Research Article

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Anthropometric Characteristics and Blood Pressure Among Children and Adolescents in Ibadan, South-Western Nigeria

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Abstract

Background: *Childhood hypertension is an emerging global public health concern, particularly in low- and middle-income countries (LMICs). Children and adolescents with elevated blood pressure are more likely to develop hypertension later in life. Identifying anthropometric indicators associated with elevated blood pressure in young populations is important for the early detection of modifiable cardiovascular risk factors. Therefore, this study aimed to determine the anthropometric correlates of elevated blood pressure among children and adolescents in Ibadan, South-West Nigeria.*

Methods: *A community-based descriptive cross-sectional study design of 335 children and adolescents aged 8-14 years, recruited using a multi-stage sampling technique. Data collected from the respondents were processed and analysed using Statistical Package for the Social Sciences (IBM SPSS Version 27.0) and R Studio. Descriptive statistics, including mean, standard deviation, frequencies, and percentages, were used to report the findings. Chi-square tests, independent samples t-tests, one-way ANOVA, and regression analysis were used to test the association and relationships between variables. The significance level was set at < 0.05, with a 95% CI.*

Results: *The majority were between age 10–14 years (72.2%) with females predominating (63.0%). Most participants had normal BMI-for-age (72.8%), while 12.8% were thin, 8.7% overweight, and 5.7% obese. Central obesity based on waist circumference was observed in 2.7% of participants. Elevated systolic blood pressure (SBP) and diastolic blood pressure (DBP) were observed in 29.9% and 36.4% of respondents, respectively. Mean anthropometric indices, including BMI-for-age, waist circumference, waist–hip ratio, and mid-upper arm circumference, did not differ significantly between participants with normal and elevated blood pressure (p > 0.05). Bivariate analysis showed significant associations between age group and sex with elevated DBP (p < 0.05), but these associations were not significant after adjustment. Linear regression and multivariable logistic regression analyses showed that none of the anthropometric or socio-demographic variables were significant predictors of elevated SBP or DBP.*

Conclusion: *Anthropometric indices were not significantly associated with systolic or diastolic blood pressure in this population. However, maintaining a healthy anthropometric status and implementing early blood pressure screening remain important for promoting long-term cardiovascular health among children and adolescents.*

Keywords: Child & Adolescent Health, Anthropometric Measures, CVD’s Burden, Nigeria

1. Introduction

Hypertension is a major global public health concern and one of the leading risk factors for cardiovascular morbidity and mortality. Although traditionally considered an adult condition, increasing evidence indicates that elevated blood pressure can begin early in life, including during childhood and adolescence [1,2]. Elevated blood pressure in children and adolescents is defined as persistently elevated systolic or diastolic blood pressure relative to age-, sex-, and height-specific reference values [3,4]. Early onset of elevated blood pressure has important implications for long-term cardiovascular health because blood pressure patterns established during childhood often persist into adulthood, increasing the risk of hypertension, cardiovascular disease, and target-organ damage later in life [2].

Globally, the burden of elevated blood pressure among children and adolescents has been rising, partly driven by changing lifestyles, urbanization, and the increasing prevalence of overweight and obesity [5,6]. Anthropometric indicators such as body mass index (BMI), waist circumference (WC), waist-hip ratio (WHR), and mid-upper arm circumference (MUAC) are commonly used to assess nutritional status and body fat distribution [7]. Anthropometric measures are particularly useful for evaluating growth patterns and identifying potential health risks associated with excess body weight during childhood and adolescence. These measures are widely applied in both clinical and epidemiological settings because they are non-invasive, relatively inexpensive, and easily applicable across different populations [8].

Primary hypertension, also referred to as essential hypertension, accounts for the majority of elevated blood pressure cases observed in children and adolescents [9,10]. Unlike secondary hypertension, which results from identifiable medical conditions such as renal or endocrine disorders, primary hypertension develops gradually and is often associated with modifiable risk factors, including obesity, dietary habits, physical inactivity, and genetic predisposition [11, 12].

Several studies have reported associations between anthropometric indicators and blood pressure among children and adolescents. In particular, increased BMI and measures of central adiposity have been identified as important predictors of elevated blood pressure in young populations [11,13]. However, findings across studies remain inconsistent, particularly in developing countries undergoing nutritional transition where undernutrition and overweight coexist within the same populations.

In Nigeria, emerging evidence suggests that elevated blood pressure among children and adolescents is becoming an important public health concern. For example, a study among adolescents in Lagos reported that approximately 26.7% of participants had elevated blood pressure or hypertension, with higher prevalence observed among older adolescents and males [14]. Similarly, research conducted among school children in Port Harcourt found that about 15.2% of participants had blood pressure levels above normal, with overweight and obesity identified as significant associated factors [15].

In addition, systematic evidence indicates that hypertension and pre-hypertension among Nigerian children and adolescents are increasingly reported across different regions of the country, emphasizing the importance of early identification of modifiable risk factors during childhood [16].

Despite these findings, few community-based studies have explored the relationship between anthropometric indices and blood pressure among children and adolescents across both rural and urban communities in Ibadan. Understanding this relationship is essential for early detection of cardiovascular risk factors and for guiding preventive interventions aimed at promoting healthy growth and reducing the long-term burden of hypertension.

Therefore, this study represents a baseline exploratory component of a larger project aimed at developing a predictive system for high blood pressure and aimed to assess the association between selected anthropometric indices and blood pressure among children and adolescents aged 8–14 years in selected communities in Ibadan, Southwest Nigeria.

2. Methodology

2.1. Study Area

The research was conducted in Ibadan, a metropolitan city located in Oyo State, southwestern Nigeria. As the administrative capital of the state, Ibadan serves as a major hub for politics and economics. The city is highly urbanized and densely populated, ranking among the largest metropolitan areas in Nigeria, according to the National Population Commission [17]. Ibadan has an estimated metropolitan population approaching four million inhabitants. Administratively, Ibadan is structured into eleven local government areas, comprising five predominantly urban local governments and six that are largely rural in character.

2.2. Study Design & Duration

This study employed a community-based descriptive cross-sectional study design, which was conducted between the period of May and November 2025 among children and adolescents aged 8 to 14 years residing in selected communities in both rural and urban settlements of Ibadan during the period of the study. The study was conducted in four LGAs and included twelve communities: Siba, Yemetu, Oke Adu, Adeoyo, Sango, Agbowo, Sapati, Kute, Olowu, Oke Aremu, Inalende, and Opoo.

