CORRELATION OF HYPERTENSION WITH BODY MASS INDEX AND AGE OF MALE AND FEMALE UNDERGRADUATE STUDENTS IN FOUR NIGERIAN UNIVERSITIES

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Abstract: Hypertension is one of the most modifiable risk factors for cardiovascular diseases associated with high Body Mass Index (BMI), age and sex. However, the relationship between blood pressure, BMI, age and sex remain poorly understood, especially in Nigeria, because of dearth of studies. This study investigated the relationships between these parameters in undergraduates in four Nigerian universities in the two contiguous states of Benue and Taraba. Results of statistical tests (Pearson correlation "r", student "t" test and linear regression) revealed that there was a significant ($P < 0.01$) positive correlation between hypertension, BMI and age among male and female undergraduates in these two states. The Pearson correlation coefficient of age- adjusted systolic and diastolic blood pressure versus BMI were ($r = 0.942$, $n = 19$, $P < 0.01$) and ($r = 0.955$, $n = 19$, $P < 0.01$), respectively. The student t-test also showed statistically significant ($P < 0.05$) association between age-adjusted BP and BMI in both male and female students. Both male and female undergraduates have considerable risks of increased BMI and associated abnormalities of elevated blood pressure. Concerted efforts should be made by the management of Nigerian Universities to educate undergraduates on the health hazards of high BMI and advantages of maintaining normal weight.

Keywords: Hypertension, blood pressure, body mass index, undergraduate students

Introduction

Hypertension is one of the most important modifiable risk factors for cardiovascular diseases worldwide (WHO, 2014). It is a condition in which a person's heart pumps blood at a higher pressure than normal through his arteries. In Nigeria, it is the number one risk factor for stroke, heart failure, ischemic heart disease and kidney failure (Ogah *et al*., 2012). In the year 2000, it was reported that more than a quarter of the world's adult population at the time – totalling nearly one billion – had hypertension, and that this proportion will increase to 29% – over 2 billion – by 2025 (Kearney *et al*., 2005). The report also suggests that men and women have a similar overall prevalence of hypertension, and that such prevalence increase with age consistently in all regions of the world. High Body Mass Index (BMI) is among the major factors that frequently contribute to abnormally high blood pressure (Jackson *et al*., 2014). Invariably, individuals who are overweight or obese run a great risk of developing hypertension; though with some variations with age and sex of subjects (Ogah *et al*., 2012).

Blood pressure (BP) is the pressure of circulating blood against the walls of the arteries (Suchismita and David, 2003). Pressure is highest during systole, when the ventricles are contracting (systolic pressure) and lowest during diastole, when the ventricles are relaxing and re-filling (diastolic pressure). Hence, BP is an important indicator of the health of the circulatory system. Muscular contraction and emotional stress such as fear, stress and excitement raise systolic blood pressure (SBP) and is at its lowest during sleep. Severe shock may lead to abnormally low BP and possibly circulatory failure. BP is usually adjusted to its normal level by the sympathetic nervous system and hormonal controls (David, 2013).

The BP level in individuals varies with age and sex (Ogah *et al*., 2012; Kearney *et al*., 2005) depending on situation, activity, and disease states, and is regulated by the nervous and endocrine systems. The prevalence of hypertension in both men and women ranged from 8 to 46.4%; with regards to gender, the prevalence of hypertension ranged from 7.9 to 50.2% in men and 3.5 to 6.8.8% in women, respectively (Ogah *et al*., 2012). There are three main categories of BP- normal blood pressure, hypotension and hypertension (The American Heart Association, 2014). A BP that is pathologically high is called hypertension, a condition when a subject's arterial blood pressure is higher than normal (Government of Victoria, 2015). Hypertension is classified as either primary (essential) or secondary hypertension. Whilst 90-95% of cases are categorized as primary hypertension (high blood pressure with no obvious underlying medical cause), just 5-10% of cases are categorized as secondary hypertension (caused by other conditions that affect kidneys, arteries, heart or endocrine system) (The American Heart Association, 2014). Complications that may arise from hypertension include atherosclerosis, heart failure, cerebral haemorrhage, and kidney failure, but early treatment may prevent their development (David, 2013).

