The Evaluation of Waist Circumference and Waist-Hip Ratio as Predictors of Hypertension in Children

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Authors' contributions

This work was carried out in collaboration among all authors. All the authors participated in the conceptualization, literature review, data collection and analysis, drafting and editing of the manuscript. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Background: Childhood hypertension is a public health concern because of associated cardio-metabolic morbidities in adulthood. Overweight and obesity are main drivers and predictors of childhood hypertension. There is paucity of studies on waist circumference (WC) and waist-hip ratio (WHR) – measures of central obesity - as predictors of hypertension in children. The study was done to determine if WC and WHR predicts hypertension in children.
Study Design: The study was a descriptive cross-sectional study.
Place and Duration of Study: Primary schools in Owerri Municipal Local Government Area (LGA), Imo State, Nigeria between September 2017 to April 2018.
Methodology: 809 school children aged 6-12 years were recruited from three public and six private primary schools using multi-staged sampling method. Their blood pressure (BP), weight, height, hip circumference and WC were measured using standard techniques. The BMI and WHR were then calculated. Central obesity was defined as WC ≥90th percentile. The data were analyzed with IBM-SPSS 21.
Results: The male female ratio was 1:1. The prevalence of pre-hypertension and hypertension

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were 8.50% and 2.70% respectively. While those of overweight, obesity and central obesity were 5.10%, 5.90% and 10.10% respectively. WC significantly and positively correlated with systolic blood pressure (SBP) [r = 0.57, p = 0.0001] and diastolic blood pressure (DBP) [r = 0.57, p = 0.0001]. WHR had a negative correlation with SBP and DBP [r = -0.33, p = 0.0001 in both cases]. Central obesity increased the odds of developing systolic and diastolic prehypertension/ hypertension by 9 and 8 folds respectively.

Conclusion: Central obesity predicted prehypertension/hypertension in primary school children in this study and therefore can be used as screening tool in programs to prevent childhood obesity and hypertension.

1. INTRODUCTION

The global burden and risk factors of disease have changed significantly over the past two decades from communicable to non-communicable diseases with hypertension being top contributor of the global burden of non-communicable diseases [1]. In the past decade, there have been significant rise in the rates of hypertension in children and adolescents ranging from 1-5% in some developed countries, like the United Kingdom (UK) and United States of America (USA) [2]. In African children, an average prevalence of hypertension was reported to be 5.5% (4.2–6.9%), whereas that of pre-hypertension was 12.7% (2.1–30.4%) [3]. A review has documented a 5.1% prevalence of hypertension in Nigerian children [4]. Some factors shown to be associated with hypertension in children within the local context have included: obesity, higher socioeconomic status, increasing age, sex, race, and physical inactivity [5-7]. These observed risk factors are consistent with those observed in high-income countries [1,8]. Hypertension in children and adolescents pose a significant public health challenge which tracks into adulthood [1].

Childhood overweight and obesity is a key contributing factor to the increasing prevalence of hypertension in children and adolescents, this probably results from changes in lifestyle, increased high-caloric dietary intake, reduced activity and westernization [1,9]. The global incidence of obesity in children have risen by 14% in the last five decades [10]. It is estimated that in 2016, more than 340 million children and adolescents aged 5-19 years were overweight or obese [10]. In Nigeria, the prevalence of obesity in children has ranged from 0.3 to 18%, especially among the high socioeconomic class [11]. BMI categorized into age and sex percentiles have been used to assess obesity and predict hypertension in children [3,5-7,9]. In a systematic review with meta-analysis of prevalence studies in Africa, Noubiap et al. [3] demonstrated that obese children were six times more likely to have hypertension. Similarly, Akor et al. [7] and Okpokowuruk et al. [8] in different parts of Nigeria have documented this relationship among apparently healthy children. While Akor et al. [7] reported that BMI had a significant positive correlation with SBP and DBP, Okpokowuruk et al. [8] documented that high BMI doubled the odds of having hypertension among their study participants. On account of the draw backs of BMI, attention is shifting to more sensitive indicators of body fat like WC and WHR [12]. Findings have shown that WC and WHR, both measures of central obesity, are more sensitive indicators of body fat, and correlate well with cardiovascular risks especially in adults, as evidence regarding this relationship in children is still emerging [13]. Therefore, this study aimed to determine if these measures of central obesity (WC and WHR) predict childhood hypertension. Findings from this study will add to the body of emerging evidence and contribute to the development and implementation of preventive interventions to curb the childhood hypertension.

