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Relationship between body mass index, mid-arm circumference and incidence of high blood pressure among adolescents in Edo state, Nigeria

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Abstract: *The relationship between body mass index (BMI), mid-arm circumference (MAC) and blood pressure (BP) among adolescents in urban and rural dwellers in Edo State of Nigeria were assessed. A total of 574 subjects comprising 185 males and 168 females from urban areas; and 113 males and 108 females from the rural areas within the age of 12 and 20 years were used for the study. Parameters, such as weight (kg), height (m), BMI (kg/m^2), MAC (cm) and blood pressure (mmHg) were determined using standard procedures. The results showed a perfect correlation between MAC and Systolic Blood Pressure, SBP, BMI and SBP, BMI and diastolic blood pressure, DBP, BMI and MAC, as well as between MAC and DBP. The MAC showed positive correlation with the mean arterial blood pressure (MAP) only among the rural males and females in the study area. Variations in the BMI between gender and the Urban/Rural communities were significant in favour of the females.*

Key Words: Body-mass index, Mid-arm circumference, Blood pressure, Adolescents, Edo State.

Introduction

Adolescence is an important period in one's life as it marks the period of rapid growth and development. It represents 20% of the global population and about 84 % in developing countries (WHO, 1986). Despite the low standard of living and the high energy expanded at this stage in life, some individuals still suffer from overweight and obesity in Nigeria. Obesity is associated with several problems among which, the most prevalent are the psychological consequences among the youths and its persistence in adult life (Neutzling *et al.*, 2008). The development of obesity early in life may compound the risk factors for cardiovascular diseases more drastically than later phase in life (Poplem, 1994). According to some researchers, obesity alone independently increases one's risk of cardiovascular morbidity and mortality (Bjorntorp and Brodoff, 1992).

A significant increase in the prevalence of obesity in higher adults (>18 years) and in younger adults (>12 years) has ultimately increased their predisposition to hypertension and other related cardiovascular diseases. In addition, overweight children are at a higher risk of developing long term chronic conditions including adulthood-onset diabetes mellitus, orthopaedic disorders and respiratory diseases (Aristmune *et al.*, 1984). The determination of BMI (Quetelet's index) is accepted as the best approach for assessing overweight and obesity (Bjorntorp and Brodoff, 1992). Barlow and Dietz noted that the ideal body mass index for maintaining a good health is between 18.5 and 25.0 kgm^2, that individuals with BMI of 18 kgm^{-2} and below are underweight, those with BMI between 26 and 30 kgm^{-2} are overweight, while those having BMI greater than 30 kgm^{-2} are considered obese (Barlow and Dietz, 1998). The mid-arm circumference, MAC, has been

recommended as an alternative surrogate measure of low body weight of babies and even young adults (Bindu, *et al.*, 2006). Blood pressure (BP) is the force exerted by circulating blood on the walls of blood vessels and constitutes one of the vital signs of life, such as heart beat, rate of breathing and temperature. It arises as the heart pumps blood into the arteries and is regulated by the response of the arteries to the flow of blood. It is expressed as systolic/diastolic blood pressure (SBP/DBP). A normal blood pressure for a healthy person is as low as 120/80 giving a blood pressure index (BPI) of 1.5 (Sembulingam and Sembulingam 2006). Blood pressures over of 130/80 (or 1.63) is considered high and ranks high among the most common risk factors for cardiovascular diseases. High blood pressure increases the risk of developing heart or renal failure, kidney disease, hypertension, hardening of the arteries (artherosclerosis or arteriosclerosis), eye damage, reduced life expectancy and stroke (Venkaiah *et al.*, 2002). Among the environmental causes of hypertension, attention has extensively been focused primarily on nutritional factors. However, additional environmental factors such as income level, social status and type of employment may also constitute a factor in the pathogenesis of hypertension (Cassono, 1990).

At present, the relationship between blood pressure, body weight, body mass index and mid-arm muscle circumference has not been investigated in Edo State. This study is perhaps the first which is aimed at assessing the relationship between blood pressure and body weight (BWt), BMI and MAC among adolescents in both Rural and Urban Communities in Edo State, Nigeria.