BMI or Quetelet Index is a measure of relative size based on the mass and height of an individual. It is a mathematical ratio of weight to the square of height that can be linked with body composition (or body fat percentage) and with indices of health risk. Obesity is usually characterized by increase in body weight (>20% of normal body weight) due to accumulation of fat in white adipose tissue of the body (Gupta, 2009).

Incidences of hypertension and obesity have become persistent and intractable global challenges. Between 1980 and 2013, the combined prevalence of overweight and obesity worldwide rose by 27.5% in adults and 47.1% in children (Tucker, 2014). A total of 26.4% of the world's adult population (26.6% of men and 26.1% of women) had hypertension in 2000; and the proportion is expected to increase to 29.2% (29.0% of men and 29.5% of women) by 2025 (Kearney *et al*., 2005). The Nigerian Medical Association (NMA) and the Pharmaceutical Society of Nigeria (PSN) have decried the number of hypertension cases in the country with its attendant complications such as heart attack, stroke, blindness and kidney failure (Gachomo, 2013). Nigeria has been witnessing an alarming increase in the prevalence of obesity as well as high BP and hypertension (WHO, 2006). In addition to this dilemma, a majority of the patients with high BP in Nigeria are unaware that they have the condition. About 11.4% of adult population in Nigeria

were affected by high BP in 1997 (Asekun-Olarimoye *et al*., 2013) - the figure rose to 22% (about 57 million people) in 2013 (The Guardian Mobile, 2013; Gachomo, 2013). Hence, there has been concerted effort by the government to fight this scourge (Akor, 2014; Adeniran *et al*., 2011). There is a dearth of studies establishing association between hypertension and BMI in the country. Hence, the present study attempted to bring more illumination on these maladies and also to investigate the correlation between hypertension with BMI and age in male and female undergraduates in Nigeria. The study hypothesis was: there is no association between BP level, BMI, sex and age.

Materials and Methods

Administration of questionnaire

Structured questionnaires were administered to the subjects directly and they included students from Benue State University, Federal University of Agriculture, Makurdi (both in Makurdi, Benue State), Federal University Wukari and Kwararafa University (both in Wukari, Taraba State), Nigeria. Consenting subjects were assembled in convenient places within the premises of the individual universities for data collection. The data needed to achieve the set objectives of this study included information on: age, sex, height, weight, BMI and BP levels of subjects.

Blood pressure measurement

Both systolic and diastolic blood pressures of subjects were measured in mm Hg using a standard sphygmomanometer (Model: Slight Touch ST-402). The cuff was wrapped around the upper arm and inflated, compressing the artery to stop the blood flow. Readings were taken as displayed on the screen and were expressed as a fraction showing systolic over diastolic pressure in mm Hg.

Hypertension determination

The BP levels of subjects were used to assess the category (Oghagbon *et al*., 2009) they fell into:

I. Normal: ≥90 to 119 mm Hg systolic/60 to 79 mm Hg diastolic pressure
II. Pre-hypertension: 120 to 139 mm Hg systolic/80 to 89 mm Hg diastolic pressure
III. Stage 1 hypertension: 140 to 159 mm Hg systolic/90 to 99 mm Hg diastolic pressure
IV. Stage 2 hypertension: 160 mm Hg systolic/100 mm Hg diastolic pressure
V. Hypertensive emergency: ≥180 mm Hg systolic/≥120 mm Hg diastolic pressure
VI. Isolated diastolic hypertension: diastolic blood pressure >90 mm Hg and systolic <160 mm Hg
VII. Isolated systolic hypertension: systolic blood pressure ≥140 mm Hg and diastolic blood pressure <90
VIII. Hypotension: < 90 mm Hg systolic/< 60 mm Hg diastolic pressure.