2. MATERIALS AND METHODS

2.1 Study Area and Population

The study was conducted in primary schools in Owerri Municipal Local Government Area (LGA) of Imo State in the South-eastern part of Nigeria. Owerri Municipal has a population of about 127,000 with an estimated enrolment of 70,000 pupils aged 6-12 years. The study population comprised of primary school pupils aged 6-12 years selected from government approved schools within the study area. The

study was carried out from September 2017 to April 2018.

2.2 Study Design and Protocol

This was a descriptive cross-sectional study. Apparently healthy children aged 6-12 years attending a selected primary school within the study area, whose parents/guardians gave permissions to their participation in the study and who gave assent (for those above seven years) were included in the study [14]. Children with gastroenteritis, hypertension or history suggestive of other cardiovascular or renal illnesses were excluded from the study. Also, children who are on any drug known to affect blood pressure for example steroid or salbutamol were excluded.

2.3 Sample Size Determination

Using the prevalence of 9.52% for hypertension in a study done among school children in Jos, Northern Nigeria [15], the sample size was estimated using the formula below;

$$N = \frac{Z^2 \, P \, (1-P)}{D^2}$$

Where N is the minimum sample size, Z is 1.96 at confidence interval of 95%, P is 0.095, D is the error margin at 3%. An allowance for Design Effect (DE) [16] and a 10% non-respondent rate were considered given a minimum sample size of 809 pupils.

2.4 Sampling Method

Multi-stage sampling was used to select the subjects. Nine schools were randomly chosen while the number of pupils to be recruited per school and per class were proportionally calculated using the formulae below;

Population of the target school x Calculated sample size/Total population of 9 schools

Population of the class x calculated number of pupils in the selected school/ Population of the target school

The subjects were then selected from each class by a simple random sampling method using the class register. Selected pupils were given the permission form and the questionnaire to take home to their parents/caregivers to fill, and measurements were taken when they returned a completely filled questionnaire. Social class

stratification of the recruited subjects was done based on the criteria set by Oyedeji [17].

2.5 Blood Pressure Measurement

The BP was measured using the protocol recommended by the National High Blood Pressure Education Program Working Group on high blood pressure in children and adolescents [8]. An average of three consecutive BP measurements taken at an interval of three minutes between measurements was adopted. The BP measurements were recorded to the nearest 2 mmHg and same read off on standard BP tables. The BP readings greater than the 95th percentile for age and sex and height of the standard were regarded as 'hypertension' while BP between the 90th and 95th percentile of the standard was regarded as 'pre-hypertension'. Only subjects whose BPs remained in the hypertension and pre-hypertension range on three consecutive occasions were so classified.

2.6 Anthropometry Measurement

Children's weights and heights were measured with a stadiometer with an adjustable head piece (Model 769; Seca, Hamburg, Germany). The pupils were weighed wearing only light clothing. The weight was recorded in the nearest 0.1 kilogram (kg). To measure a child's height, the head piece was moved to touch the crown of the child's head standing erect with feet together, arms hanging freely, head aligned so that the external auditory meatus and lower border of the eye sockets are in the same horizontal plane, and the back and heels are in contact with the vertical bar of the scale. The height was recorded to the nearest 0.1centimetre (cm). To ensure accuracy, the scale was standardized every morning before use. BMI was calculated using the formula below and read off standard charts;

$$BMI = Weight \ (kilograms)/ \ Height^2 \ (metres^2)$$

BMI less than the 5th percentile was categorized as 'underweight', between the 5th percentile to less than the 85th percentile as 'normal weight', between the 85th percentile to less than the 95th percentile as 'overweight' and BMI equal to or greater than the 95th percentile as 'obesity'.