2.3. Eligibility Criteria

Inclusion criteria: Children and adolescents aged 8–14 years residing in the selected communities were eligible. Participants <12 years, whose written informed consent was obtained from parents/guardians, and parental consent and individual assent for those ≥12 years participated in the study.

Exclusion criteria: Participants were excluded if they had a known chronic illness, were taking anti-hypertensive drugs, or were unable to undergo anthropometric measurements.

2.4. Sample Size Determination

After adjusting for a 10% non-response rate, a total of 335 respondents were recruited using Cochran's formula to estimate the sample size for a single proportion:

$$n = \frac{Z^2 P(1-P)}{d^2}$$

Where:
n = required sample size
z = standard normal deviate (1.96 for 95% confidence level)
p = expected prevalence 26.7%, adapted from [18]
d = margin of error (5%)

$$n = \frac{(1.96)^2 \times 0.267 \ (1-0.267)]}{(0.05)^2}$$

$$n = \frac{3.8416 \times 0.1957}{0.0025}$$

$$n = \frac{0.7518}{0.0025}$$

Adjustment for non-response:

$$n(final) = \frac{n}{1 - non\ response\ rate}$$

$$n(final) = \frac{301}{0.90} = 334.4 \approx 335$$

2.5. Sampling Technique

The eligible participants were selected using a multistage sampling technique. These stages included:

Stage 1: A list of all local governments in Ibadan was obtained, which comprises 11 local government areas: Ibadan North, Ibadan North-West, Ibadan North-East, Ibadan South-West, Ibadan South-East, Akinyele, Lagelu, Egbeda, Ona-Ara, Oluyole, and Ido. The local government was stratified into urban LGAs, comprising Ibadan North, Ibadan North-west, Ibadan North-East, Ibadan South-West, and Ibadan South-East, and rural LGAs, comprising Ido, Lagelu, Egbeda, Ona-Ara, Akinyele, and Oluyole.

From each stratum, two urban LGAs (Ibadan north and Ibadan north-west) and two rural LGAs (Ido and Lagelu) were randomly selected via balloting.

Stage 2: In each selected LGA, three communities (Siba, Yemetu, Oke Adu, Adeoyo, Sango, Agbowo, Sapati, Kute, Olowu, Oke Aremu, Inalende, and Opoo) were purposely selected based on the accessibility of children and adolescents, as well as population distribution.

Stage 3: A house-to-house survey was conducted in the selected communities. Systematic sampling was used to select households. A sampling interval was determined with a random starting point, and every third household was selected until the required sample size was achieved.

Stage 4: In households with more than one eligible child and adolescent, simple random sampling via balloting was used to select up to two children or adolescents per household. Each eligible child or adolescent's name or number was placed in a lottery, and a child or adolescent was selected by balloting. This ensured wider representation across households while preventing over-representation from any single household.

2.6. Data Collection Instrument

Data were collected using a pre-tested, semi-structured, interviewer-administered questionnaire designed to obtain information on the sociodemographic characteristics and anthropometric indicators of selected children and adolescents. The anthropometric indicators included height, weight, BMI, WC, WHR, and MUAC. The questionnaire was administered by well-trained research assistants who underwent one week of training before data collection. In addition, 25 community mobilizers across the 12 selected communities were consulted to facilitate entry and navigation within the communities and to enhance community participation. An average duration of 20–25 minutes was spent with each respondent, which included a 5-minute rest period before blood pressure measurement and the taking of duplicate blood pressure readings. The questionnaire comprised three major sections:

1. Sociodemographic characteristics of the respondents
2. Anthropometric measurements
3. Blood pressure measurements

All anthropometric measurements were obtained using the World Health Organization (WHO) standardized procedures. Height was measured to the nearest 0.1 cm using a stadiometer, with participants standing upright without shoes and with their head positioned in the Frankfort horizontal plane. Weight was measured to the nearest 0.1 kg using a digital weighing scale, with participants wearing light clothing and no shoes. BMI was subsequently calculated as weight in kilograms divided by height in meters squared (kg/m^2).

WC was measured to the nearest 0.1 cm using a non-elastic flexible measuring tape at the midpoint between the lowest rib and the iliac crest at the end of normal expiration. Hip circumference (HP) was also measured using a non-elastic flexible measuring tape, and WHR was calculated as the ratio of waist circumference to hip circumference.

MUAC was measured to the nearest 0.1 cm on the left arm (unless contraindicated) at the midpoint between the acromion process of the scapula and the olecranon process of the ulna, using a non-elastic flexible measuring tape.

Blood pressure readings were obtained using WHO standardized procedures. Measurements were taken using an "ANDON" automatic blood pressure monitor with a cuff size appropriate for children and adolescents. Each participant was allowed to rest for 5 minutes before measurement, after which two blood pressure readings were taken at a 5-minute interval, and the average of the two readings was used to determine the participant's systolic and diastolic blood pressure. All measurements followed the National High Blood Pressure Education Program (NHBPEP) guidelines for blood pressure measurement among children and adolescents [19].

2.7. Validity and Reliability of the Study Instrument

To ensure measurement reliability, all anthropometric and blood pressure measurements were taken by trained research assistants following standardized WHO procedures. Inter-rater reliability testing was conducted during the pilot phase by comparing measurements obtained independently by two observers on a subset of participants. The intraclass correlation obtained indicated good agreement between observers. The weighing scale and Automated BP monitor were calibrated before data collection each day.

2.8. Data Analysis

Data collected from the field were cleaned, coded, and analyzed using the Statistical Package for the Social Sciences (IBM SPSS Version 27.0) for descriptive statistics, while R Studio was used for regression analysis. Descriptive statistics, including mean and standard deviation (SD), were used to summarize continuous variables such as age, weight, height, BMI, WC, WHR, and MUAC. BMI for age and sex was computed using WHO AnthroPlus software, and frequencies and percentages were used to summarize categorical variables such as sex, class level, school type, BMI category, WC category, SBP, and DBP category.