Body mass index estimation

Consenting subject's weight and height were taken using a weighing scale/stadiometer (Brecknell HS-300 Digital Handrail Scale). Weight (W) was taken to the nearest 0.05 kg and height (H) to the nearest 0.05 m, and BMI was calculated for each subject using the standard formula (Richard *et al*., 2011);

$$\frac{W(kg)}{H^2(m^2)} \quad \ldots \text{(Equation 1)}$$

BMI categories included: < 18.5: underweight, 18.5-24.9: normal, 25-29.9: overweight, 30-34.9: obese class I, 35-39.9: obese class II and > 40.0: obese class III (David, 2013).

Sample size determination

A total of 382 students was sampled (sample size determined using the Raosoft online sample size calculator) from a combined population size of 45,600. The margin of error was 5%, confidence level, 95%, and response distribution, 50%.

Data analysis

The data were summarised as both absolute frequencies and/ or percentages. Statistical package for social scientists (SPSS) version 21 and the student t-tests ($P < 0.05$) were used to determine the Pearson product moment correlation coefficient, r ($P < 0.01$) to establish the degree of association between the variables.

Location of study areas

Makurdi is the administrative headquarters of Benue State, Nigeria. Benue State University (BSU) and Federal University of Agriculture (FUAM) are respectively located on the south and north banks of River Benue, in Makurdi metropolis, Nigeria. Federal University Wukari (FUW) and Kwararafa University (KU) are both located in Wukari, in the southern part of Taraba state, Nigeria. Whereas Makurdi in Benue state is geographically situated in the middle belt between the coordinates 7°43′50″N 8°32′10″E, Wukari in Taraba state is located in the north-eastern part of Nigeria between the coordinates 7°51′N 9°47′E. The two states are however, contiguous. At the time of the study, BSU and FUAM had students' population of over 20,000 each whereas FUW and KU had students' population under 10,000.

Statement of ethical clearance

Ethical approvals were obtained from the various universities' committee for research ethics, and were strictly adhered to throughout the research.

Results and Discussion

Characteristics of the study population

Table 1 presents the BP and BMI status of the subjects. The mean age of the subjects was 26 years. There were 50% males and 50% females. Values represent mean ± S.D. The mean systolic and diastolic blood pressures (SBP and DBP) and BMI were 126.3 mm Hg ± 8.7, 78.0 mm Hg ± 5.6 and 21.9 ± 2.4 kg m^{-2}, respectively. All BMI, SBP and DBP increased progressively with age among both male and female subjects. Most of the subjects (69.1%) had normal weights; 20.8% were underweight while less than 9% were overweight with just over 2% with outlying BMI reaching obesity status. The proportion of the subjects and their respective BP status included: 42.7% - normal BP (NBP), 45.3% - high- normal BP (HNBP), 1.8% - high BP (HBP), 9.4% Isolated Systolic Blood Pressure (ISBP) and 0.8% Isolated Diastolic Blood Pressure (IDBP) (Table 2).

For male subjects specifically, 19.4% had NBP, 58.6% HNBP, 3.7% HBP, 17.8% ISBP and 0.5% IDBP. In the female group, 66.0% had NBP, 31.9% HNBP, 1.0% ISBP and 1.0% IDBP. Furthermore, 60% of those with HNBP and 58% of NBP were between ages 22-26 years. Overall, 3.5% of all 17-21 year olds were hypertensive - HBP, ISBP or IDBP, 15% of 22-26 years and 13% of 27-≥31 year olds.

