

Original Research Article

Raised body mass index and cardiovascular indices in secondary school students, South-South Nigeria

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ABSTRACT

Background: Raised body mass index (obesity and overweight), is abnormal or excessive accumulation of fat that may impair health. The prevalence of obesity in Nigerian adolescents ranges between 1 and 10%. In children, raised body mass index is complicated with the development of cardiovascular diseases, which are consequences of arterial stiffness. The hallmark of arterial stiffness is wide pulse pressure which precedes isolated elevation of systolic blood pressure. Other manifestations of arterial stiffness are elevated diastolic blood pressure and increased mean arterial pressure. This study educated the students on healthy lifestyle and checked their cardiovascular indices.

Methods: This was a descriptive cross-sectional study of students. Their weight, height and blood pressure were measured and cardiovascular indices were calculated.

Results: There were 248 students, age between 8 and 16 years, 135 (54.4%) were males with adolescents comprising 96.8%. The prevalence rate of wide pulse pressure, raised body mass index, elevated blood pressure and increased mean arterial pressure was 26.6%, 16.1%, 8.5% and 4.0% respectively. More females and early adolescents comparably had raised body mass index.

Conclusions: The mean values for cardiovascular indices were comparably higher in those with raised body mass index.

Keywords: Obesity, Blood, Pulse, Pressure, Arterial, Stiffness

INTRODUCTION

Raised body mass index which includes obesity and overweight, is abnormal or excessive accumulation of fat that may impair health.¹ It is an energy imbalance between caloric intake and caloric expenditure.¹ Obesity in children between 5 and 19 years of age is defined as body mass index (BMI) for age greater than 2 standard deviations (SD) above the WHO growth reference median while overweight is between >1 and 2 SD.¹

Globally, about 600 million people are obese out of which 220 million are school age children.² In Africa, about 10.6 million children have raised BMI as of 2014.¹ The prevalence of obesity in Nigerian adolescents ranges between 1 and 10%.³⁻⁷ In children, raised BMI is complicated with the development of cardiovascular (CV) diseases.⁸⁻¹⁰ Although risk increases with increased BMI, both obesity and overweight predispose to the same complications, hence the emphasis on raised BMI.¹ Arterial stiffness (AS) occurs in raised BMI and CV events are the consequences.¹¹ The hallmark of AS is

wide pulse pressure (PP) which precedes isolated systolic hypertension (HTN).¹² Other manifestation of arterial stiffness are elevated diastolic blood pressure (DBP) and increased mean arterial pressure (MAP).^{8,9,13-16} Systolic BP has always been the determinant of CV risk but recently PP has been shown to be the major determinant, and a rise in the prevalence of widened PP in children, as well as HTN have been noted in this era of childhood obesity.^{4,6,14,16,17} Fortunately, raised BMI and likewise, its complications are largely preventable.¹ Maintenance of good weight through reduction in caloric intake and increasing physical activity is the first step in the management of obesity-associated AS and subsequent HTN, although medical and/or surgical intervention may be required in the long run.¹⁸ It is therefore pertinent to promote education concerning the harmful consequences of raised BMI and its association with CV disease and advocate healthy lifestyle and health policy measures that make preventive behaviours an affordable option. The association of raised BMI with PP in our country has not gained publicity. The Junior secondary school student cohort is supposed to be in their early adolescence when AS due to obesity is likely to start developing, as this has been noted to start from adolescents (10 years) to old age.^{9,13} Influencing their lifestyle at this age will be most beneficial. This study educated secondary school children on healthy lifestyle, screened the junior students for raised BMI, elevated SBP, DBP, MAP and PP. Further lifestyle modification counselling was given to those who already have raised BMI and CV indices.

METHODS

This was a descriptive cross-sectional study of the junior students in two randomly selected secondary schools in Asaba: one boys' school and one girls' school.

The total population of secondary school students in Asaba was 14,148 and using the formula where estimated population is more than 10,000 and a prevalence rate of obesity of 10%, a minimum sample size of 166 was calculated. Using the Neymann allocation for stratified sampling and the total population of junior students in both school (259), the number of subjects to be selected from each school was 90 from boys' school and 76 from girls' school.⁷ However, a total population study of all the junior students in the two schools whose parents consented, was done. The students were grouped into 3 age cohorts: 6-9 years (childhood), 10-13 years (early adolescence) and 14-16 years (middle adolescence).