Inferential statistics using the chi-square test of association were also applied to examine associations between variables. Independent sample t-tests and one-way analysis of variance (ANOVA) were used to compare mean anthropometric indices (BMI, WC, WHR, and MUAC) across blood pressure categories. In addition, simple linear regression and binary logistic regression analyses were conducted to assess the relationship between anthropometric indices and blood pressure, and to identify independent predictors of SBP and DBP, such as age, sex, area of residence, and school ownership type. Statistical significance was set at $p < 0.05$ with 95% confidence intervals (CI).

2.9. Variable Definition and Classification

The dependent variables in this study were BP, which was classified following the 2017 American Academy of Pediatrics (AAP) [20] pediatric hypertension guideline. For children aged <13 years, blood pressure categories were defined using age-, sex-, and height-specific percentiles: normal (<90th percentile), and elevated BP (≥90th to <95th percentile). For adolescents aged ≥13 years, fixed thresholds were applied (normal <120/<80 mmHg, elevated BP 120–129/<80 mmHg). Screening BP values from the AAP simplified table were used to identify participants requiring further evaluation.

Participants were classified as having elevated SBP or elevated DBP if their measured SBP or DBP met or exceeded the recommended screening threshold for their age and sex. Separate variables were created for SBP and DBP status, which were coded as 0=Normal SBP/DBP, and 1=Elevated SBP/DBP. This approach ensured age-and sex-specific appropriate classification, aligning with recommended pediatric standards and improving accuracy over adult-based thresholds.

BMI was calculated using the standardized formula: weight (kg) divided by height squared (m^2). In children and adolescents, BMI is age- and sex-specific and expressed as BMI-for-age. Calculated BMI values and corresponding ages were converted to z-scores using WHO 2007 reference data for children and adolescents aged 5–19 years [21]. Participants were classified as thinness (< -2SD), normal weight (-2SD to +1SD), overweight (+1SD), and obese (+2SD).

WC was used as a measure of central adiposity and was classified based on age- and sex-specific percentiles, with values below the 90th percentile considered normal and values at or above the 90th percentile for age and sex classified as central obesity.

Given the absence of a known universally accepted MUAC cut-off for children and adolescents aged 8–14 years, MUAC was analyzed as a continuous variable rather than categorized, in order to avoid potential misclassification.

WHR was calculated as waist circumference divided by hip circumference. Due to the lack of universally accepted WHR cut-offs for children and adolescents aged 8-14 years [22], WHR was analysed as a continuous variable rather than categorized.

2.10. Ethical Approval

This study is part of the larger study on the Development of an Automated System for Dynamic Prediction of High Blood Pressure in School Children and Adolescents". Ethical approval for the umbrella study was obtained from the UI/UCH Ethics committee. The approval is documented in the ethics certificate number UI/EC/25/0662. The implementation of the project ensured the confidentiality of the participants and privacy during data collection.

Voluntary parental consent was obtained for respondents below 12 years old, and for respondents 12 years and above, parental consent and individual assent were obtained prior to participation in the study. Participants who wish to exit/withdraw from the study for any reason or other were granted the right to withdraw with no consequences or punishment. All information provided by the participants was handled with strict confidentiality.

3. Results

Variable	Category	Frequency (%)
Age Group	≤ 9 years 10–14 years	93 (27.8) 242 (72.2)
Sex	Male Female	124 (37.0) 211 (63.0)
Religion	Christianity Islam Traditional	134 (40.0) 199 (59.4) 2 (0.6)
Tribe	Yoruba Igbo Hausa	328 (97.9) 4 (1.2) 3 (0.9)
Area of Residence	Urban Rural	190 (56.7) 145 (43.3)
Are you currently in School?	Yes No	330 (98.5) 5 (1.5)
Class/Grade Level	Primary 5 Primary 6 JSS 1 JSS 2 JSS 3 SS1 SS2	181 (54.0) 27 (8.1) 43 (12.8) 46 (13.7) 17 (5.1) 15 (4.5) 6 (1.8)
Drop-out Class/Level	Primary 5 JSS 3 SS1	1 (20.0) 1 (20.0) 3 (60.0)
School Ownership Type	Public Private Out of school	122 (36.4) 208 (62.1) 5 (1.5)
Living Arrangement	With both parents With Mother Only With Father Only With Guardian (s)	330 (98.5) 2 (0.6) 1 (0.3) 2 (0.6)

Table 1a: Socio-Demographic Characteristics of Respondents (n = 335)

Variable	Category	Frequency (%)
Household Size	One Two Three Four Five & above	290 (86.8) 24 (7.2) 4 (1.2) 16 (4.8) 1 (0.3)
Birth Order in the Family	One Two Three Four Five & above	93 (27.8) 90 (26.9) 71 (21.2) 49 (14.6) 32 (9.6)
Father's Highest Educational Level	No formal education Primary Secondary Tertiary Don’t know	6 (1.8) 45 (13.4) 179 (53.4) 59 (17.6) 46 (13.7)

Mothers' Highest Educational Level	No formal education Primary Secondary Tertiary Don't know	6 (1.8) 55 (16.4) 170 (50.7) 56 (16.7) 48 (14.3)
Fathers Occupation	Civil servant Trader Farmer Skilled worker Unemployed Unskilled	28 (8.4) 123 (36.7) 8 (2.4) 113 (33.7) 5 (1.5) 58 (17.3)
Mothers Occupation	Civil servant Trader Farmer Skilled worker Unemployed Unskilled	23 (6.9) 220 (65.7) 1 (0.3) 68 (20.3) 8 (2.4) 15 (4.5)

Table 1b: Socio-Demographic Characteristics of Respondents (n = 335)

Table 1a & b summarizes the socio-demographic characteristics of the respondents (n = 335). Most respondents were aged 10–14 years (72.2%), while 27.8% were aged ≤9 years. Females constituted 63.0% of the sample, compared with 37.0% males. The majority of respondents were Muslims (59.4%), followed by Christians (40.0%), with a small proportion practicing traditional religion (0.6%). Most respondents were of Yoruba ethnicity (97.9%) and resided in urban areas (56.7%), while 43.3% lived in rural areas. Nearly all respondents were currently in school (98.5%), predominantly attending public schools (62.1%), and most were in Primary 5 (54.0%), followed by JSS 2 (13.7%) and JSS 1 (12.8%).