The WC and HC were measured using the WHO protocol [18]. The participants were allowed to wear light clothing during the measurements. Measurement was taken from the midpoint

between the lowest border of the rib cage and the top of the lateral border of the iliac crest during minimal expiration. Similarly, HC was measured at the greatest horizontal circumference below the iliac crest at the level of the greater trochanter using a non-stretchable tape. Both WC and HC were recorded to the nearest 0.1 cm. Central obesity was defined as WC ≥90th percentile [19]. The waist-hip ratio was subsequently calculated using the formula below [18];

$$WHR = \frac{\text{Waist circumference (centimetres)}}{\text{Hip circumference (centimetres)}}$$

2.7 Data Analysis

The data were analysed using Statistical Package for the Social Sciences (SPSS) version 21. The data were characterised using descriptive statistics. The age of the participants, WC, WHR, SBP and DBP were all normally distributed and hence summarised using means and standard deviation, while the categorical variables including gender, class of participants and social class were summarised using frequencies and proportions. The Pearson's correlation test was done to determine the strength and direction of association between BP and WC, WHR and age of the participants. SBP and DBP were categorised into 'normal' and 'abnormal' (pre-hypertension/hypertension) and central obesity was defined as WC≥90th percentile. Test of association using Chi-square (χ^2) was used to assess relationships between the categorical variables. Where a significant relationship was observed between the categorical variables, logistic regression analyses were done to identify the strength of association. A p-value of less than 0.05 at a 95% confidence interval was set for statistical significance.

3. RESULTS

A total of 809 pupils were recruited into the study with a mean age of 9.11± 1.87 (range: 6–12) years [Table 1]. The male to female ratio was 1:1.

Table 1. Baseline socio-demographic characteristics of the participants

Variables [n=809]	Frequencies (%)	Mean ± SD
Age (years)		9.11 ± 1.87
Gender		
Male	404 (49.90)	
Female	405 (50.10)	
School type		
Public	396 (48.90)	
Private	413 (51.10)	
Class of participants		
Primary 1	137 (16.90)	
Primary 2	130 (16.10)	
Primary 3	120 (14.80)	
Primary 4	158 (19.50)	
Primary 5	128 (15.80)	
Primary 6	136 (16.80)	
Social Class		
Upper	502 (62.10)	
Middle	222 (27.40)	
Lower	85 (10.50)	

SD = Standard deviation

The mean SBP range from 91.80 ± 9.36 mmHg at 6 years to 106.71 ± 8.62 mmHg at 12 years while the DBP range from 49.90 ± 6.42 mmHg at 6 years to 65.54 ± 9.35 mmHg at 12 years. The overall prevalence for pre-hypertension was 8.50% while that for hypertension was 2.70%. Three (0.40%) of the study participants had both diastolic and systolic hypertension [Fig. 1].
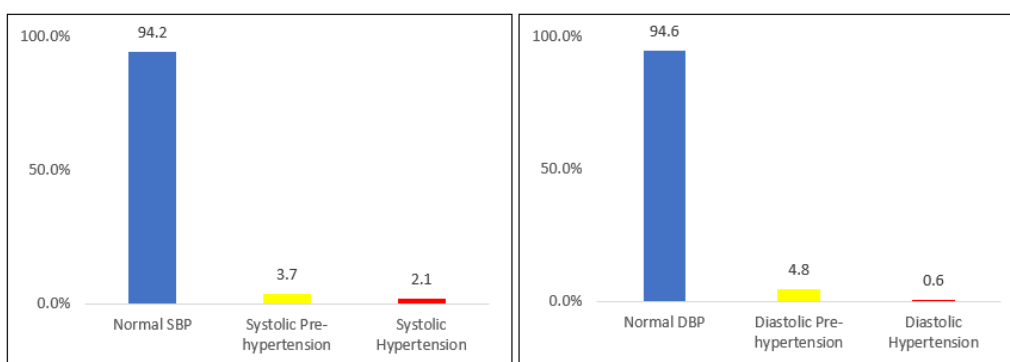

Fig. 1. Prevalence of hypertension in study participants

While the WC increases with age, the WHR decreased with age. The prevalence of overweight and obesity were 5.10% and 5.90% respectively, while the prevalence of central obesity was 10.10% [Fig. 2].

