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Anthropometric Predictors of Blood Pressure among Nigerian Children and Adolescents

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ABSTRACT

Elevated blood pressure (Hypertension) is a well-established risk factor for cardiovascular disease. This cross-sectional study of one thousand (1000) Nigerian children and adolescents aged 7 to 18 years in Port-Harcourt City, Rivers State, Nigeria involved the measurements of anthropometric variables such as; height, weight and four skinfold thicknesses as well as blood pressure (systolic and diastolic B.P). Data obtained was analyzed using SPSS version 21 and XLSTAT statistical software. Results indicated the mean ages as; 12.2±2.52, 12.6±2.58, and 12.4±2.56 for males, females and the entire sample respectively. Mean body mass index (BMI) for the whole sample, males and females respectively were; 18.24±3.24, 17.64±3.12 and 18.73±3.26. The females showed significantly higher height and weight values and a significantly higher BMI than males ($p<0.05$). Also, females presented significantly higher values in all skinfold thicknesses than males ($p<0.05$). There was no sex difference in both blood pressure ($p>0.05$). Skinfold thicknesses correlated significantly with blood pressure in females ($p<0.05$) whereas only subscapular and supraspinal skinfolds showed a significant relationship with blood pressure in males. BMI showed a significant positive correlation with blood pressure in both sexes. The relationship between skinfold thickness and blood pressure appeared to be sex-dependent. The study has established that a relationship may exist between adiposity indices of body composition and blood pressure. Hence, these associations can be considered as factors that may influence blood pressure which could lead to the development of hypertension if uncontrolled early before adulthood.

Keywords: Blood pressure, skinfold thicknesses, BMI, Port-Harcourt

INTRODUCTION

It was only a few decades ago that hypertension was being reported in children due to several environmental stressors, low physical activity levels, a higher prevalence of obesity and unhealthy lifestyle patterns[1]. Some authors have suggested that the worldwide increase in obesity amongst children over the last two decades probably resulted in the increase in hypertension in children[2,3]. Recent data from the United States of America suggested that the level of blood pressure (BP) and the incidence of hypertension in childhood is rising[4]. Global prevalence of children and adolescents varied by age, ranging from 4.32% among 6-year-olds to 3.28% among 19-year-olds, peaking at 7.89% among 14-year-olds[5]. Among the several risk factors for hypertension, obesity is considered a risk factor that has shown a consistent relationship with hypertension, with an increasing prevalence globally[6]. Some population studies have revealed a risk estimate of about two-thirds of hypertension resulting from obesity[7]. Disorders of the cardiovascular system and metabolic abnormalities due to obesity may appear in childhood and adolescence and continue unnoticed for several years before observations are clinically detected [8].

Among adults, hypertension and excess body weight are co-morbidities as obese individuals are likely to be hypertensive[9]. Hypertension and excess body weight often originate in childhood and adolescence, and overweight adolescents are more likely to remain overweight into adulthood adults[10]. Body mass index (BMI) and skinfold thicknesses are used as indices of adiposity or obesity in body composition assessment. The relationship between obesity and BMI has long been established by various researchers[11].

Although skinfold thickness is argued to provide a better estimate of body fatness than BMI [12], BMI is still the index of choice in assessing general adiposity as it is derived from simple measurements that have widespread use and are highly reproducible than skinfold measurements. Also, it exhibits a stronger statistical relationship with morbidity and mortality from many diseases, including cardiovascular diseases (CVD)[13-16]. However, skinfold thickness measurements are considered good indicators of adiposity as they directly measure the amount of subcutaneous fat at various body regions though these measurements are site- and sex-specific[17]. The subscapular and triceps skinfolds are commonly used[18]. Skinfolds are especially used to monitor variation in the amount of fat in the young as they have small body size, with most of their body fat located subcutaneously, even among the obese[19,20]. On the contrary, skinfolds have a weaker statistical relationship with percentage body or overall body fat in children and adults[21]. The skinfold measurement is however limited as it cannot be used with extremely obese persons, as there is both the difficulty in grasping a large skinfold with the caliper and the limitation in the range of measurement for different calipers. Also, there is difficulty in identifying bony anatomical landmarks in obese individual[22]. Owing to this difficulty, the upper limits for the distribution of skinfold measurements for a population remain unknown.

The rising prevalence of risk factors linked to hypertension and obesity has contributed to the global increase in cardiovascular diseases. However, these risk factors can be modified, particularly when identified and managed early in childhood. Unfortunately, this age group often receives little to no attention in this regard. This study is therefore focused on elucidating the relationships between selected anthropometric variables and blood pressure to find better predictors of blood pressures -SBP and DBP (systolic and diastolic B.P), as risk factors for hypertension.