Table 1: Mean BP and BMI of subjects by age and sex

Age (Years)	Sex				Mean		
	Male	Female	Total	%	SBP (mm Hg)	DBP (mm Hg)	BMI (kg m^{-2})
17	0	1	1	0.26	117.5 ± 12.70	70.5 ± 2.30	20.8 ± 2.95
18	0	7	7	1.83	118.5 ± 6.10	71.8 ± 5.90	21.5 ± 3.05
19	4	11	15	3.93	120.2 ± 8.60	66.3 ± 9.90	19.7 ± 3.30
20	9	24	33	8.64	120.4 ± 11.70	71.7 ± 7.20	19.2 ± 2.30
21	9	21	30	7.85	122.3 ± 14.50	74.3 ± 8.30	19.8 ± 2.50
22	22	27	49	12.8	123.2 ± 14.70	71.1 ± 7.60	20.8 ± 4.50
23	23	30	53	13.9	121.2 ± 13.70	71.6 ± 9.64	20.6 ± 2.92
24	34	27	61	16.0	124.2 ± 13.20	72.7 ± 9.42	22.2 ± 4.92
25	29	16	45	11.8	127.5 ± 13.60	75.9 ± 10.6	21.1 ± 2.45
26	18	8	26	6.81	122.9 ± 12.70	72.3 ± 7.90	21.3 ± 4.30
27	11	11	22	5.76	119.7 ± 11.10	71.3 ± 8.10	21.7 ± 4.80
28	18	4	22	5.76	124.8 ± 13.30	73.1 ± 9.01	21.2 ± 3.35
29	5	1	6	1.57	123.4 ± 11.30	75.2 ± 7.80	22.4 ± 1.82
30	4	2	6	1.57	118.8 ± 11.70	71.8 ± 5.50	23.0 ± 2.90
31	0	1	1	0.26	123.5 ± 11.30	77.5 ± 7.60	28.9 ± 2.72
32	1	0	1	0.26	126.0 ± 12.72	76.5 ± 9.55	20.5 ± 3.55
33	1	0	1	0.26	130.0 ± 11.35	71.5 ± 8.25	25.2 ± 2.75
34	1	0	1	0.26	171.5 ± 10.55	171.5 ± 5.50	24.5 ± 2.55
35	2	0	2	0.52	143.5 ± 9.25	75.8 ± 0.48	22.6 ± 2.65

Table 2: Categories of BP among the subjects

Age (years)	Sex			Mean BP(mm Hg)		BP Status
	Male	Female	Total	Systolic	Diastolic	
17-21	4	39	43	112.30	69.70	NBP
22-26	22	73	95	110.90	67.30	
27-≥31	11	14	25	111.40	67.30	
Total	**37**	**126**	**163**	**111.53**	**68.10**	
17-21	15	25	40	127.00	72.40	HNBP
22-26	73	31	104	128.00	74.40	
27-≥31	24	5	29	127.10	75.40	
Total	**112**	**61**	**173**	**127.37**	**74.07**	
17-21	1	0	1	169.50	101.40	HBP
22-26	5	0	5	143.40	94.50	
27-≥31	1	0	1	171.50	102.40	
Total	**7**	**0**	**7**	**161.50**	**99.00**	
17-21	2	0	2	158.00	84.80	ISBP
22-26	25	2	27	146.20	78.10	
27-≥31	7	0	7	146.70	81.00	
Total	**34**	**2**	**36**	**150.30**	**81.30**	
17-21	0	0	0	0.00	0.00	IDBP
22-26	1	2	3	152.70	104.20	
27-≥31	0	0	0	0.00	0.00	
Total	**1**	**2**	**3**	**152.70**	**104.20**	
Grand total	**191**	**191**	**382**	**142.63**	**87.19**	

Classes of BMI

The classes of BMI are presented in Table 3. These included: underweight (UW), normal weight (NW), overweight (OW) and obesity I (OB I), OB II and OB III. Majority (69%) of the study population had NW- of which males constituted 55% while females constituted 45%. The respective BMI in ages 17-21, 22-26 and 27-≥31 were 20, 63 and 17%. Approximately 20.4% of the study population were underweight, of which 39% were males and 61% females. About 11% of the study population was overweight (OW)- 41% were males and 59% females.

Association of BP and BMI

Table 4 represents the association of BMI and BP in the study population. Variations in BMI were associated with corresponding variations in both systolic and diastolic BP by age and sex. Expectedly, subjects with higher BMI tended to have greater systolic or diastolic BP. At age 19, the mean systolic and diastolic BP and BMI for male subjects were 126.6 mm Hg, 61.6 mm Hg and 19.7 kg m^{-2} respectively. For age 30, they were 125.0 mm Hg, 73.9 mm Hg and 22.7 kg m^{-2}. Similarly, among the female subjects; at age 19 the mean systolic and diastolic BP and BMI were 117.8 mm Hg, 68.00 mm Hg and 20.0 kg m^{-2}, respectively. For age 30, the figures were 106.5 mm Hg, 67.8 mm Hg and 23.7 kg m^{-2}.