Materials and Methods

A total of 574 persons between the ages of 12 to 20 (classified as adults; WHO, 1986) comprising 185 males and 168 females from urban areas and 113 males and 108 females from rural areas were sampled from randomly selected secondary schools in Benin metropolis and Orhionmwon and Uhunmwonde Local Government Areas of Edo State. The geographical classification was based on the qualitative and quantitative definitions given by Rios and Rose (1988) and Obika *et al* (1995). Almost all the students in the selected classes who are within the defined age limits, according to WHO (1986), participated with high level of compliance.

The data were collected by direct measurement. The weights of the individuals were measured while on barefoot and on light clothes using a digital scale and results were recorded to the nearest 0.1 kg. The heights were measured also while on barefoot using standard measuring tape and the values were recorded to the nearest 0.1 km. The body mass index was calculated from the expression: Body weight (Kg) ÷ Height (m^2) (Eknoyan, 2008). The MAC was measured midway between the tip of the acromion and elocranon process on the right arm with a tape. Blood pressure was recorded using automated Omron HEM-712C Digital Blood Pressure Monitor. The subject was made to sit in a calm upright position and the cuff was wrapped round the arm before switching on the Monitor. The values of systolic (SBP) and diastolic blood pressure (DBP) were recorded directly from the monitor display screen in mmHg. The mean arterial pressure (MAP) was then calculated from the expression: MAP = DBP + 1/3 (SBP - DBP) and expressed in mmHg. The mean and standard error of the mean (SEM) of each gender-sensitive status were calculated using Computer Excel Statistical Package, while the data obtained was statistically analyzed using the Statistical Package for Social Sciences (SPSS) Windows Version 7.5 MS Excel, 2007.

Results and Discussion

The mean values and standard error of the mean (SEM) of the tested parameters: age, weight (Wt), height (Ht), BMI, SBP, DBP, MAP and MAC for Urban males and females as well as rural males and females are presented in Table 1. It is evident from the results that there were significant variations in BMI between urban males and females (Fig. 1) in favour of the urban females as well as between urban and rural females (Fig. 4) in favour of the urban females. The BMI ranged from an average of 19.59 ± 0.29 – 21.28 ± 0.27 Kg/m^2 across the gender in the urban and rural communities studied. This is however within the recommended range of an ideal body mass index of 18.5 – 25 Kg/m^2 for maintaining a good health (Barlow and Dietz 1998). Although women generally have greater tendency to grow fatter than their men counterparts, the results of this study does not indicate any case of overweight (26–30 Kg/m^2) or obesity (> 30 Kg/m^2) in both gender cases according to Barlow and Dietz (1998).

The results of t- test analyses between the various blood pressure parameters indicated significant differences, ($p < 0.05$) between urban and rural males in their DBP, MAP and MAC values, (Fig.3) as well as between urban and rural females in their SBP, DBP and MAP values, (Fig.4). The systolic blood pressure also varied significantly between the urban males and females (Fig.1) and between urban and rural females, while DBP and MAP varied significantly between rural males and females (Fig.2). The arterial blood pressure, made up of SBP, DBP, MAP and pulse pressure (SBP - DBP), increased with age and obese people are more prone to higher blood pressure than lean persons, (Sembulingam and Sembulingam 2006). The SBP represents the pressure in the arteries as the muscle of the heart contracts and pumps blood into them, while the DBP represents the pressure in the arteries as the muscle of the heart relaxes after it contracts.

The relationship between body weights and blood pressure index (ratio of SBP/DBP) is shown in Fig.5, indicates a linear variation. Persons with higher weights are more likely to develop higher BP. The study also reveals it is obvious that, people living in the urban cities are generally heavier compared with their rural counterparts and that under the same environment and conditions of living; men are relatively heavier than their female counterparts (Table 1).