MATERIALS AND METHODS

Study Location: The study was carried out in the Port-Harcourt metropolis (an urban area which consists of the Port-Harcourt city within the Port-Harcourt local government area itself and parts of Obio-Akpor accordingly)[23]. It is located in the South-South geopolitical region of Nigeria.

Study Design: The study was conducted as a descriptive cross-sectional survey on children and adolescents drawn from primary and secondary schools within Port-Harcourt Metropolis.

Sample Size: The sample size was determined using Fischer's formula for infinite or large population (>10,000) to estimate the sample proportion and also the Cochran formula for the sample size determination.

Applying Cochran[24] sample size (SS) determination formulae[24,25];

$$SS = \frac{Z^2 \text{ x p x q}}{d^2}$$

Where; z =critical value of 1.96, p= 0.20 (estimated proportion of working population in Port-Harcourt), d = 0 .03 (tolerance level of 0.05 was adjusted)

Therefore, Sample size = $\frac{1.96^2 \text{ x } 0.20 \text{ x } 0.80}{0.03^2}$ = 682.95

Total minimum sample size = 682.95+ 68.30 =751.25, approximately 751 (by adding a 10% attrition rate of the determined sample size). However, the sample size used in the study is 1000.

Sampling Technique: The children and adolescents were selected by stratified randomized sampling method.

Ethical Consideration: The study was formally approved by the University of Port-Harcourt Research and Ethics committee with an assigned reference number; UPH/CEREMAD/REC/04. Additionally, both verbal and formal written consent was obtained from the subjects depending on their ages. The confidentiality of each subject was strictly adhered to, such that obtained data on each subject was not in any way disclosed to others.

*Inclusion Criteria/ Exclusion Criteria***:** Only subjects between the ages of 7 to 18 years who consented to the study and are physically healthy, without any overt abnormality were recruited into the study. Those outside the age range with observable illnesses or deformities of body parts that could interfere with the measurements were excluded.

Instruments used/measurements taken: height-weight series weighing machine, of the floor type model RGZ-160(made in China) to measure both height and weight; slim guide skinfold caliper (creative health product, Made in Plymouth, Michigan, USA) for all skinfolds measurements (Triceps, subscapular, suprailiac and medial calf skinfolds) and digital blood pressure devices of variable cuff sizes (Omron M2 basic and Omron M6 comfort, HEM-7120-E and HEM-7321 respectively)

Measurement procedure: All anthropometric variables were measured following the guidelines stated in the manual of the International Society for Advancement in Kinanthropometry (ISAK)[26]. Blood pressure was measured following the American Heart Association guideline[27]. Two consecutive readings were taken at an interval of 3-5minutes and the mean value was used for each subject.

*Statistical Analysis***:** The data obtained was analyzed by using SPSS (Statistical Package for Social Sciences (IBM® version 23, Armonk, New York). Both Descriptive and Inferential statistics were done. Also, Pearson correlation (with univariate regression equation) was carried out on the data to determine the relationships between anthropometric indices for adiposity and blood pressure.

RESULTS

Table 1 shows the descriptive statistics for anthropometric and blood pressure parameters measured between male and female subjects.

The mean values for all anthropometric variables are relatively higher in females than in males. The mean values for height and weight, as well as for skinfold thicknesses showed that the females were relatively taller and weightier and had more subcutaneous fat than males. In contrast, mean blood pressure was higher in males than in females.

Table 1. Descriptive statistics of anthropometric and blood pressure variables for Mean and standard deviation (S.D) values.

Parameter	Male (N=500)	Female (N=500)	Total (N=1000)
	Mean± S.D	**Mean± S.D**	**Mean± S.D**
Age (yrs)	12.4±2.76	12.8±2.76	
Height (m)	1.48±0.16	1.50±0.12	1.49±0.14
Mass (kg)	40.8±13.50	43.3±11.83	42.04±12.74
BMI (kgm^{-2})	18.26±3.52	18.85±3.24	18.56±3.39
Triceps SF	6.19±3.08	9.62±4.49	7.90±4.21
Subscapular SF(mm)	5.86±2.69	8.47±3.78	7.17±3.53
Supraspinal SF(mm)	4.61±2.63	7.08±3.57	5.85±3.37
Calf SF(mm)	7.09±3.42	10.08±4.44	8.58±4.23
Blood pressure			
Systolic BP (mmHg)	97.74±13.13	97.41±12.79	97.81±12.73
Diastolic BP (mmHg)	60.93±9.21	60.59±8.68	60.73±8.69

SD= standard deviation, max=maximum value, min=minimum value

Table 2 depicts the results for comparing between both genders the variables studied. The females showed significant differences in their mean values when compared with their male counterparts for height, mass, BMI and all skinfold thicknesses ($p<0.05$). It is worthy of note that the mean values for all skinfold thicknesses in females were significantly higher than those of male subjects($p<0.0001$).