The majority lived with both parents (98.5%). Household size was predominantly one child (86.8%), and birth order was most commonly first (27.8%) or second (26.9%). Most fathers had secondary education (53.4%), while 17.6% had tertiary education; similarly, most mothers had secondary education (50.7%), with 16.7% attaining tertiary education. Trading was the most common occupation among both fathers (36.7%) and mothers (65.7%), followed by skilled work among fathers (33.7%) and mothers (20.3%).

Variable	**Category**	**Frequency (%)**
BMI-for-age (kg/m²)	Thinness (< - 2 SD) Normal Weight (-2 to +1 SD) Overweight (+1 to ≤ +2 SD) Obesity (+2 SD)	43 (12.8) 244 (72.8) 29 (8.7) 19 (5.7)
Waist Circumference (WC)	Normal (<90th percentile) Central Obesity (≥90th percentile)	326 (97.3) 9 (2.7)
Variable	**Mean ± SD**	
Weight (Kg)	29.8 ± 9.4	
Height (cm)	131.9 ± 13.2	
BMI-for-age (kg/m²)	-0.4 ± 1.6	
Mid-Upper Arm Circumference (cm)	20.4 ± 7.7	
Waist-Hip-Ratio	0.89 ± 0.15	

Table 2: Anthropometric Characteristics of Participants (n = 335)

Table 2 shows that 335 participants were included in the study. Based on BMI-for-age classification, the majority of the participants had normal weight (244; 72.8%). Thinness (< −2 SD) was observed in 43 participants (12.8%), while 29 participants (8.7%) were classified as overweight (+1 to ≤ +2 SD). Obesity (+2 SD) was recorded among 19 participants (5.7%). Assessment of waist circumference showed that most participants had normal waist circumference (<90th percentile), accounting for 326 participants (97.3%), whereas central obesity (≥90th percentile) was observed in only 9 participants (2.7%). Regarding the continuous anthropometric measurements, the mean body weight of the participants was 29.8 ± 9.4 kg, while the mean height was 131.9 ± 13.2 cm. The mean BMI-for-age z-score was −0.4 ± 1.6, indicating that, on average, participants had BMI values slightly below the reference median. The mean mid-upper arm circumference (MUAC) was 20.4 ± 7.7 cm, and the mean waist-hip ratio (WHR) was 0.89 ± 0.15.

Variable	Category	Frequency (%)
SBP Status	Normal SBP	235 (70.1)
	Elevated SBP	100 (29.9)
DBP Status	Normal DBP	213 (63.6)
	Elevated DBP	122 (36.4)

Table 3: Distribution of Blood Pressure Status Among the Respondents (n = 335)

Table 3 shows the distribution of systolic blood pressure (SBP) and diastolic blood pressure (DBP) status among the 335 study participants. With respect to systolic blood pressure, the majority of the respondents had normal SBP, accounting for 235 participants (70.1%), while 100 participants (29.9%) were classified as having elevated SBP. Similarly, for diastolic blood pressure, 213 participants (63.6%) had normal DBP, whereas 122 participants (36.4%) were found to have elevated DBP.

Variable	Normal SBP (Mean ± SD)	Elevated SBP (Mean ± SD)	t-value	p-value
BMI-for-age (kg/m²)	-0.5 ± 1.6	-0.3 ± 1.8	-0.819	0.413
Waist Circumference (cm)	58.3 ± 12.3	57.4 ± 11.2	0.627	0.531
Waist-hip ratio	0.9 ± 0.2	0.9 ± 0.1	0.075	0.940
Mid-Upper Arm Circumference (cm)	20.5 ± 7.1	20.3 ± 8.9	0.125	0.900

Table 4: Comparison of Mean Anthropometric Measurements by Systolic Blood Pressure (n = 335)

Table 4 presents the comparison of mean anthropometric measurements between participants with normal SBP and those with elevated SBP. The mean BMI-for-age among participants with normal SBP was −0.5 ± 1.6, compared with −0.3 ± 1.8 among those with elevated SBP. However, this difference was not statistically significant (t = −0.819, p = 0.413). Similarly, the mean waist circumference for participants with normal SBP was 58.3 ± 12.3 cm, while those with elevated SBP had a mean waist circumference of 57.4 ± 11.2 cm. This difference was also not statistically significant (t = 0.627, p = 0.531). For the waist-hip ratio, the mean value among participants with normal SBP was 0.9 ± 0.2, compared with 0.9 ± 0.1 among those with elevated SBP, with no statistically significant difference observed (t = 0.075, p = 0.940). Likewise, the mean mid-upper arm circumference (MUAC) was 20.5 ± 7.1 cm among participants with normal SBP and 20.3 ± 8.9 cm among those with elevated SBP. However, the difference was not statistically significant (t = 0.125, p = 0.900).

Variable	Normal DBP (Mean ± SD)	Elevated DBP (Mean ± SD)	t-value	p-value
BMI-for-age (kg/m²)	-0.4 ± 1.6	-0.4 ± 1.8	-0.161	0.872
Waist Circumference (cm)	58.3 ± 12.4	57.4 ± 11.3	0.696	0.487
Waist-hip ratio	0.9 ± 0.1	0.9 ± 0.2	-1.089	0.277
Mid-Upper Arm Circumference (cm)	20.3 ± 6.8	20.7 ± 9.2	-0.481	0.631

Table 5: Comparison of Mean Anthropometric Measurements by Diastolic Blood Pressure (n = 335)

Table 5 presents the comparison of mean anthropometric measurements between participants with normal DBP and those with elevated DBP. The mean BMI-for-age among participants with normal DBP was −0.4 ± 1.6, while participants with elevated DBP also had a mean value of −0.4 ± 1.8. This difference was not statistically significant (t = −0.161, p = 0.872). For waist circumference, the mean value among participants with normal DBP was 58.3 ± 12.4 cm, compared with 57.4 ± 11.3 cm among those with elevated DBP.

This difference was not statistically significant (t = 0.696, p = 0.487). Similarly, the mean waist-hip ratio among participants with normal DBP was 0.9 ± 0.1, whereas those with elevated DBP had a mean value of 0.9 ± 0.2. No statistically significant difference was observed ($t = -1.089$, $p = 0.277$). Mean mid-upper arm circumference (MUAC) among participants with normal DBP was 20.3 ± 6.8 cm, while those with elevated DBP had a slightly higher mean value of 20.7 ± 9.2 cm. However, this difference was also not statistically significant ($t = -0.481$, $p = 0.631$).