The data in Table 1 were also subjected to Pearson's cross correlation analysis. The results of the two-tailed correlation matrices between the blood pressure parameters in both gender and communities are presented in Tables 2 to 5. Comparing urban males and females (Table 2), there was perfect correlation between SBP and MAC ($r = 1.0$) > that between the BMI and DBP ($r = 0.916$) > BMI and MAP ($r = 0.711$). This suggests that the higher the mid-arm muscle circumference or body mass

Table 1. Data on the urban and rural males and females

Gender/ Comty	Age	Weight	Height	BMI	SBP	DBP	MAP	MAC	BPI
Urban male	15.6± 0.10	56.04± 0.64	1.67± 0.01	19.4± 1.17	117.08± 0.01	67.54± 1.87	83.58± 0.97	25.09± 0.19	1.73
Urban female	15.19± 0.08	54.76± 0.73	1.66± 0.06	21.28± 0.27	112.11± 1.40	68.54± 0.99	83.85± 1.11	24.39± 0.23	1.68
Rural male	15.9± 0.23	49.35± 0.92	1.58± 0.01	19.59± 0.29	117.67± 1.73	70.04± 1.11	86.67± 0.91	23.73± 0.26	1.64
Rural female	15.56± 0.17	48.31± 0.84	1.55± 0.01	19.95± 0.28	118.19± 1.42	72.10± 1.00	87.59± 0.86	24.08± 0.22	1.64

index, the more the incidence of higher blood pressure. In this same class, there were inverse relationships between BMI and SBP (r = - 0.508) and MAC (r = - 0.521). Among the rural males and females (Table 3), positive correlations were observed between BMI and blood pressure in the order: BMI and MAP (r = 0.996), (p < 0.01) > BMI and DBP (r = 0.978) > BMI and SBP (r = 0.918) and with MAC (r = 0.996), p< 0.05. A positive correlation was also observed between MAC and DBP (r= 0.989) > MAC and MAP (r = 0.988) > MAC and SBP (r = 0.893) as well as between SBP and MAP (r = 0.948) p< 0.05. In the rural and urban males in Edo State (Table 4), the BMI showed positive correlation only with DBP (0.601), while the MAC and MAP were inversely related (r= - 0.648). Correlation between the DBP and MAP was highly positive (r = 0.993), while correlations between SBP and DBP and MAP were about 50 % respectively. Comparing the rural and urban females (Table 5), there were inverse relationships between the BMI and MAP (r = - 0. 897) > BMI and SBP (r = - 0.870) > BMI and DBP (r = - 0.867). Correlation between SBP and DBP or MAP were however very linear (r = 0.997 in each case at p < 0.01). The DBP and MAP also showed the same perfect correlation (r = 0.998).

Table 2. Pearson's Cross Correlation Matrix for the determined Parameters between Urban Males and Females in Edo State

	BMI	SBP	DBP	MAP	MAC
BMI		*0.492*	*0.084*	*0.289*	*0.479*
SBP	- 0.508			*Sig. level*	*0.000*
DBP	0.916				*0.855*
Corr. Coeff.					
MAP	0.711				*0.864*
MAC	- 0.521		1.000	- 0.145	0.136

Correlation is Significant (P< 0.05); (2-tailed), Right upper part in italis is Sig. level, Left lower part is Correlation coeffient

Table 3. Pearson's cross correlation matrix for the determined parameters between rural males and females in edo state

	BMI	SBP	DBP	MAP	MAC
BMI		*0.082*	*0.022*	*0.004*	*0.004*
SBP	0.918*			*Sig. level*	*0.107*
DBP	0.978*				*0.011*
Corr. Coeff.					
MAP	0.996**				*0.012*
MAC	0.996**		0.893*	0.989*	0.988*

*Correlation is Significant (P< 0.05); **Correlation Significant (P< 0.01) (2-tailed)

Right upper part in italics is Significant level, Left lower part is Correlation Correlation coeffient

Table 4. Pearson's cross correlation matrix for the determined parameters between rural and urban males in edo state.

	BMI	SBP	DBP	MAP	MAC
BMI		*0.813*	*0.399*	*0.727*	*0.571*
SBP	0.187		*0.463*	*0.452*	*0.972*
DBP	0.601	0.537		*0.067*	*0.628*
MAP	0.273	0.548	0.993		*0.352*
MAC	0.429	0.028	- 0.372	-0.648	

Table 5. Pearson's cross correlation matrix for the determined parameters between rural and urban females in edo state.