Permission was sought from the Principals of the selected schools and written informed consent obtained from parents of the students. For the students living in the dormitory, they took the consent form to their parents during the midterm break. A minimum of two visits were made to each of the selected schools; the first was to get approval from the school authorities and drop the parental consent forms, introduce the researchers, the study objectives and design. On subsequent visit, all the

students had an interactive session with the researchers on healthy lifestyle, obesity and complications and the junior students whose parents gave their consent were screened for raised BMI and cardiovascular indices.

A proforma designed for the study was used to record the biodata, the clinical history, the vital signs and anthropometric measurements. The clinical history included information on their physical activity and history of hypertension in the first-degree relatives: father, mother and siblings. Optimal physical activity was defined as at least 60 minutes of moderate- to vigorous-intensity daily physical activity (dancing, brisk walking, swimming, jumping rope), which can also be multiple shorter bouts such as 2 bouts of 30 minutes.¹⁹ Vigorous intensity activity (running, footballing) for at least 3 times a week also defined adequate physical activity in this study.¹⁹ Social class was determined using the classification proposed by Olusanya et al and a score was awarded to each child based on the father's occupation and the mother's highest educational attainment.²⁰

The, SECA 750 mechanical floor scale (SECA GmbH a co.kg, Hamburg, Germany) and SECA 213 stadiometer (SECA GmbH & co.kg, Hamburg, Germany) were used for measuring the weight and the height respectively. The weight was measured to the nearest 0.1kg with subjects on light clothing and without footwear and the standing height was measured to the nearest 0.1cm, with the subject's head, buttocks and heel touching the metallic measuring tape fixed horizontally on the instrument. The body mass index for age and sex was computed using weight (kg)/height² (m²) and BMI z-score chart was used to assign BMI status to each student.¹ Blood pressure of the participants was measured after they were seated for at least 5 minutes, using the ACCOSON mercury sphygmomanometer (Essex CM19 5QP, DEKAMET MK.3, England) with appropriate cuff size. Those with raised BMI were referred to the paediatric endocrinology clinic of FMC, while those with elevated blood pressure and/or proteinuria were referred to the paediatric nephrology clinic to confirm persistency of findings and follow them up.

Definitions of cardiovascular indices

Elevated SBP and DBP is respective values greater than or equal to 95th centile for gender, age, and height.²¹

Pulse pressure is the difference between SBP and DBP, determined by stiffness of large arteries and elevated if >40 mmHg.¹⁴

Mean arterial pressure is DPB + one third PP, determined by the function of small resistant arteries and cardiac output.¹⁴ Normal value for age ranges between 60.6 and 96.0mmHg for 6-11.9 years and between 65.3 and 103.7mmHg for 12-17.9 years.²²

Data analysis

Data obtained was entered into excel spread sheet and later analyzed using the Statistical Package for Social Sciences (SPSS) version 22.0. Descriptive statistics which includes frequency, percentages, means and standard deviations were used to summarize the variables. Determination of association between categorical variables was by chi-squared test. Results were presented in prose and tables as appropriate. All tests were 2-tailed and significant at less than 0.05.

RESULTS

There were 259 junior students enrolled in both schools (119 girls and 140 boys), but only 248 were analyzed (5 did not give consent and 6 had missing data). The students' age ranges between 8 and 16 years. There were 113 (45.6%) females and 135 (54.4%) males with F: M ratio of 1:1.2, majority (86.7%, 215/248) of who were in their early adolescence age and belong to middle SEC (Table 1). The prevalence rate of wide PP, raised BMI, HTN and increased MAP was 26.6%, 16.1%, 8.5% and

4.0% respectively, (table 1). Table 2 shows the mean age, BMI, SBP, DBP, PP and MAP, of the study population. Both schools have playground and games' period was inculcated in their school curriculum: 1 hour per week in the girls' school and 1 hour daily in the boys' school. The prevalent physical exercise included sports activities such as football, basketball, swimming, dancing, lawn tennis, taekwondo, skipping and jogging. Only 23.4% (58/248) engage in optimal physical activity and those who have positive family history of obesity and HTN were 36.3% and 9.7% respectively. Females and early adolescents are more likely to have raised BMI, (table 3). Although majority of the students with raised BMI do not have increased SBP, DBP, MAP, PP and HTN as shown in table 3, those few with raised BMI still have higher mean systolic BP, diastolic BP and MAP, table 4. Students with elevated SBP and HTN have wide PP and increased MAP. Of the 13 students with elevated SBP, 11 had wide PP, $p \leq 0.0001$ and 55 other subjects with wide PP had no elevated SBP, $p \leq 0.0001$. The 3 students who had increased MAP also had elevated DBP and SBP, ($P \leq 0.0001$ respectively). There is weak but positive correlation between raised BMI and age, SBP, DBP and MAP.

