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Body mass index and blood pressure correlate in nursery school children in Port Harcourt, Nigeria

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Abstract: *Introduction:* Blood pressure (BP) is a vital indicator of health in children and adults. The relationship between body mass index (BMI) and BP is well established in children; and BMI has been shown to maintain an independent relationship with BP even after controlling for many other variables that characterize individuals. High BMI significantly increases the risk of hypertension. Epidemiological studies in various countries have been conducted to determine the relationship between BP and BMI in children; similar comparative studies are lacking in Nigeria, thus necessitating this study.
Aim: To determine the relationship between BMI and BP in nursery pupils in Port Harcourt.
Methods: Multi-staged sampling technique was used to select 710 nursery pupils from 13 schools. Biodata was obtained using a self-administered (parent) questionnaire. Height and weight measurement were taken, and BMI calculated. BP was measured using a mercury sphygmomanometer; and relevant data analysis done.
Result: There were 710 pupils 365 (51.4%) males and 345(48.6%) females. Mean systolic BP was 93.2 ± 10.6mmHg (70–130 mmHg); while mean diastolic BP was 58.8 ± 8.0mmHg(40 – 88.7 mmHg). Mean BMI was 15.0 ± 1.8 kg/m^2(9.1 - 25.5 kg/m^2). There is a positive linear relationship between systolic and diastolic BP and BMI (correlation coefficient r = 0.03). Obese pupils had significantly higher BP rates (25%) (X^2= 15.35, p =0.002). BMI and height were significant predictors of diastolic BP (p<0.001).
Conclusion: There is a positive correlation between BMI and BP; and high BMI is an important predictor of high BP in nursery pupils in Nigeria.

Keywords: Blood Pressure, BMI, Nursery pupils, Nigeria

Introduction

Blood pressure (BP) is the force (per unit area) exerted by circulating blood on the walls of blood vessels[1,2]. Blood pressure is an important vital sign in children and adults and abnormal levels in childhood can track into adulthood. Various studies on BP in childhood and adolescence have repeatedly demonstrated this "Tracking phenomenon" and the tendency for "familial aggregation" of BP levels[3,4.] Blood pressure tracking patterns confirm that persistent BP increase in childhood is related to hypertension in adulthood[5]. The relationship between body mass index (BMI) and BP has also been well established in children and adolescents; and BMI has been shown to maintain an independent relationship with BP even after controlling for many other variables that characterize individuals[6]. High BMI significantly increases the risk of hypertension. This suggest that based on a child's BMI, early identification for high BP can be made, and mitigated, to prevent hypertension and its debilitating complications in adulthood[7]. Thus, an understanding of the relationship between BMI and blood pressure in young children is very important in the primordial prevention of adult hypertension.

The updated blood pressure (BP) tables for children and adolescents are based on recently revised child height percentiles and also include the BP data from the 1999-2000 NHANES (National Health and Nutrition Examination Survey)[8] of the United States of America which also has world wide application. This updated blood pressure tables, based on the NHANES 1999-2000 data, now include the 50th, 90th, 95th, and 99th percentiles. The 50th percentile has been added to provide the clinician with the midpoint of normal blood pressure range, and the 99th percentile was to allow more precise staging of hypertension, which begins at the 95th percentile. In children, normal blood pressure is defined as systolic and diastolic pressures < 90th percentile for age, sex and height[9,10,11]. Prehypertension is defined as average systolic/diastolic blood pressure (SBP/DBP)   90th and <

95th percentiles (previously defined as "high normal")[9,10,11] The definition of hypertension is regarded as SBP and/or DBP 95th percentile for age, gender, and height measured on 3 separate occasions[9,10,11]. Local comparative data on BMI and BP in younger nursery-school children (2- 5 year olds) the Niger Delta region of Nigeria where Port Harcourt is located is lacking, hence necessitating the study.

Study objective

The study's aim to determine the relationship (if any) between the body mass index and the systolic and diastolic blood pressures of nursery school children in Port Harcourt.

Materials and method

This was a cross sectional school-based study carried out in 2016 in Port Harcourt City (PHC), capital of Rivers State. Rivers State is located in the Niger-Delta Basin of Southern Nigeria. PHC is one of the 23 Local Government Areas of the State and has three school districts: Township, Diobu, and Trans Amadi. There are a total of 140 nursery schools in PHC; 71 public schools and 69 private schools. Diobu district has the largest number with 67 schools (35 public and 32 private), followed by Township with 53 schools (25 public and 28 private) while Trans-Amadi district has the least with 20 schools (11 public and 9 private). Each nursery school has three classes, from Nursery I to III, with an average of one arm in each class, in both the private and public schools. Each class has between 20 and 30 pupils.

Using a multistage sampling technique with the schools acting as sample frame, 710 preschool children were randomly selected for the study.