Table 3: Classes of BMI by age and sex

Age (years)	Sex			Mean Weight (Kg)	Mean Height (m)	Mean BMI (kg m^{-2})	BMI Status
	Male	Female	Total				
17-21	7	22	29	49.6	1.70	17.1	Under weight
22-26	16	24	40	50.6	1.70	17.5	
27-≥31	7	2	9	53.7	1.80	17.4	
Total	**30**	**48**	**78**	**51.3**	**1.70**	**17.3**	
17-21	13	40	53	55.7	1.60	20.6	Normal weight
22-26	99	68	167	59.8	1.70	20.9	
27-≥31	32	12	44	62.0	1.70	21.4	
Total	**144**	**120**	**264**	**59.2**	**1.70**	**21.0**	
17-21	2	2	4	65.0	1.55	26.8	Over weight
22-26	7	13	20	69.4	1.60	27.2	
27-≥31	4	4	8	71.5	1.64	26.5	
Total	**13**	**19**	**32**	**68.6**	**1.60**	**26.8**	
17-21	0	0	0	0	0	0	Obesity I
22-26	2	2	4	74.3	1.50	32.7	
27-≥31	0	1	1	57.0	1.40	30.8	
Total	**2**	**3**	**5**	**65.6**	**1.50**	**31.8**	
17-21	0	0	0	0	0	0	Obesity II
22-26	0	1	1	67.0	1.30	37.3	
27-≥31	1	0	1	77.0	1.40	38.7	
Total	**1**	**1**	**2**	**72.0**	**1.35**	**38.0**	
17-21	0	0	0	0	0	0	Obesity III
22-26	1	0	1	55.0	1.10	49.4	
27-≥31	0	0	0	0	0	0	
Total	**1**	**0**	**1**	**55.0**	**1.10**	**49.4**	
Grand total	**191**	**191**	**382**	**62.0**	**1.50**	**30.7**	

Table 4: Association of BP and BMI

Age (years)	Male			Female		
	SBP (mm Hg)	DBP (mm Hg)	BMI (kg m^{-2})	SBP (mm Hg)	DBP (mm Hg)	BMI (kg m^{-2})
17	0	0	0	117.50±3.43	70.50±2.71	20.83±2.31
18	0	0	0	118.50±3.55	71.79±2.79	21.51±2.38
19	126.63±11.46	61.63±7.95	19.72±1.53	117.82±3.64	67.95±2.90	19.64±2.47
20	129.00±11.76	73.11±7.38	19.46±1.49	117.15±3.77	71.13±2.77	19.09±2.49
21	135.28±12.15	77.39±7.61	21.18±1.41	116.79±3.94	73.02±2.87	19.24±2.43
22	133.77±12.60	72.09±7.90	21.22±1.45	114.50±4.14	70.30±3.01	20.38±2.34
23	129.43±13.13	73.28±8.14	19.88±1.49	114.90±4.33	70.23±3.11	21.12±2.34
24	130.18±13.71	72.84±8.47	22.37±1.40	116.61±4.57	72.46±3.19	21.97±2.40
25	132.14±14.39	78.10±8.81	21.03±1.47	119.03±4.91	71.84±3.42	21.32±2.55
26	125.69±15.21	72.94±9.30	21.02±1.50	116.75±5.22	71.00±3.70	21.96±2.63
27	123.64±15.95	71.27±9.79	21.63±1.51	115.68±5.76	71.27±3.96	21.79±2.80
28	126.50±16.59	73.19±10.20	20.86±1.58	117.25±6.53	72.75±4.31	23.01±2.95
29	124.70±17.57	74.70±10.84	22.52±1.51	117.00±7.67	77.50±5.03	21.54±3.37
30	125.00±18.39	73.88±11.78	22.71±1.66	106.50±9.81	67.75±5.63	23.68±2.99
31	0	0	0	123.50±3.06	77.50±.2.77	28.86±2.34
32	126.00±19.05	76.50±12.85	20.50±1.88	0	0	0
33	130.00±18.93	71.50±14.78	25.20±1.19	0	0	0
34	171.50±16.17	102.00±5.16	24.02±0.85	0	0	0
35	143.50±13.22	75.75±7.22	22.55±0.96	0	0	0