Variable	Category	Normal SBP n (%)	Elevated SBP n (%)	χ^2	p-value
BMI-for-age (kg/m²)	Thinness (< - 2 SD) Normal Weight (-2 to +1 SD) Overweight (+1 to ≤ +2 SD) Obesity (+2 SD)	29 (67.4) 174 (71.3) 20 (69.0) 12 (63.2)	14 (32.6) 70 (28.7) 9 (31.0) 7 (36.8)	0.771	0.856
Waist Circumference (cm)	Normal (<90th percentile) Central Obesity (≥90th percentile)	228 (69.9) 7 (77.8)	98 (30.1) 2 (22.2)	0.257	0.612
Age group	≤ 9 years 10-14 years	59 (63.4) 176 (72.7)	34 (36.6) 66 (27.3)	2.767	0.096
Sex	Male Female	85 (68.5) 150 (71.1)	39 (31.5) 61 (28.9)	0.241	0.624
Area of Residence	Urban Rural	130 (68.4) 105 (72.4)	60 (31.6) 40 (27.6)	0.626	0.429
School type	Public Private Out of School	85 (69.7) 147 (70.7) 3 (60.0)	37 (30.3) 61 (29.3) 2 (40.0)	0.286	0.867

Table 6: Bivariate Association Between Participants' Characteristics and Elevated Systolic Blood Pressure (n = 335)

Table 6. The proportion of participants with elevated SBP was 32.6% among those with thinness, 28.7% among normal weight, 31.0% among overweight, and 36.8% among obese participants, with no significant association observed ($\chi^2 = 0.771$, $p = 0.856$). Similarly, 30.1% of participants with normal waist circumference and 22.2% of those with central obesity had elevated SBP ($\chi^2 = 0.257$, $p = 0.612$). By age group, 36.6% of children ≤ 9 years and 27.3% of those aged 10–14 years had elevated SBP ($\chi^2 = 2.767$, $p = 0.096$). Regarding sex, 31.5% of males and 28.9% of females had elevated SBP ($\chi^2 = 0.241$, $p = 0.624$), while for area of residence, 31.6% of urban and 27.6% of rural participants exhibited elevated SBP ($\chi^2 = 0.626$, $p = 0.429$). Finally, by school type, 30.3% of public school attendees, 29.3% of private school attendees, and 40.0% of out-of-school participants had elevated SBP ($\chi^2 = 0.286$, $p = 0.867$).

Variable	Category	Normal DBP n (%)	Elevated DBP n (%)	χ^2	p-value
BMI-for-age (kg/m²)	Thinness (< - 2 SD) Normal Weight (-2 to +1 SD) Overweight (+1 to ≤ +2 SD) Obesity (+2 SD)	25 (58.1) 159 (65.2) 18 (62.1) 11 (57.9)	18 (41.9) 85 (34.8) 11 (37.9) 8 (42.1)	1.108	0.775
Waist Circumference (cm)	Normal (<90th percentile) Central Obesity (≥90th percentile)	205 (62.9) 8 (88.9)	121 (37.1) 1 (11.1)	2.558	0.163
Age group	≤ 9 years 10-14 years	51 (54.8) 162 (66.9)	42 (45.2) 80 (33.1)	4.250	0.039
Sex	Male Female	70 (56.5) 143 (67.8)	54 (43.5) 68 (32.2)	4.323	0.038
Area of Residence	Urban Rural	118 (62.1) 95 (65.5)	72 (37.9) 50 (34.5)	0.413	0.520

School type	Public Private Out of School	77 (63.1) 133 (63.9) 3 (60.0)	45 (36.9) 75 (36.1) 2 (40.0)	0.051	0.968

Table 7: Bivariate Association Between Participants' Characteristics and Elevated Diastolic Blood Pressure (n = 335)

Table 7. The proportion of participants with elevated DBP was 41.9% among those with thinness, 34.8% among normal weight, 37.9% among overweight, and 42.1% among obese participants, with no significant association observed ($\chi^2 = 1.108$, p = 0.775). Similarly, 37.1% of participants with normal waist circumference and 11.1% of those with central obesity had elevated DBP, with no statistically significant difference ($\chi^2 = 2.558$, p = 0.163). By age group, 45.2% of children ≤ 9 years and 33.1% of those aged 10–14 years had elevated DBP, and this association was statistically significant ($\chi^2 = 4.250$, p = 0.039). Regarding sex, 43.5% of males and 32.2% of females had elevated DBP, with a significant association observed ($\chi^2 = 4.323$, p = 0.038). For the area of residence, 37.9% of urban and 34.5% of rural participants exhibited elevated DBP, with no significant association ($\chi^2 = 0.413$, p = 0.520). Finally, by school type, 36.9% of public school attendees, 36.1% of private school attendees, and 40.0% of out-of-school participants had elevated DBP, with no significant difference ($\chi^2 = 0.051$, p = 0.968).

Variable	Predictor	Regression coefficient (β)	95% CI	p-value
SBP (mmHg)	BMI-for-age (kg/m²)	-0.03	-1.28 – 0.67	0.545
	WC (cm)	-0.03	-0.17 – 0.11	0.672
	WHR	-0.02	-12.79 – 9.79	0.794
	MUAC (cm)	0.04	-0.13 – 0.29	0.457
	Age	0.06	-1.58 – 5.70	0.267
DBP (mmHg)	BMI-for-age (kg/m²)	-0.04	-1.11 – 0.56	0.520
	WC (cm)	0.07	-0.05 – 0.20	0.239
	WHR	-0.01	-9.75 – 9.60	0.987
	MUAC (cm)	0.06	-0.09 – 0.27	0.328
	Age	0.03	-2.35 – 3.85	0.636

Table 8: Simple Linear Regression Analysis of Anthropometric Indices and Respondents' SBP and DBP (n = 335)

Table 8. For systolic blood pressure (SBP), none of the anthropometric measures or age were significantly associated with SBP. Specifically, the regression coefficient for BMI-for-age was β = −0.03 (95% CI: −1.28 to 0.67, p = 0.545), for waist circumference (WC) β = −0.03 (95% CI: −0.17 to 0.11, p = 0.672), for waist-hip ratio (WHR) β= −0.02 (95% CI: −12.79 to 9.79, p = 0.794), for mid-upper arm circumference (MUAC) β = 0.04 (95% CI: −0.13 to 0.29, p = 0.457), and for age β = 0.06 (95% CI: −1.58 to 5.70, p = 0.267). Similarly, for diastolic blood pressure (DBP), none of the predictors were significantly associated. The regression coefficient for BMI-for-age was β = −0.04 (95% CI: −1.11 to 0.56, p = 0.520), for WC β = 0.07 (95% CI: −0.05 to 0.20, p = 0.239), for WHR β = −0.01 (95% CI: −9.75 to 9.60, p = 0.987), for MUAC β= 0.06 (95% CI: −0.09 to 0.27, p = 0.328), and for age β= 0.03 (95% CI: −2.35 to 3.85, p = 0.636).