Each nursery school pupil had his/her anthropometric measurement (weight and height) done and their respective body mass index (BMI) was calculated using the formula Weight (kg)/height (m^2). A BMI less than the 5th percentile was regarded as underweight. BMI between the 5th percentile to less than the 85th percentile was regarded 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 obese [12].

Blood Pressure: Basal BP (i.e. BP measured under resting conditions and after all attempts had been made to reduce the influence of the emotional state of the child on BP) was measured using a mercury sphygmomanometer with appropriate cuff. Any BP reading greater than the 95th percentile for age, sex and height was regarded as high blood pressure.

Data analysis

Data was analyzed using the Epidemiological Information Software (EPI-INFO) version 7.1.0.6. Data are presented as charts, graphs and tables. Comparison of means was done using the Student t test and chi square for proportions. A p-value of less than or equal to 0.05 was considered as statistically significant.

Results

Table 1: Age and gender distribution of study subjects
Of the 710 pupils studied, 365 (51.4%) were males and 345 (48.6%) were females giving a male to female ratio of 1.1:1. Age ranged from 2 – 5 years with a mean age of 3.79 ± 1.06 years and mode of 5 years (32.54%). Table I shows the age and sex distribution of the study subjects. The mean age of 3.81 ± 1.06 years for males was not significantly different from the mean age of 3.77 ± 1.07 years for females. (X^2= 1.013, df=3, p = 0.568).

Table 1: Age and gender distribution of study population			
	Gender		
Age (months)	Male (%)	Female (%)	Total (%)
24-35	54 (48.7)	57 (51.3)	111 (100)
36-47	83 (52.9)	74 (47.1)	157 (100)
36-47	105 (49.8)	106 (50.2)	211 (100)
60-71	123 (53.3)	108 (46.7)	231 (100)
Total	365 (51.5)	345 (48.6)	710 (100)

Table 2: Mean systolic BP according to gender.
The mean systolic BP of the pupils according to age and gender is depicted in Table 2. The mean systolic BP increased with age. The average rate of increase was 2.3mmHg/year of life. The overall mean systolic BP of the males was 94.0 ± 9.7mmHg compared to 92.4 ± 11.5mmHg of the females. The difference was statistically significant (t=2.008, p=0.045). The mean systolic BP of the males was higher than that of the females in each age category except at age 5 years. The difference was statistically significant only at age 2 years (t=2.439; p=0.016)

Table 3: Mean diastolic BP according to age and gender
Table 3 shows that the mean diastolic BP increased with age. The average rate of increase was 1.6 mm/year of life. The mean diastolic BP of the males was higher than that of the females in each of the ages except age 5 years. The difference was statistically significant only at age 2 years (t=2.429, p=0.017).

Table 4: Mean weight according to age and gender
The overall mean weight of the pupils was 16.5 ± 3.3 kg with a range of 8 – 32kg. The mean weight increased with age as shown in Table 4. The overall mean weight for males was higher than that of the females and the difference was statistically significant (t=2.889, p=0.004). In addition, the mean weight for males was higher than that of the females in each of the ages. However, the difference was only statistically significant at age 2 years (t=3.491, p=0.007).

Table 2: Mean systolic BP according to gender

Age (month)	All subjects		Male		Female		t	p-value
	No.	SBP	No.	SBP	No.	SBP		
24-35	111	88.2 ± 9.9	54	90.5 ± 9.4	57	86.0 ± 9.9	2.439	0.016*
36-47	157	92.3 ± 10.8	83	93.9 ±10.2	74	90.6 ±11.2	1.912	0.058
48-59	211	94.6 ± 10.6	105	94.9 ± 9.7	106	94.3 ±11.5	0.420	0.675
60-71	231	95.0 ± 10.1	123	94.9 ± 9.1	108	95.2 ±11.1	0.212	0.832
all ages	710	93.2 ± 10.6	365	94.0 ± 9.7	345	92.4 ±11.5	2.008	0.045*

*Statistically significant; †SBP –systolic blood pressure

Table 3: Mean diastolic BP according to age and gender

Age (month)	All subjects		Male		Female		t	p-value
	No.	DBP	No.	DBP	No.	DBP		
24-35	111	55.4 ± 7.7	54	57.2 ± 8.3	57	53.7 ± 6.6	2.429	0.017*
36-47	157	58.2 ± 8.1	83	58.9 ± 8.4	74	57.4 ± 7.6	1.177	0.241
48-59	211	59.7 ± 8.6	105	60.2 ± 8.5	106	59.2 ± 8.7	0.856	0.393
60-71	231	60.2 ± 7.1	123	59.8 ± 6.8	108	60.6 ± 7.4	0.828	0.409
all ages	710	58.8 ± 8.0	365	59.3 ± 8.0	345	58.3 ± 8.1	1.645	0.100