Correlation between hypertension and BMI

Tables 5 and 6 show the extent of the relationship between hypertension, BMI and age. Statistical analyses of the data using Pearson product moment correlation coefficient (r), and student '*t*' test showed significant positive linear correlation ($P < 0.01$; $t > t_{critical}$, $P < 0.05$) between hypertension, BMI and age among male and female undergraduates. The 'r' of age-adjusted SBP and DBP vs BMI was 0.942 and 0.955, $P < 0.01$, respectively. The only exception was the age group 22-26 years, which showed a significant linear negative correlation between the age- adjusted SBP vs BMI ($r = -0.026$, $P < 0.01$). Also, a very strong and positive correlation between BP and BMI was observed in both male and female subjects (male SBP vs BMI: $r = 0.979$, $P < 0.01$; DBP vs BMI: $r = 0.972$, $P < 0.01$ while female SBP vs BMI: $r = 0.976$, $P < 0.01$; DBP vs BMI: $r = 0.981$, $P < 0.01$). The coefficient of determination (r^2) of the regression analysis of age- adjusted SBP vs BMI and DBP vs BMI were 0.887 and 0.911, respectively.

Table 5: Pearson correlation matrix of BMI, blood pressure and age

Variable		BMI	SBP	DBP	Age group (yr)		
					17-21	22-26	27-≥31
BMI		1.000	0.978	0.971	0.942	0.867	0.956
SBP		0.978	1.000	0.992	0.999	-0.026	0.928
DBP		0.971	0.992	1.000	0.984	0.257	0.940
Age group (yr)	17-21	0.942	0.999	0.984	1.000	-	-
	22-26	0.867	-0.026	0.257	-	1.000	-
	27-≥31	0.956	0.928	0.940	-	-	1.000

Table 6: Summary of the student t-test

Variable	N	Student t-test							
		SBP				DBP			
		t	df	$t_{critical}$	P	t	df	$t_{critical}$	P
Age-adjusted BP/BMI	19	15.44	18	2.10	0.05	14.93	18	2.10	0.05
17-21 years	5	6.00	4	2.78	0.05	6.19	4	2.78	0.05
22-26 years	5	124.57	4	2.78	0.05	79.18	4	2.78	0.05
27-≥31 years	9	10.07	8	2.31	0.05	9.03	8	2.31	0.05
Sex									
Male BP/BMI	19	39.89	15	2.13	0.05	28.31	15	2.13	0.05
Female BP/BMI	19	99.03	15	2.14	0.05	73.85	15	2.14	0.05

Hypertension is an important worldwide public-health challenge (Kearney *et al.* 2005), and is widely recognized as probably the most modifiable risk factor for cardiovascular diseases. However, its relationship with blood pressure, BMI, age and sex is poorly understood. Results of the present study show certain levels of association between them. Only 12% of the subjects had high BP, the majority of the study population had NBP and HNBP, contrasting with the 3.4% prevalence observed by Oghagbon *et al*. (2009) in a study involving undergraduate students in Delta state university, Abraka-southern Nigeria. It contrasts also with the 25% reported among undergraduate students in Ebonyi state university, Abakaliki- eastern Nigeria (Dimkpa and Ojo, 2010), 18% among undergraduates at Makerere University, Uganda (Bimenya *et al*., 2005) and 23.5% reported by Simão *et al*. (2008) in another similar study in Lubango, Angola.