Variable	Category	AOR	95% CI	p-value
BMI-for-age	Thinness (< - 2 SD) Normal Weight (-2 to +1 SD) Overweight (+1 to ≤ +2 SD) Obesity (+2 SD)	**1.0 (ref)** 0.86 0.68 0.73	- 0.28 – 2.74 0.25 – 1.83 0.21 – 2.52	- 0.809 0.448 0.618
Waist Circumference	Normal (<90th percentile) Central Obesity (≥90th percentile)	**1.0 (ref)** 1.35	- 0.25 – 7.17	- 0.723

Age group	≤ 9 years 10-14 years	**1.0 (ref)** 1.56	- 0.91 – 2.66	- 0.101
Sex	Male Female	**1.0 (ref)** 1.09	- 0.67 – 1.79	- 0.710
Area of Residence	Urban Rural	**1.0 (ref)** 1.17	- 0.70 – 1.93	- 0.541
School type	Public Private Out of School	**1.0 (ref)** 0.58 0.53	- 0.09 – 3.80 0.08 – 3.37	- 0.572 0.498

Table 9: Multivariable Logistic Regression Analysis of Factors Associated with Elevated Systolic Blood Pressure (n =335)

Table 9. Using participants with thinness (BMI-for-age < −2 SD), normal waist circumference, age ≤ 9 years, male sex, urban residence, and public school attendance as reference categories, none of the examined variables were significantly associated with elevated SBP. Specifically, compared with thin participants, the adjusted odds ratios (AOR) for elevated SBP were AOR = 0.86 (95% CI: 0.28–2.74, p = 0.809) for normal weight, AOR = 0.68 (95% CI: 0.25–1.83, p = 0.448) for overweight, and AOR = 0.73 (95% CI: 0.21–2.52, p = 0.618) for obese participants.

Participants with central obesity had an AOR of 1.35 (95% CI: 0.25–7.17, p = 0.723) compared with those with normal waist circumference. Children aged 10–14 years had a non-significant increased odds of elevated SBP compared with those ≤ 9 years (AOR = 1.56, 95% CI: 0.91–2.66, p = 0.101). Females had similar odds as males (AOR = 1.09, 95% CI: 0.67–1.79, p = 0.710), while participants residing in rural areas had a non-significantly higher odds compared with urban residents (AOR = 1.17, 95% CI: 0.70–1.93, p = 0.541). Finally, compared with public school attendees, the odds of elevated SBP were lower but not significant among private school attendees (AOR = 0.58, 95% CI: 0.09–3.80, p = 0.572) and out-of-school participants (AOR = 0.53, 95% CI: 0.08–3.37, p = 0.498).

Variable	**Category**	**AOR**	**95% CI**	**p-value**
BMI-for-age	Thinness (< - 2 SD) Normal Weight (-2 to +1 SD) Overweight (+1 to ≤ +2 SD) Obesity (+2 SD)	**1.0 (ref)** 0.98 0.67 0.75	- 0.32 – 3.07 0.25 – 1.82 0.22 – 2.55	- 0.978 0.438 0.640
Waist Circumference	Normal (<90^{th} percentile) Central Obesity (≥90^{th} percentile)	**1.0 (ref)** 3.70	- 0.43 – 31.72	- 0.232
Age group	≤ 9 years 10-14 years	**1.0 (ref)** 1.64	- 0.98 – 2.75	- 0.058
Sex	Male Female	**1.0 (ref)** 1.54	- 0.97 – 2.46	- 0.068
Area of Residence	Urban Rural	**1.0 (ref)** 1.09	- 0.67 – 1.77	- 0.713
School type	Public Private Out of School	**1.0 (ref)** 0.68 0.62	- 0.10 – 4.73 0.09 – 4.20	- 0.700 0.621

Table 10: Multivariable Logistic Regression Analysis of Factors Associated with Elevated Diastolic Blood Pressure (n =335)

Table 10. Using participants with thinness (BMI-for-age <- 2 SD), normal waist circumference, age ≤ 9 years, male sex, urban residence, and public school attendance as reference categories, none of the variables were independently associated with elevated DBP. Compared with participants with thinness, the adjusted odds ratios (AOR) for elevated DBP were AOR = 0.98 (95% CI: 0.32–3.07, p = 0.978) for normal weight, AOR = 0.67 (95% CI: 0.25–1.82, p = 0.438) for overweight, and AOR = 0.75 (95% CI: 0.22–2.55, p = 0.640) for obese participants. Participants with central obesity had higher but non-significant odds of elevated DBP compared with those with normal waist circumference (AOR = 3.70, 95% CI: 0.43–31.72, p = 0.232).

Children aged 10–14 years had increased but non-significant odds of elevated DBP compared with those aged ≤ 9 years (AOR = 1.64, 95% CI: 0.98–2.75, p = 0.058). Females also showed higher but non-significant odds of elevated DBP compared with males (AOR = 1.54, 95% CI: 0.97–2.46, p = 0.068). Similarly, rural residence was not significantly associated with elevated DBP compared with urban residence (AOR = 1.09, 95% CI: 0.67–1.77, p = 0.713). In addition, compared with public school attendees, the odds of elevated DBP were lower but not statistically significant among private school attendees (AOR = 0.68, 95% CI: 0.10–4.73, p = 0.700) and out-of-school participants (AOR = 0.62, 95% CI: 0.09–4.20, p = 0.621).