Pearson's correlation test represented on a scatter plots showed significant associations between SBP, DBP, WC and WHR (*P*<.0001 for all). Both SBP and DBP had positive correlation with WC (r = 0.57, r = 0.51 respectively) and negative correlation with WHR (r = -0.33) [Figs. 3 & 4].

Children who were overweight and obese were more likely to have both systolic and diastolic pre-hypertension/hypertension [OR (95% CI) = 3.24 (1.16-9.06) & 11.66 (5.58-24.35) respectively for systolic pre-hypertension/ hypertension and OR (95% CI = 8.16 (3.72-17.90) and 4.20 (1.59-11.07) respectively for diastolic pre-hypertension/hypertension]. Likewise, having central obesity increased the odds of having both systolic and diastolic pre-hypertension/hypertension [OR (95% CI) = 9.28 (4.94-17.46) and 7.58 (3.95-14.57) respectively] [Tables 2 & 3].
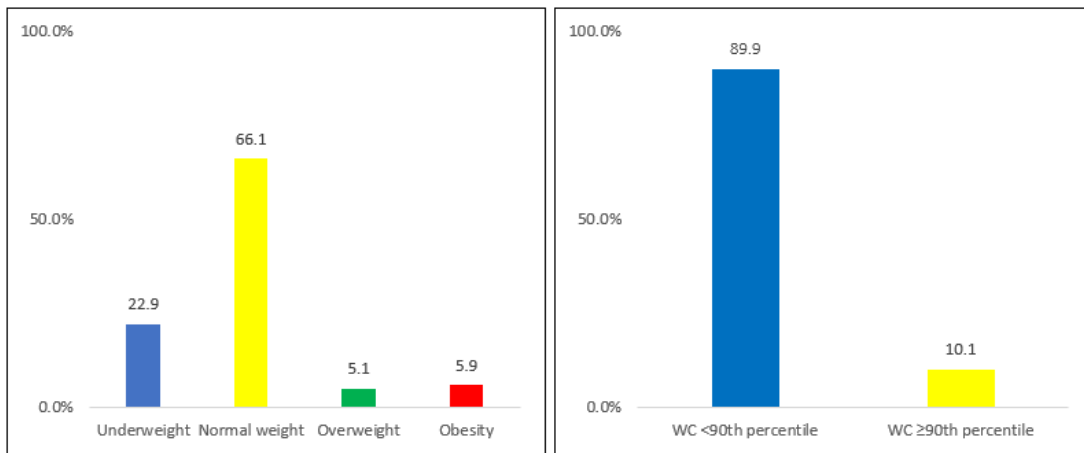

Fig. 2. Prevalence of overweight, obesity and central obesity

Table 2. Association between systolic blood pressure and body mass index and waist circumference categories

Variables [n=809]	Participants with normal systolic blood pressure [n (%)]	Participants with systolic pre-hypertension/ hypertension [n (%)]	χ^2	p-value	OR (95% CI)
BMI Categories					
Normal weight	513 (63.40)	22 (2.70)	76.82	<.0001*	1
Underweight	181 (22.40)	4 (0.50)			0.52 (0.18-1.52)
Overweight	36 (4.40)	5 (0.60)			3.24 (1.16-9.06)
Obesity	32 (4.00)	16 (2.00)			11.66 (5.58-4.35)
Total	762 (94.20)	47 (5.80)			
WC categories					
WC<90th percentile	701 (86.70)	26 (3.20)	65.37	<.0001*	1
WC≥ 90th percentile	61 (7.50)	21 (2.60)			9.28 (4.94-17.46)
Total	762 (94.20)	47 (5.80)			