Table 1: General characteristics of the study population.

Parameters		Number	Percentage (%)
Gender	Male	135	54.4
	Female	113	45.6
Age groups	Childhood (6-9 years)	8	3.2
	Early adolescence (10-13 years)	215	86.7
	Middle adolescence (14-16 years)	25	10.1
Socioeconomic class	High	112	45.2
	Middle	132	53.2
	Low	4	1.6
HTN in the first degree relative	Yes	24	9.7
	No	224	90.3
Diastolic hypertension	Yes	15	6.0
	No	233	94.0
Systolic hypertension	Yes	13	5.2
	No	235	94.8
Elevated blood pressure	Yes	21	8.5
	No	227	91.5
Increased mean arterial pressure	Yes	3	1.2
	No	247	98.8
Wide pulse pressure	Yes	66	26.6
	No	182	73.4
Obesity	Yes	8	3.2
	No	240	96.9
Overweight	Yes	32	12.9
	No	216	87.1
Raised body mass index	Yes	40	16.1
	No	208	83.9

Table 2: Mean parameters of the study population.

Parameters	Mean± SD	95% CI, p value
Age in years	11.7±1.4	11.5 to 11.8, <0.0001
Weight in kg	43.3±9.5	42.0 to 44.4, <0.0001
Height in cm	155.2±9.6	154.0 to 156.4, <0.0001
Systolic blood pressure (mmHg)	101±13	99.0 to 102.2, <0.0001
Diastolic blood pressure (mmHg)	62±10	61.0 to 63.6, <0.0001
Pulse pressure	38±10	37.1 to 39.5, <0.0001
Mean arterial pressure	75.2±10.1	73.9 to 76.4, <0.0001
Body mass index in kg/m ²	17.8±2.8	17.5 to 18.2, <0.0001

Table 3: Raised body mass index (BMI) and study population characteristics.

Parameters (n)		Raised BMI n=40		χ^2 (p value)
		n	%	
Age group	Childhood (8)	4	10.0	7.031 (0.030) [#]
	Early adolescence (215)	32	80.0	
	Middle adolescence (25)	4	10.0	
Gender	Male (135)	13	32.5	9.252 (0.002) [#]
	Female (113)	27	67.5	
Socioeconomic class	High (112)	21	52.5	1.632 (0.442)
	Middle (132)	19	47.5	
	Low (4)	0	0.0	
Adequate exercise	Yes (58)	10	25.0	0.069 (0.792)
	No (190)	30	75.0	
HTN in first degree	Yes (24)	4	10.0	0.006 (1.000)*
	No (224)	36	90.0	
Increased MAP*	Yes (3)	2	5.0	5.733 (0.069)*
	No (247)	38	95.0	
Systolic hypertension	Yes (13)	3	7.5	0.490 (0.446)*
	No (235)	37	92.5	
Diastolic hypertension	Yes (15)	7	17.5	11.006 (0.001) [#]
	No (233)	33	82.5	
Hypertension	Yes (21)	7	17.5	5.020 (0.025) [#]
	No (227)	33	82.5	
Wide pulse pressure	Yes (66)	12	30.0	0.280 (0.597)
	No (182)	28	70.0	

*=Fisher's exact. # indicates significant values; *MAP= Mean arterial pressure

Table 4: Mean parameters with cardiovascular indices and raised BMI.

Parameters	Age in years	SBP in mmHg	DBP in mmHg	BMI in Kg/m ²	PP in mmHg	MAP in mmHg
Raised body mass index						
Yes	11.3±1.5	106±13	67±11	22.7±2.1	38±9	80.3±11.1
No	11.7±1.4	100±13	61±10	16.9±1.8	38±10	74.2±9.7
P value	0.122	0.008 [#]	0.002 [#]	<0.0001 [#]	0.916	<0.0001 [#]
Elevated systolic blood pressure (SBP)						
Yes	11.8±1.2	128±8	74±11	19.4±3.0	54±13	92.3±8.2
No	11.7±1.4	103±67	62±10	17.7±2.8	37±9	74.2±9.4
P value	0.774	<0.0001 [#]	<0.0001 [#]	0.034 [#]	0.001 [#]	<0.0001 [#]
Elevated diastolic blood pressure (DBP)						
Yes	11.7±1.0	116±11	83±4	19.4±3.6	34±9	94.0±5.7
No	11.7±1.4	104±67	61±9	17.7±2.7	39±10	74.0±9.1
P value	0.836	<0.0001 [#]	<0.0001 [#]	0.098	0.072	<0.0001 [#]

Continued.