Although the mean blood pressures were higher in males than in females, this difference was not statistically significant.

Table 2. Comparative statistics for anthropometric and blood pressure variables based on Independent t-test.

Parameter	Male (N=500)	Female (N=500)	Independent t-test		
	Mean±S.D	**Mean±S.D**	**t-value**	**P value**	**inference**
Age (yrs)	12.4±2.76	12.8±2.76	2.27	0.029	Significance
Height (m)	1.48±0.16	1.50±0.12	3.03	0.006	Significance
Mass (kg)	40.8±13.50	43.3±11.83	4.42	0.002	Significance
BMI(kgm^{-2})	18.26±3.52	18.85±3.24	4.98	0.006	Significance
Triceps SF	6.19±3.08	9.62±4.49	13.950	<0.001	Significance
Subscapular SF	5.86±2.69	8.47±3.78	12.466	<0.001	Significance
Supraspinale SF	4.61±2.63	7.08±3.57	12.363	<0.001	Significance
Calf SF	7.09±3.42	10.08±4.44	11.811	<0.001	Significance
Blood pressure					
Systolic BP (mmHg)	97.74±13.13	97.41±12.79	-0.36	0.719	*Not Significance*
Diastolic BP (mmHg)	60.93±9.21	60.59±8.68	-0.53	0.596	*Not Significance*

SF=skinfold thickness, BMI=body mass index, p value <0.05 is significant

Table 3 shows the correlation between BMI and skinfold thickness with blood pressure. In this table, it is observed that in both males and females, BMI correlates positively and significantly with both SBP and DBP (r=0.286 and r=0.202 for males; r=0.277 and r=0.149 for females). All skinfold thicknesses in males correlated positively with both SBP and DBP (range of correlation, 0.082 - 0.208). However, the correlations of skinfold thickness with blood pressure in males were only significant for subscapular and supraspinale skinfold thicknesses (p<0.05). In contrast, the correlation of skinfold thicknesses with blood pressure (SBP and DBP) were all significant, with correlation coefficient (r) values relatively higher in females.

Table 3. Association of anthropometric variables with blood pressure

Variables measured	Gender of the studied sample							
	Male				Female			
	SBP (*r*)	**P-value**	**DBP (*r*)**	**P-value**	**SBP (*r*)**	**P-value**	**DBP (*r*)**	**P-value**
BMI	0.286*	<0.001	0.202*	<0.001	0.277*	<0.001	0.149*	0.001
Triceps SF	0.097	0.055	0.082	0.106	0.235*	<0.001	0.136*	0.003
Subscapular SF	0.208*	<0.001	0.159*	0.002	0.265*	<0.001	0.183*	<0.001
Supraspinale SF	0.123*	0.014	0.101*	0.045	0.215*	<0.001	0.152*	0.001
Calf SF	0.095	0.061	0.083	0.100	0.256*	<0.001	0.157*	0.001

NB: * indicates significant values where p<0.05

Table 4 showed that in the general male population, the univariate regression models indicate that BMI, subscapular and supraspinale skinfold thickness were the only significant independent predictors of B.P.($p<0.05$)

Table 4. Univariate regression models characteristics (with regression equations) for the prediction of blood pressure among the male sampled population of children and adolescents

	Predictor of SBP (mmHg)				**Predictor of DBP (mmHg)**			
Variable*	R^2(%)	R_E	p-value	Inf.	R^2(%)	R_E	p-value	Inf.
BMI	8.20	76.596+1.192BMI	0.000	***S***	4.10	50.463+0.591BMI	0.000	***S***
TSF	0.90	95.152+0.429TSF	0.055	*NS*	0.70	59.420+0.254TSF	0.106	*NS*
Sub-scapular SF	4.30	91.984+1.003SubSF	0.000	***S***	2.50	57.862+0.538SubSF	*0.002*	***S***
Supra- SF	1.50	95.037+0.632SupraSF	0.014	***S***	1.00	59.398+0.363SupSF	0.045	***S***
Calf SF	0.90	95.237+0.374CalfSF	0.061	*NS*	0.70	59.428+0.231CalfSF	0.100	*NS*

Sub=subscapular, supra=supraspinale; SF=skinfold thickness, R_E= regression equation, NS=not significant; S=significant, Inf=inference, p-value=probability value; *Model is a good fit with $p<0.05$, p Values (in bold) indicates the significant prediction equations for blood pressure.