(*) = Statistically significant, OR = Odds Ratio, CI = Confidence Interval, χ^2 = Chi-square, BMI = Body Mass Index, WC = Waist Circumference, Underweight = <5th percentile, Normal weight = 5th - <85th percentile, Overweight = 85th - <95th percentile, Obesity = ≥95th percentile
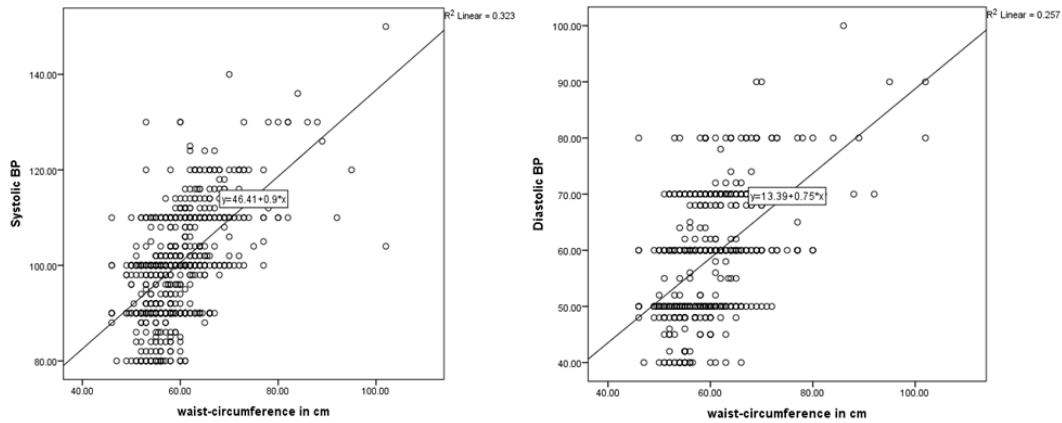
Fig. 3. Correlation between systolic blood pressure and waist circumference & waist-hip ratio
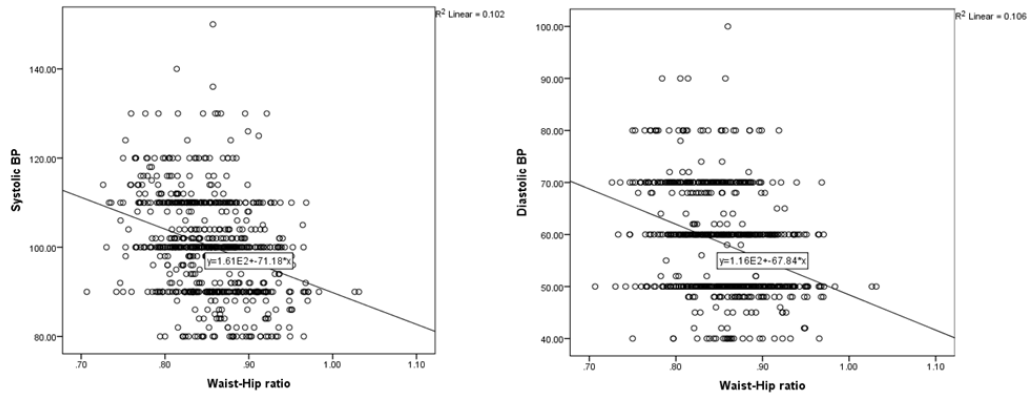

Fig. 4. Correlation between diastolic blood pressure and waist circumference & waist-hip ratio

Table 3. Association between diastolic blood pressure and body mass index and waist circumference categories

Variables [n=809]	Participants with normal diastolic blood pressure [n (%)]	Participants with diastolic pre-hypertension/ hypertension [n (%)]	χ^2	p-value	OR (95% CI)
BMI categories					
Normal	514 (63.50)	21 (2.60)	47.53	<.0001*	1
Underweight	180 (22.20)	5 (0.60)			0.68 (0.25-1.83)
Overweight	35 (4.30)	6 (0.70)			4.20 (1.59-11.07)
Obesity	36 (4.40)	12 (1.50)			8.16 (3.72-17.90)
Total	765 (94.60)	44 (4.40)			
WC categories					
WC<90th percentile	701 (86.70)	26 (3.20)	48.38	<.0001*	1
WC≥ 90th percentile	64 (7.90)	18 (2.20)			7.58 (3.95-14.57)
Total	765 (94.60)	44 (4.40)			

(*) = Statistically significant, OR = Odds Ratio, CI = Confidence Interval, χ² = Chi-square, BMI = Body Mass Index, WC = Waist Circumference, Underweight = <5th percentile, Normal weight = 5th - <85th percentile, Overweight = 85th - <95th percentile, Obesity = ≥95th percentile.