4. Discussion

This study represents an exploratory component of a larger project aimed at developing a predictive system for elevated blood pressure, and examined the relationship between anthropometric indices and blood pressure among children and adolescents in selected communities in Ibadan, Nigeria. The findings provide important insights into the nutritional status and blood pressure profile of school-aged children in this population and contribute to the growing body of epidemiological evidence on early cardiovascular disease risk factors in low- and middle-income countries. The socio-demographic profile of the respondents revealed that most participants were aged 10–14 years (72.2%), with females constituting a larger proportion of the sample (63.0%).

The majority of respondents were Yoruba and resided in urban areas, while most were enrolled in public schools. These characteristics reflect the demographic structure of many urban and peri-urban communities in southwestern Nigeria and provide context for interpreting the anthropometric and cardiovascular findings of the study. With respect to nutritional status, most participants had normal BMI-for-age (72.8%), while the prevalence of overweight (8.7%) and obesity (5.7%) was relatively low. Thinness was observed in 12.8% of the participants. In addition, only 2.7% of respondents exhibited central obesity based on waist circumference.

These findings suggest that undernutrition and normal weight status remain more prevalent than overweight and obesity in this population. The mean BMI-for-age z-score of −0.4 ± 1.6 further indicates that, on average, participants had BMI values slightly below the international reference median [21]. Similar patterns of relatively low obesity prevalence among school-aged children have been reported in several Nigerian studies, although the prevalence of childhood overweight and obesity has been gradually increasing due to nutritional and lifestyle transitions associated with urbanization and changing dietary patterns [22].

Despite the relatively favorable anthropometric profile observed in this study, a notable proportion of participants were found to have elevated blood pressure. Approximately 29.9% of respondents had elevated systolic blood pressure, while 36.4% had elevated diastolic blood pressure. These findings highlight that elevated blood pressure can occur even in populations with relatively low levels of overt obesity. The prevalence observed in this study is comparable to reports from other Nigerian and sub-Saharan African studies that have documented increasing rates of elevated blood pressure among children and adolescents [23].

The present study found no statistically significant differences in anthropometric measurements between participants with normal and elevated systolic or diastolic blood pressure. Specifically, BMI-for-age, waist circumference, waist-hip ratio, and mid-upper arm circumference did not differ significantly between blood pressure groups. Similarly, simple linear regression analysis demonstrated no significant linear associations between these anthropometric indices and either systolic or diastolic blood pressure. These findings suggest that anthropometric measures alone may not adequately explain variations in blood pressure among children and adolescents in this population.

4.1. BMI and Blood Pressure

In the present study, BMI-defined nutritional status was not significantly associated with either systolic or diastolic blood pressure. Although some differences in blood pressure levels were observed across BMI categories, these differences were not statistically significant. This finding aligns with the report of who demonstrated that BMI may not fully capture variations in visceral adiposity and fat distribution and therefore may have limited ability to predict hypertension risk among children and adolescents [24]. Similarly, a study by among Nigerian preschool children found no significant association between BMI and blood pressure levels, suggesting that BMI may not always be a reliable predictor of early cardiovascular disease risk in younger populations [25]. Furthermore, highlighted that BMI does not adequately capture age-related changes in body composition during childhood and adolescence, a period characterized by rapid growth, hormonal changes, and alterations in fat distribution [26].

These physiological changes may weaken the relationship between BMI and cardiovascular outcomes during early life stages. Additionally, emphasized that cardiovascular risk in adolescents may be influenced by psychosocial, behavioral, and environmental factors beyond anthropometric indicators alone [27]. However, these findings contrast with several studies that have reported a positive association between BMI and blood pressure among children and adolescents. For instance, reported a significant correlation between BMI and blood pressure among Nigerian adolescents, suggesting that increasing adiposity may contribute to elevated blood pressure levels [28]. Similarly, found that overweight and obese adolescents in Lagos had a higher prevalence of hypertensive-range blood pressure compared with those with normal BMI [29]. Differences in sample composition, prevalence of obesity, lifestyle behaviors, and socioeconomic factors may partly explain these inconsistencies across studies.

4.2. WC and Blood Pressure

WC was also not significantly associated with systolic or diastolic blood pressure in this study. Although central obesity is widely regarded as an important marker of cardiometabolic risk, only a very small proportion of participants in this study (2.7%) exhibited central obesity. The limited prevalence of abdominal adiposity may have reduced the statistical power to detect a meaningful association between waist circumference and blood pressure. This finding is consistent with the report by, who observed that increased waist circumference did not necessarily correspond with elevated blood pressure among school-aged children. Similarly, reported no significant relationship between waist circumference and blood pressure among adolescent girls in Kano, Nigeria [30,31].

In contrast, other studies have identified abdominal adiposity as a significant determinant of cardiometabolic risk in pediatric populations. For example, reported that central obesity is strongly associated with hypertension and metabolic abnormalities among children and adolescents. Additionally, highlighted that waist circumference may serve as a sensitive indicator of central adiposity and cardiovascular risk among Nigerian children [32,33]. A more recent investigation by also demonstrated a positive correlation between waist circumference and blood pressure among children aged 6–12 years [34]. The discrepancies between these findings and those of the present study may reflect differences in age distribution, prevalence of obesity, and duration of exposure to excess adiposity. The relatively young age of participants in the present study (8–14 years) may represent an early stage in the development of cardiometabolic risk, during which vascular changes associated with adiposity have not yet become fully established.

4.3. WHR and Blood Pressure

Similarly, continuous analysis of the WHR demonstrates no significant association with systolic or diastolic blood pressure in this study. This finding is consistent with that reported by, who also observed no significant association between waist-hip ratio and blood pressure among Nigerian adolescents [29]. In addition, reported in their study that the WHR was not significantly related to elevated blood pressure among adolescent girls. However, other studies have reported contrasting findings [31].

For instance, found a significant association between WHR and elevated blood pressure among adolescents in southwestern Nigeria [35]. Likewise, reported varying degrees of association between WHR and hypertension risk among children and adolescents [34,36]. The absence of a significant association in the present study may be attributed to the relatively low variability in anthropometric measures among participants and the low prevalence of central obesity. Furthermore, physiological compensatory mechanisms during childhood may maintain normal vascular function despite moderate variations in body composition.