*Statistically significant; †DBP – diastolic blood pressure

Table 4: Mean weight according to age and gender

Age (month)	All subjects		Male		Female		t	p-value
	No.	Mean weight ± SD	No.	Mean weight ±SD	No.	Mean weight ± SD		
24-35	111	13.6 ± 3.2	54	14.7 ± 3.9	57	12.6 ± 1.9	3.491	0.007*
36-47	157	15.0 ± 2.3	83	15.3 ± 2.3	74	14.7 ± 2.2	1.472	0.143
48-59	211	17.1 ± 3.3	105	17.3 ± 2.9	106	16.9 ± 3.6	0.899	0.370
60-71	231	18.4 ± 2.6	123	18.5 ± 2.4	108	18.2 ± 2.4	0.934	0.351
all ages	710	16.5 ± 3.3	365	16.9 ± 3.2	345	16.1 ± 3.5	2.889	0.004*

* Statistically significant

Table 5: Mean height according to age and gender
The mean height of the pupils was 104.6 ± 9.2cm with range of 74 – 142.1cm. The mean height increased with age as shown in Table 5. The overall mean height of the males was 105.2 ± 8.7cm compared to 103.9 ± 9.7cm for the females. Males were taller than females at ages 2 and 3 years with the observed difference being statistically significant at age 2 years. (t=3.120, p = 0.00)

Table 6: Mean BMI according to age and gender.
The mean BMI of the pupils was $15.0 ± 1.8$ kg/m^2 with a range of 9.1 - 25.5 kg/m^2. The mean BMI showed a gradual decrease with age as shown in Table 6. The overall mean BMI of the males was $15.2 ± 1.8$ kg/m^2 compared to $14.9 ± 1.9$ kg/m^2 for females and the observed difference was statistically significant (t=2.306, p=0.021). The mean BMI for the males was higher than that of the females in each of the ages. However, the observed difference across the ages was not statistically significant.

Table 5: Mean height according to age and gender

Age (month)	All subjects		Male		Female		t	p-value
	No.	Mean height ± SD	No.	Mean height ± SD	No.	Mean height ± SD		
24-35	111	92.2 ± 7.7	54	94.5 ± 9.2	57	90.1 ± 5.3	3.120	0.002*
36-47	157	99.5 ± 5.5	83	100.1 ± 5.6	74	98.8 ± 5.3	1.475	0.142
48-59	211	106.9 ± 6.3	105	106.9 ± 5.5	106	106.9 ± 7.0	0.036	0.971
60-71	231	111.8 ± 5.4	123	111.9 ± 5.3	108	111.8 ± 5.6	0.149	0.882
all ages	710	104.6 ± 9.2	365	105.2 ± 8.7	345	103.9 ± 9.7	0.219	0.067

* Statistically significant

Table 6: Mean BMI according to age and gender

Age (month)	All subjects		Male		Female		t	p-value
	No	Mean BMI ± SD	No	Mean BMI ± SD	No	Mean BMI ± SD		
24-35	111	15.9 ± 1.9	54	16.2 ± 2.2	57	15.5 ± 1.6	1.917	0.058
36-47	157	15.1 ± 1.4	83	15.2 ± 1.3	74	15.1 ± 1.5	0.554	0.581
48-59	211	14.9 ± 2.1	105	15.1 ± 1.8	106	14.8 ± 2.3	1.288	0.199
60-71	231	14.7 ± 1.7	123	14.8 ± 1.6	108	14.5 ± 1.8	1.283	0.201
all ages	710	15.0 ± 1.8	365	15.2 ± 1.8	345	14.9 ± 1.9	2.306	0.021*

Table 7 shows the BMI classification according to age. Subjects aged 5 years ranked highest for underweight classification. However, the highest prevalence of overweight and obesity was observed at age 2 years.

Age (month)	BMI Classification				Total (%)
	Under-weight (%)	Normal (%)	Over-weight (%)	Obese (%)	
24-35	2 (1.8)	80 (72.1)	16 (14.4)	13 (11.7)	111 (100)
36-47	18 (11.5)	121 (77.1)	12 (7.6)	6 (3.8)	157 (100)
48-59	27 (12.8)	159 (75.3)	12 (5.7)	13 (6.2)	211 (100)
60-71	35 (15.1)	174 (75.3)	14 (6.1)	8 (3.5)	231 (100)
All ages	82 (11.6)	534 (75.2)	54 (7.6)	40 (5.6)	710 (100)

Table 7: BMI classification according to age

Relationship between Blood Pressure and BMI

Figure 1 shows the relationship between systolic blood pressure and BMI in the subjects. There is a positive linear relationship between systolic blood pressure and BMI with a correlation coefficient r = 0.03.