Parameters	Age in years	SBP in mmHg	DBP in mmHg	BMI in Kg/m ²	PP in mmHg	MAP in mmHg
Elevated blood pressure						
Yes	11.8±1.2	123±10	77±10	19.4±3.2	46±16	92.1±6.8
No	11.6±1.4	103±68	61±9	17.7±2.7	38±9	73.6±8.9
P value	0.729	<0.0001 [#]	<0.0001 [#]	0.006 [#]	0.028 [#]	<0.0001 [#]
Wide pulse pressure (PP)						
Yes	11.6±1.3	111±12	61±11	18.1±2.6	51±7	77.6±10.5
No	11.7±1.4	102±76	63±10	17.7±2.9	34±6	74.3±9.9
P value	0.947	<0.0001 [#]	0.112	0.410	<0.0001 [#]	0.022 [#]
Increased mean arterial pressure (MAP)						
Yes	12.0	140	90	22.9	50	107
No	11.7±1.4	104±65	62±10	17.8±2.8	38±10	75±10
t (p value)	0.681	<0.0001 [#]	<0.0001 [#]	0.032 [#]	0.213	0.003 [#]

[#]=significant values

Table 5: Correlation between BMI and age, anthropometric and CV indices.

Parameters	r	P value
Age in years	0.24	<0.0001
Weight in kg	0.82	<0.0001
Height in cm	0.30	<0.0001
Systolic Blood Pressure in mmHg	0.25	<0.0001
Diastolic Blood Pressure mmHg	0.26	<0.0001
Pulse Pressure in mmHg	0.08	0.210
Mean Arterial Pressure in mmHg	0.28	<0.0001

Only 3 students with raised BMI came for follow up in the paediatric endocrinology clinic and none of the students with elevated BP responded to the follow up visit.

DISCUSSION

The prevalence of raised BMI was high (16.1%) and predominant in females and could be explained partly by the physiologic differential increase in the percentage body fat in females from 5-6 years through adolescence, attributed to hormonal changes accompanying puberty.²³ The abnormal CV indices observed in the index study showed no association with raised BMI. Although the few students with HTN, wide PP and increased MAP had comparably higher mean values for the CV indices, they did not have raised BMI. This may be explained by the fact that greater proportion of the raised BMI are overweight and it has been shown that complications from raised BMI occur with increasing BMI value and visceral adiposity (abdominal obesity and renal sinus fat).^{1,4,5,8,13,17} Moreso, complications from obesity and overweight are due to the excess fat mass which BMI does not directly assess because BMI does not differentiate between increased in mass due to fat, lean tissue and bone.¹⁸ Chandramohan et al found an association between wide PP and high waist circumference but not with obesity calculated from BMI.²⁴ Mechanism of CV events in raised BMI has been linked to arterial stiffness following activation of renal sympathetic nervous system (SNS) by hyperleptinaemia,

angiotensin II, hyperinsulinaemia, physical compression of the kidneys by visceral fat (abdominal obesity).^{11,12} These activators abound in raised BMI including renal SNS activity (release of norepinephrine and renin) and can partly explain the arterial stiffness, sequel to both overall increase in collagen and reduction in elastin synthesis in the arteries.^{11,18} Leptin on the other hand, is an adipokine released by adipocytes in direct proportion to the degree of adiposity and increases renal SNS activity.¹⁸ The hallmark of arterial stiffness is wide pulse pressure (PP) which precedes isolated systolic hypertension.¹² Other manifestation of arterial stiffness are elevated diastolic blood pressure (DBP) and increased mean arterial pressure (MAP).^{8,9,13-16} However, those who had these manifestations of arterial stiffness did not have raised BMI, probably because, as observed by Chandramohan et al, central obesity relates more to CV events than obesity defined by BMI calculation (that was used in this study).²⁴ Elevated SBP was associated with a comparably wider PP but wide PP was not associated with higher SBP. Therefore, if these abnormal CV indices observed in this current study were not due to arterial stiffness and its attendant widened PP, some other factors may have contributed to the abnormal CV indices in this population. White coat phenomenon could have contributed to the elevated BP but the failure of the affected students to come for follow up and lack of ambulatory BP monitoring made it difficult to substantiate this proposition. In one of the studies, the prevalence of hypertension dropped from 12% with initial measurements to 5.4% with repeated measurements.⁶

CONCLUSION

The mean values for SBP, DBP, and MAP were comparably higher in those with raised BMI.

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