Although, the majority of the study population had NW, a statistically significant ($p < 0.05$) chunk (11%) was overweight. There were 20% more OW females than males. The occurrences of all the classes of obesity I, II and III were, however statistically insignificant ($p > 0.05$), but overall, there appeared to be some level of association between BMI and age as, 4.7% of all 17-21 year olds, 11.2% of 22-26 year olds and 15.6% of all 27-≥31 year olds were obese (OW, OB I, OB II and OB III). Subjects with high BMI were at increased risk for high BP as accentuated by the independent effect of change in BMI on SBP and DBP in both males and females by age. The proportion of male subjects with high BP was greater than that of females (22% versus 2%); but the reverse was true for normal weight (9% versus 12%). The independent effect of change in BP in both male and female subjects by age was similar to the work of Simao *et al*. (2008) in Lubango University, Angola where 19% of the males had high BP compared to just 8.4% of females.

The significant positive linear correlation ($P < 0.01$; $t > t_{critical}$, $P < 0.05$) observed in these results between hypertension, BMI and age in male and female undergraduates was indicative of their close association. Consequently, the null hypothesis was rejected as indicated by the 'r' of age-adjusted SBP and DBP vs BMI ($r = 0.942$, $P < 0.01$) and ($r = 0.955$, $P < 0.01$), respectively. The strong association between BMI and SBP has also been reported by Aliyu *et al*. (2014) in a study involving undergraduate students in University of Maiduguri. Except for the age group 22-26 years, the positive association between BP (DBP and SBP) and age was a lot stronger than the association between age and BMI, especially for the 17-21 year olds. Although, this is in consonance with the report of Mungreiphy *et al*. (2011) in their work with Tangkhul Naga tribal males of northeast India, the reason for the linear negative correlation between age and SBP ($r = -0.026$, $P < 0.05$) was not very clear. However, age has previously been reported (Nirmala, 2001) to affect SBP more strongly than DBP. Also, recently, Goel *et al*. (2016) observed a highly significant association ($P < 0.01$) between sex, BMI, SBP, family history of hypertension, and birth weight with DBP in their work with adolescents in the Bhopal district of Madhya Pradesh, Central India.

Furthermore, the association between BP and BMI was strong in both genders, but more statistically significant ($P < 0.05$) in the females than in the males. The coefficient of determination (r^2) of the regression analysis in the present study however, signifies a better predictability of the SBP/BMI than the DBP/BMI relationships.

Conclusion

Previous studies on blood pressure/BMI relationships, especially amongst university students have looked at single or individual universities. To our knowledge, this is the first comprehensive study that researched at least four universities at once from two different states in the country. SBP and DBP as well as BMI vary significantly with age and sex. The association between BP and BMI was statistically more significant in females than in male students. People with high BMI are at increased risk for high blood pressure that could degenerate into hypertension.

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Conflict of Interest

The authors declare that there is no conflict of interest related to this study..

References

Adeniran OS, Adeniyi OS, Jimoh AK & Alao OO 2011. Underweight, overweight and obesity in adult Nigerians living in rural and urban communities of Benue State. *Ann. Afr. Med*., 10(2): 139-143.

Akor G 2014. Benue Distributes Monitoring Devices to Diabetic Patients. Daily Independent, (Abuja). Retrieved on 18th October, 2014.

Aliyu SU, Ahmad JT & Oyeyemi AY 2014. Relationship between body mass index and blood pressure among university students in Maiduguri, Nigeria. *Int. J. Rec. Adv. Multidiscipl. Res.*, 01(11): 091-096.

Asekun-Olarimoye EO, Akinwusi PO, Adebimpe WO, Isawumi MA, Hassan MB, Olowe OA, Makajuola OB, Adebiosu CO & Adewale TA 2013. Prevalence of hypertension in the rural adult population of Osun State, Nigeria. *Int. J. Gen. Med.*, 6: 317-322.

Bimenya GS, Byarugaba W, Kalungi S, Mayito J, Wanzira H & Muhame M 2005. Blood pressure profiles among Makerere University undergraduate students. *Afr. Health Sci.*, 5(2): 99-106.

David CD 2013. Health Risks of Obesity. National Institute of Health. http://www.nlm.nih.gov/medlineplus/ercy/patientinstructions/000348.htm. Retrieved on 17th January, 2015.