4. DISCUSSION

The prevalence of pre-hypertension and hypertension observed in this study is similar to various studies done in Nigeria [20,21]. This prevalence may suggest that there has not been a remarkable difference in hypertension rates within Nigeria [4]. Nevertheless, the higher rate of pre-hypertension may indicate that Nigerian children are at risk of developing hypertensive disease in the future if no targeted intervention is implemented to reverse this trend. Although some authors in Nigeria have documented rates varying from this study, these could be accounted for by differing age of participants, gender and the methodology employed for measuring BP [15,22,23]. Significantly, differences in prevalence for pre-hypertension and hypertension have not been observed globally and within Africa [3,24].

The prevalence for overweight and obesity observed is comparable to the range documented by Ejike [11] over three decades (5.0-12.0% for overweight and 0.0-5.8% for obesity). This finding further agrees with studies which have shown a lower and stable trend for overweight and obesity in Nigerian children [11,20,25] despite growing urbanization, westernized lifestyle, high sugar intake and reduced physical activity. This paradoxical observation may reflect the impact of economic instability, insurgency and other disasters the country has faced in recent times [26]. This may also explain the lower prevalence of obesity found in this study compared to rates in countries with more stable economies [27,28].

Waist circumference was found in this study, to significantly predict hypertension among the participants, as documented by some authors [7,29]. A possible explanation for this finding may be linked to the accumulation of visceral fat, dyslipidemia and atherosclerosis associated with increasing WC, ultimately leading to hypertension. Anthropometric indicators like WC have been proposed as epidemiological screening tools to detect children with cardiovascular risk, on account of their low cost, easy application and non-invasiveness. However, these advantages have been limited by the lack of global consensus on cut-offs and reference values, which also make comparison between studies difficult. On the contrary, Sebanjo et al. [30] reported that although WC was a more sensitive measure of body fat, it was not a good predictor for hypertension in children. Unlike in this study, Sebanjo et al. [30] used a lower cut-off for central obesity (WC ≥75% percentile) which may have increased the sensitivity of WC to measure abdominal obesity but not predict hypertension.

A negative correlation observed between BP and WHR in this study, is consistent with studies by Taylor et al. [31] in New Zealand and Rosaneli et al. [28] in Brazil. The reason for this negative correlation could suggest that WHR may not be a good predictor for hypertension in children, since it is not a direct measure of abdominal fat and may be influenced by various factors like abdominal contents (non-fat and fat), amount and tone of abdominal wall muscles [18,32]. Additionally, it could also be affected by spinal curvature, posture, bony and muscular dimensions at the hips which are constantly evolving in children. On the contrary, Menekse et al. [33] in Turkey and Abolfotouh et al. [34] in Egypt found that WHR significantly predicts hypertension. However, in contrast to this study, their studies were in adolescents in whom fat accumulation around the hips may have become more static, thus be more useful in diagnosing excess body fat [35].

5. CONCLUSION

The WC positively and significantly correlated with SBP and DBP. The odds of children with elevated WC having systolic and diastolic pre-hypertension/hypertension were 9 and 8 folds respectively, buttressing the ability of WC to predict prehypertension/hypertension in school-aged children. Therefore, WC can be employed as a pre-screening tool in school health programs targeted at preventing childhood obesity and hypertension. WHR had a negative correlation with SBP and DBP, showing that it may not be a good predictor for cardiovascular risk in school-aged children. In this study, central obesity was not classified using WHR due to the lack of global consensus on cut-offs and reference values. Even though, central obesity was classified using WC, regional discrepancies on cut-offs and reference values remain, making it difficult for comparison within studies. These highlight the need for further studies to develop these reference charts and cut-offs for global consensus on the classification of central obesity.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

Patient's written consent were collected and preserved by the authors as per international and/or university standards.

ETHICAL APPROVAL

Ethical approval was obtained from the Ethics Committee of the Federal Medical Centre (FMC) Owerri. A protocol approval and permission were then gotten from the Imo State Universal Basic Education Board (IMSUBEB) and the headmasters/headmistresses of the selected schools.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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