In Table 5 representing the prediction of blood pressure for the general female population; BMI and all four skinfolds are seen as significant independent predictors of blood pressure($p<0.05$).

Table 5. Univariate regression model characteristics (with regression equations) for the prediction of blood pressure among the female sampled population of children and adolescents

	Predictor of SBP (mmHg)				**Predictor of DBP(mmHg)**			
Variables*	R^2(%)	R_E	p-value	Inf.	R^2(%)	R_E	p-value	Inf.
BMI	7.70	78.580+1.081BMI	0.000	*S*	2.20	53.768+0.396BMI	0.000	*S*
TSF	5.50	92.629-0.658TSF	0.000	*S*	1.80	58.755+0.257TSF	0.003	*S*
SubSF	7.00	91.484+0.880SubSF	0.000	*S*	3.40	57.720+0.413SubSF	*0.000*	*S*
SupraSF	4.60	93.529+0.773SupraSF	0.000	*S*	2.30	58.628+0.370SupSF	0.001	*S*
Calf SF	6.60	91.745+0.721CalfSF	0.000	*S*	2.50	58.239+0.299CalfSF	0.001	*S*

Sub=subscapular, supra=supraspinale; SF=skinfold thickness, R_E= regression equation, NS=not significant; S=significant, Inf=inference, p-value=probability value; *Model is a good fit with $p<0.05$, p Values (in bold) indicates the significant prediction equations for blood pressure.

DISCUSSION

This study investigates the relationship between adiposity measurements and blood pressure among children and adolescents residing in Port Harcourt, Nigeria. The findings reveal that the mean ages of the studied population were 12.4 ± 2.76 years for males and 12.8 ± 2.76 years for females, with females exhibiting a significantly higher mean age. This age difference is reflected in the anthropometric measurements, as females demonstrated greater height, weight, and BMI compared to their male counterparts. Similar observations have been reported in previous studies, where female subjects showed higher values in these parameters[28,29].

Analysis of skinfold thickness measurements indicated that females had significantly higher mean values across all sites compared to males. These findings align with previous research, which consistently reports greater skinfold thickness among female subjects[30,31].

A significant association was observed between BMI and blood pressure (BP) in both sexes, corroborating previous studies[32,33]. Additionally, while the association between skinfold thickness and blood pressure was relatively weak, it remained statistically significant. Notably, this

association was more pronounced in females, as all measured skinfold thicknesses, indicative of both regional and central adiposity, showed significant correlations with blood pressure exclusively in female participants.
The stronger association between skinfold thickness and blood pressure in females aligns with findings from Pavlica *et al*. [34], who reported similar patterns in older women from Novi Sad, Serbia. This may be attributable to the continuous accumulation of adipose tissue in females from early childhood into adulthood. Skinfold thickness, recognized as a physiological marker of maturation, has been shown to correlate significantly with blood pressure in both adolescents and adults. Previous studies indicate that this relationship is consistent across racial and sex groups[35].

Sex-based differences in the association between adiposity measures, specifically skinfold thickness, and blood pressure have also been documented in existing literature[38]. In our study, subscapular skinfold thickness demonstrated a stronger correlation with both systolic (SBP) and diastolic blood pressure (DBP) compared to triceps skinfold thickness in both sexes. This finding agrees with previous research, which suggests that central adiposity, as indicated by subscapular skinfold measurements, has a stronger association with hypertension than peripheral adiposity (e.g., triceps and calf skinfolds). Furthermore, both subscapular and supraspinale skinfold thicknesses exhibited significant correlations with blood pressure in males. This may be attributed to the differential role of central adiposity in hypertension, as suggested by earlier studies. Additionally, Charles *et al*.[39] proposed that the relationship between subscapular and supraspinale skinfolds with blood pressure may be less influenced by sex-specific variations in fat distribution at certain developmental stages.

When compared to skinfold thickness, BMI emerged as a stronger predictor of blood pressure. This observation aligns with previous research findings, which suggest that BMI has a greater predictive value for blood pressure than other anthropometric adiposity indices[31,32].

Our univariate analysis further supports this conclusion, demonstrating that BMI exhibits a higher R^2 value in predicting blood pressure compared to other measures of adiposity in both sexes. These results are consistent with prior studies that have highlighted the superior predictive capacity of BMI for blood pressure across different populations[40,41].

CONCLUSION

BMI appears to be the most robust predictor of blood pressure, while skinfold thickness, particularly subscapular and supraspinale measurements, exhibit stronger associations with blood pressure in females. These findings contribute to the growing body of evidence supporting the role of adiposity in blood pressure regulation and highlight the importance of early interventions to mitigate the risk of hypertension in paediatric populations.

Conflict of interest: None exists

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