4.4. MUAC and Blood Pressure

MUAC was also analysed continuously, and findings showed MUAC is not significantly associated with either systolic or diastolic blood pressure. Although MUAC is widely used as a screening tool for undernutrition, particularly in younger children, its role as an indicator of cardiovascular risk remains less clearly established [37]. This finding is consistent with that of Ma and colleagues, who reported that MUAC did not significantly differentiate hypertensive from non-hypertensive children aged 7–12 years [38]. Similarly, Fatchurohmah et al. found no significant association between MUAC and blood pressure among young adults, despite observing associations with other anthropometric measures [39]. These findings suggest that MUAC may not serve as a reliable independent predictor of elevated blood pressure in pediatric populations, particularly in settings where both undernutrition and overweight coexist.

4.5. Sociodemographic Factors and Blood Pressure

Bivariate analysis revealed that age group and sex were significantly associated with elevated diastolic blood pressure, with younger children (≤9 years) and males showing higher proportions of elevated DBP. However, these associations did not remain statistically significant after adjustment in the multivariable logistic regression model. This suggests that the observed relationships may have been influenced by confounding factors. Previous studies have reported mixed findings regarding the influence of age and sex on blood pressure among children and adolescents found in their study higher blood pressure levels among older adolescents due to pubertal hormonal changes and increased body mass, while others have reported higher blood pressure among males due to sex-related physiological differences in vascular function [40]. The lack of statistically significant associations in the adjusted analysis suggests that blood pressure levels in this population may be influenced by multiple interacting determinants rather than single demographic factors.

4.6. Multivariable Predictors of Elevated Blood Pressure

Multivariable logistic regression analysis was conducted to determine whether anthropometric indices and socio-demographic characteristics independently predicted elevated systolic and diastolic blood pressure among the participants. After adjusting for potential confounders, none of the variables examined in this study demonstrated a statistically significant association with elevated systolic blood pressure. Specifically, BMI-for-age categories, waist circumference, age group, sex, area of residence, and school type were not independently associated with elevated systolic blood pressure. Similarly, in the adjusted model for diastolic blood pressure, none of the examined variables remained statistically significant predictors. Although the adjusted models did not reveal statistically significant associations, some variables demonstrated trends toward increased odds of elevated blood pressure.

For example, children aged 10–14 years had higher odds of elevated systolic blood pressure compared with those aged ≤9 years (AOR = 1.56), although this did not reach statistical significance. Likewise, females demonstrated slightly higher odds of elevated diastolic blood pressure compared with males (AOR = 1.54), but the confidence intervals were wide and crossed unity, indicating statistical uncertainty.

The lack of statistically significant predictors in the multivariable models may be explained by several factors. First, the relatively low prevalence of obesity and central adiposity observed in this population may have limited the ability to detect strong associations between anthropometric measures and blood pressure. Previous studies by have shown that the relationship between adiposity and hypertension becomes more pronounced in populations with higher levels of overweight and obesity [41].

In addition, childhood blood pressure is influenced by a complex interplay of biological, environmental, and behavioral factors beyond anthropometric status alone. Factors such as dietary sodium intake, physical inactivity, psychosocial stress, genetic predisposition, and early life exposures have been shown to contribute to elevated blood pressure in pediatric populations [42]. Third, the relatively narrow age range of participants in this study may have limited the variability in both anthropometric and cardiovascular parameters.

The vascular and metabolic consequences of excess adiposity often accumulate over time, and stronger associations between anthropometric measures and blood pressure may emerge later during adolescence or adulthood. Nevertheless, the absence of statistically significant independent predictors in this study does not diminish the importance of early cardiovascular risk surveillance. Evidence from longitudinal cohort studies suggests that elevated blood pressure during childhood often tracks into adulthood and is associated with increased risk of hypertension and cardiovascular disease later in life [2,43]. Early identification of children with elevated blood pressure, therefore, remains a critical component of preventive cardiovascular health strategies.

4.7. Epidemiological Implications

Collectively, the absence of significant associations between anthropometric indices and blood pressure in this study suggests that cardiovascular risk among children in this population may be influenced by a broader set of determinants beyond body size alone. Factors such as dietary habits, salt intake, physical activity levels, psychosocial stress, genetic predisposition, and environmental exposures may play important roles in shaping early cardiovascular health. From an epidemiological perspective, these findings underscore the importance of adopting a comprehensive approach to cardiovascular risk assessment in children and adolescents.

While anthropometric indicators remain valuable tools for monitoring nutritional status, they may not fully capture early vascular or metabolic changes associated with hypertension risk. The relatively high prevalence of elevated blood pressure observed in this study highlights the need for early screening programs in schools and communities. Routine monitoring of blood pressure during childhood provides an opportunity for early identification of individuals at risk of future hypertension and cardiovascular disease.

In addition, preventive strategies aimed at promoting healthy dietary practices, physical activity, and healthy weight maintenance among children should remain a public health priority. Evidence from longitudinal studies indicates that elevated blood pressure during childhood often tracks into adulthood and may contribute to the development of hypertension, cardiovascular disease, and metabolic disorders later in life [42]. The findings of this study generally contribute to the growing body of epidemiological evidence on pediatric cardiovascular risk in sub-Saharan Africa and highlight the importance of continued surveillance of both anthropometric and cardiovascular indicators among school-aged populations.

5. Conclusion

The findings of this study suggest that anthropometric indices, including BMI-for-age, WC, WHR, and MUAC, were not significantly associated with SBP or DBP among the children and adolescents studied. These results indicate that variations in blood pressure within this population may be influenced by factors beyond body size or simple anthropometric measures alone. Nevertheless, maintaining a healthy anthropometric status during childhood and adolescence remains important for optimal growth and long-term cardiovascular health.

The relatively high prevalence of elevated blood pressure observed in this study further highlights the need for routine blood pressure screening and comprehensive cardiovascular risk assessment among school-aged populations. Future research should explore the influence of behavioral, dietary, environmental, and genetic factors on early blood pressure changes to better inform preventive strategies for childhood hypertension.

5.1. Limitations

The cross-sectional design of the study limits the ability to establish causal relationships between nutritional status and BP; therefore, only associations can be inferred. WHR and MUAC measurement was part of the anthropometric indicators of nutritional status used in this study. However, both anthropometric indicators were analyzed as continuous variables due to the absence of standardized cut-offs for this age group, which has been noted in previous pediatric nutrition research. Although BP was measured twice and the average value was used for analysis, measurements were obtained during a single visit. Temporary factors such as emotional state or recent physical activity may still have influenced blood pressure readings.

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