Dimkpa U & Oji JO 2009. Association of heart rate recovery after exercise with indices of obesity in healthy, non-obese adults. *Eur. J. Appl. Physiol*., DOI 10.1007/s00421-009-1276-2.

Gachomo M 2013. Hypertension in Nigeria: Rising to the Challenge. *Abonema Foundation News*. Retrieved on 3rd January, 2015.

Goel M, Pal P, Agrawal A & Ashok C 2016. Relationship of body mass index and other life style factors with

hypertension in adolescents. *Ann. Pediatr. Cardiol*., 9(1): 29–34.

Government of Victoria 2015. Blood pressure (high) hypertension: conditions and treatment; healthy living, relationship and family. Better Health Channel. State Government of Victoria. www.betterhealt.vic.gov.au. Retrieved on 3rd January, 2015.

Gupta PP 2009. Textbook of Biochemistry: with biomedical significance for medical and dental students and undergraduate and postgraduate students of biochemistry and life sciences. CBS Publishers and Distributors, New Delhi, India.

Jackson M, Walker S, Forrester T, Cruickshank JK & Wilks R 2014. Social and dietary determinants of body mass index of old Jamaicans of African origin. *Eur. J. Clin. Nutr.*, 57(4): 621-627.

Kearney PM, Whelton M, Reynolds K, Munter P, Whelton PK & He J 2005. Global Burden of Hypertension: Analysis of World Wide Data, pp. 217-223.

Mungreiphy NK, Kapoor S & Sinha R 2011. Association between BMI, blood pressure, and age: study among Tangkhul Naga tribal males of northeast India. *J. Anthropol.*, Article ID 748147, 6 pages. doi:10.1155/2011/748147.

Nirmala A 2001. Age variation in blood pressure: Effect of sex and urbanization in a genetically homogeneous caste population of Andhra Pradesh. *Am. J. Hum. Biol*., 13(6): 744-52.

Ogah OS, Okpechi I, Chukwuonye II, Akinyemi J, Onwubere BJC, Falase AO, Stewart S & Sliwa K 2012. Blood pressure, prevalence of hypertension and hypertension related complications in Nigerian Africans: A review. *World J. Cardiol*., 4(12): 327-340.

Oghagbon KE, Odili VU, Nwangwa EK & Pender KE 2009. Body mass index and blood pressure pattern of students in a Nigerian university. *Int. J. Health Res*., 2(2): 177-182.

Richard A, Robert WJ & Denise RF 2011. Lippincott's Illustrated Reviews: Biochemistry. Lippincott Williams & Wilkins Publishers, Philadelphia, USA.

Shuchismita D & David G 2003. Molecule of the month: Hemoglobin. doi:10.2210/rcsbpdb/mom_2003_5. Retrieved on 17th January 2015.

Simão M, Hayashida M, dos Santos CB, Cesarino EJ & Nogueira MS 2008. Hypertension among undergraduate students from Lubango, Angola. *Revista Lantino-Americana de Enfermagem.*, 16(4): 672-678.

The American Heart Association 2014. Understanding Blood Pressure Readings. http:www.heart.org/HEARTORG/Conditions/HighBlood/Pressure/HighBloodPressure/Understanding-Blood-Pressure-Readings_UCM_301764_Article.jsp. Retrieved on 4th January 2015.

The Guardian Mobile 2013. 57 Million Nigerians are Hypertensive, Says Experts 2013. http://theguardianmobile.com/readnewsItem1.php?nid=12327 Retrieved on 2nd January, 2015.

Tucker ME 2014. Obesity Epidemic Is Global. www.medscape.com/viewarticle/825858. Retrieved 19th October, 2014.

World Health Organisation 2006. Facts about Over-weight and Obesity. Fact Sheet No 311. http//www.who.It/Entity/mediacentre//Factsheet/en. Retrieved on 30th October, 2014.

World Health Organisation 2014. Global Strategy on Diet, Physical Activity, and Health: Childhood Overweight and Obesity. Retrieved on 30th October, 2014.