight, BMI, waist, and hip circumferences ($r = 0.08$; 0.07 ; 0.02 ; and 0.10 , respectively) as shown in Table 2.

The multiple linear regressions of age and anthropometric parameters as the independent predictors of oscillometric systolic and diastolic BP showed only significant

Table 2: Correlation of age, anthropometric parameters, and blood pressure

Variable	Males (n=873)				Females (n=872)			
	SBP (mmHg)		DBP (mmHg)		SBP (mmHg)		DBP (mmHg)	
	r	P	r	P	r	P	r	P
Age	0.027	0.421	-0.045	0.183	0.126	<0.001	0.015	0.658
Weight	0.192	0.001	0.050	0.142	0.206	<0.001	0.078	0.021
Height	0.098	0.004	-0.016	0.645	0.168	<0.001	0.033	0.327
BMI	0.106	0.002	0.106	0.002	0.148	<0.001	0.074	0.028
WC	0.158	0.001	0.079	0.019	0.209	<0.001	0.098	0.004
HC	0.195	0.001	0.077	0.023	0.215	<0.001	0.100	0.003
WHR	-0.083	0.014	-0.012	0.719	-0.051	0.136	-0.017	0.607

r: Pearson correlation coefficient, BMI: Body mass index, WC: Waist circumference, HC: Hip circumference, WHR: Waist-to-hip ratio, BP: Blood pressure, SBP: Systolic BP, DBP: Diastolic BP

**Figure 2: Diastolic blood pressure distribution**

relationship with weight, height, and BMI as shown in Table 3.

DISCUSSION

The mean systolic BP (103.8 ± 11.0 mmHg) from the current study was similar to the value recorded in Kogi State^[11] (about 300 Km from Ilorin), Nigeria, but higher than the values recorded in the Democratic Republic of Congo (DRC)^[20] and South Africa.^[21] However, the mean systolic BP in the current study was lower than the results obtained in Pakistan^[22] and the UK.^[23] The similarities with the current study compared to the Nigerian^[11] study may be due to the fact that both studies were done in the same North-central region of the country with the two states (Kogi and Kwara) sharing boundaries. The lower value of the mean systolic BP recorded in the South African study was among rural children who were noted to have low BP. On the other hand, the Pakistan^[22] study used a single cuff for all the children, which could have affected the results.

The mean diastolic BP in the current study was higher than the value obtained in DRC^[20] and South Africa,^[21] but lower than the values recorded in Pakistan^[22] and the UK.^[23] The higher value reported in the Pakistan^[22] study could be attributed to the use of a single cuff for all the children as well as a small sample size. The higher values found in the UK^[23] were among African-Caribbean children, who were noted to have

Table 3: Multiple linear regression analysis of predictors of blood pressure

Variable	SBP (mmHg)			DBP (mmHg)		
	β	SE	P	β	SE	P
Age	-0.204	0.195	0.297	-0.145	0.153	0.341
Weight	1.273	0.284	<0.001	0.858	0.222	<0.001
Height	-0.516	0.128	<0.001	-0.425	0.100	<0.001
BMI	-1.943	0.548	<0.001	-1.491	0.428	<0.001
WC	0.502	0.420	0.216	0.315	0.328	0.336
HC	-0.212	0.373	0.569	-0.087	0.291	0.765
WHR	-32.322	27.252	0.236	-16.168	21.295	0.448

BMI: Body mass index, WC: Waist circumference, HC: Hip circumference, WHR: Waist-to-hip ratio, SE: Standard error, BP: Blood pressure, SBP: Systolic BP, DBP: Diastolic BP

higher BP in the same study and it was attributed to ethnic and genetic variations in BP.

The mean systolic BP in the current study was higher among females compared with the males, which was similar to the findings in DRC^[20] and Japan.^[24] In contrast, studies from Kogi,^[11] US,^[25] and China^[26] reported higher systolic BP among males compared with females. The mean diastolic BP was also higher in females compared to males in the present study which was similar to the reports from China^[26] and Japan.^[24] The lower BPs recorded in males in the current study could be due to the different levels of physical activities in the genders. Studies among the Nigerian school children have documented the higher level of physical activities in males compared to their females counterparts.^[27,28] The physical activities cause vasodilatation of the skeletal muscle arteries, reduction in the peripheral resistance, and decrease sympathetic tone with resultant effects of lower BP.^[29,30]

The current study also showed the weak levels of correlations between systolic BP and anthropometrics parameters in both males and females which was consistent with the findings of other researchers.^[10,11,26,31] However, the observation of hip circumference as the best in strength of correlations for systolic BP differs from some of the findings of previous workers.^[26,31] LA de Hoog *et al.*^[31] reported BMI as the best correlate of systolic BP while Sung *et al.*^[26] found the

weight as the best correlate, although the two studies did not include hip circumference among the anthropometric variables. The best correlate for diastolic BP among the anthropometric parameters in males and females were BMI and hip circumference, respectively. Similar to the current study was the findings from Abeokuta,^[10] South Western Nigeria, where BMI was reported as the best correlate of oscillometric diastolic BP.

The current study showed that the independent predictors of BPs in both genders were weight, height, and BMI. These three anthropometric parameters have been well documented in many studies to influence BP in children and adolescents.^[32] The rise in BP associated with the increase in height and weight are part of physiological adaption in the cardiovascular system to increase in body demand as the child grows.^[33] The clinical import of these findings is the fact that more than one anthropometric parameter predict BP among children and these are needed to be considered while dealing with their BP.

CONCLUSIONS

There was a weak correlation between the oscillometric BP and anthropometric parameters with the weight, height, and BMI being the independent predictors of BP among the children. Thus, the anthropometric parameters (height, weight, and BMI) should be taken into consideration while evaluating the BP of a child.

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Conflicts of interest

There are no conflicts of interest.

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