Fig 1: Correlation of Systolic Blood Pressure and BMI
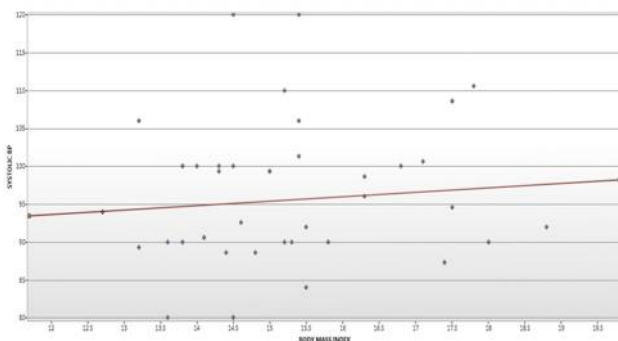
Figure 2 shows the relationship between diastolic blood pressure and BMI in the subjects. There is a positive linear relationship between diastolic blood pressure and BMI with a correlation coefficient r = 0.03.

Fig 2: Correlation of Diastolic Blood Pressure and ……….
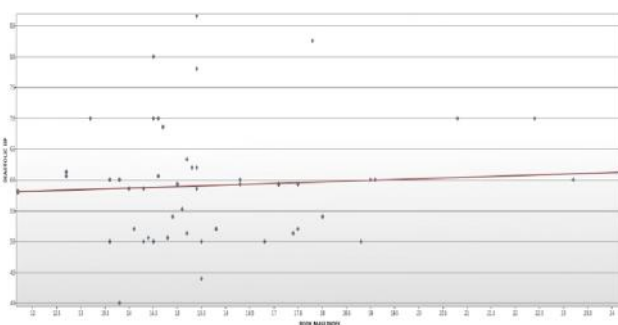
Discussion

This study showed that the mean systolic BP of the children was 88.2 ± 9.9mmHg at 2 years and increased with age to a mean value of 95.0 ± 10.1mmHg at 5 years of age. The mean diastolic BP was 55.4 ± 7.7mmHg at 2 years and increased with age to a mean value of $60.2 \pm$

7.1mmHg at 5 years of age. This is similar to the findings of Ogunkunle et al[13] and de Swiet et al[14] but contrasts with the findings of Hashimoto et al[15] whose BP values were higher, with a mean systolic BP of 97.7mmHg at the age of 2 years. A strong reason for this difference could be the method of blood pressure measurement. While this study as well as the study by Ogunkunle et al[13] and de Swiet et al[14] used the conventional sphygmomanometer, Hashimoto et al[15] used an oscillometric device which has been shown to give higher blood pressure values[16]. This observed progressive increase in BP among preschool children with age, is similar to other studies carried out both in preschool and older children[17,18-20] This increase in BP with age has also been demonstrated with the use of the oscillometric device as shown by Park and Menard[21]; who examined American children aged 2 weeks to 5 years using an oscillometric device.

In the present study, both systolic and diastolic BP increased with age. This is similar to the findings of Ogunkunle et al[13] but contrasts with those of Hashimoto et al[15] where age had an effect only on diastolic BP. The average rate of rise per year for mean systolic BP in this study, which was 2.3 mmHg/year, is however higher than the 1.4mmHg/year reported by Ogunkunle et al[13] On the other hand Ogunkunle et al[13] found a rate of rise of 1.7mmHg/year for mean diastolic BP similar to the 1.6mmHg/year in this study. The reason for the difference in systolic blood pressure may be due to environmental factors and differences in ethnicity as the Ogunkunle study was carried out in the Western region of Nigeria.

Opinions have differed concerning the relationship between gender and BP. Studies consistently reported that mean systolic BP is slightly higher in girls than in boys up to the age of 12 years, after which boys showed a higher mean systolic BP[22-25]. This pattern has not been demonstrated with diastolic BP[25]. The present study however showed higher mean systolic and diastolic BP in males compared to females. This was similar to the findings of de Swiet et al[14] who studied blood pressure in the first 10 years of life and found that the blood pressure of males was higher than that of females by 1mmHg at all age groups (p=<0.0001) even after allowing for the effect of weight. In contrast to these findings, Brady[26] showed there was no difference in blood pressure between male and female children younger than six years but found that at puberty and beyond males had a slightly higher blood pressure than females. Ogunkunle et al[13] observed no gender-related difference in BP in children aged 1 – 5 years except in the 12 – 23-month age group where the females had a significantly higher BP than the males. The reason for these variations in BP with respect to gender is unclear; however, that findings in the Ogunkunle[13] study differed from findings in the present study suggested possible ethnic/cultural influences in the gender-related blood pressure values of younger children in various regions in Nigeria and requires further exploration for specific determinants. It may also suggest that younger male children in the

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