	BMI	SBP	DBP	MAP	MAC
BMI		*0.130*	*0.133*	*0.103*	*0.858*
SBP	- 0.870*		*0.003*	*0.003*	*0.832*
DBP	- 0.867*	0.997**		*0.002*	*0.907*
MAP	- 0.897*	0.997**	0.998**		*0.883*
MAC	0.142	- 0.168	0.093	- 0.117	

*Correlation is Significant (P< 0.05); **Correlation Significant (P< 0.01) (2-tailed)

Right upper part in italics is Significant level, Left lower part is Correlation coeffient

The body mass index is a useful surrogate for measuring obesity and chronic energy deficiency in children and adults. Obesity in young adults is a significant public health concern because of its negative impact on the physical and psychological health of people and

as a risk factor in the development of chronic cardiovascular and metabolic diseases later in life (Cassono, 1990; Julius, *et al.,* 2000). The relatively higher body mass index observed among the females over the male counterparts in both urban and rural areas could have been due to their regular eating habits and relaxed disposition, which consequently increased their fat accumulation and greater muscle mass. Under-muscularity was more marked in the rural areas than in the urban. This could be accounted for by the regular energy sapping physical activities such as long distance walk and manual farming operations they often engage in unlike the urban dwellers that are characterized by sedentary lifestyle, more indoor activities (television, video games) and reduced energy expenditure. Consequently, the mean blood pressure indices among the urban dwellers were relatively higher (BPI = 1.71) than that of the rural people (1.64). This is in line with the WHO, (1986) findings, that inadequate diet and distressed habitation in developing countries may adversely influence the growth and nutrition among adolescents resulting in short stature and lean body mass. Although the results showed that the rural dwellers had higher systolic and diastolic blood pressure values compared with the urban, the net relative blood pressure indices (Table 1) revealed that the urban dwellers have higher prevalence of developing high blood pressure than the rural people contrary to earlier reports by Lavelle and Harbert; that the Australian rural dwellers were more likely to develop hypertension and that the prevalence of hypertension in Rural residents in New South Wales was three percent (3%) higher than the urban residents.

Our observation of the prevalence of high blood pressure indices in the rural community over the normal standard (1.5) could be attributed to multiple psychogenic factors such as fear, anxiety, over happiness etc. In rural areas, most subjects became excited at the first sight of the digital blood pressure recorder. This may stimulate the sympathetic nerve supply to the heart and consequent increase in contractility and rhythmicity. In part, it could be adduced due to the higher muscularity (resulting from more physical activities) and lower adiposity of their mid arms. The diastolic blood pressures were generally lower than the systolic in all the groups (Fig. 1-4). This probably reflects a general vasodilatation necessitated by the hot seasons to facilitate heat loss and thus maintain normal body temperature. This is in consonance with the findings of Etta and Watson (1976). The diastolic blood pressure represents the pressure in the arteries as the muscle of the

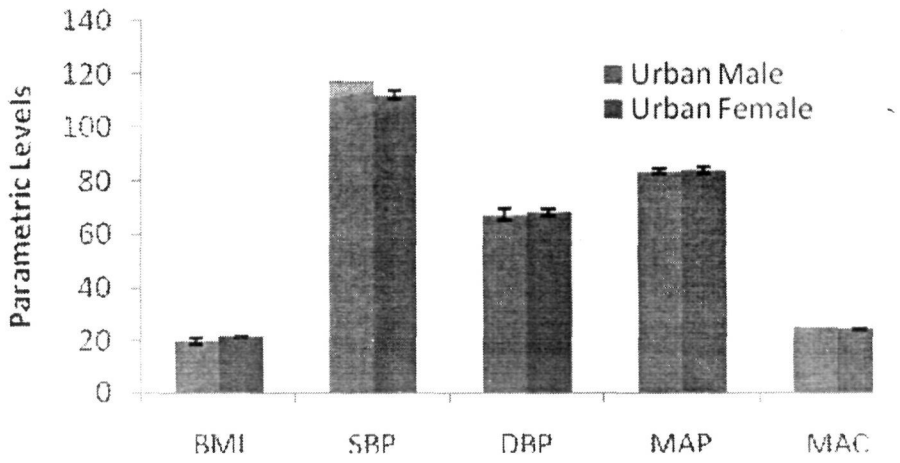

Fig. 1 Variations between urban males and females and their BMI, SBP, DBP, MAP and MAC distributions in Edo State

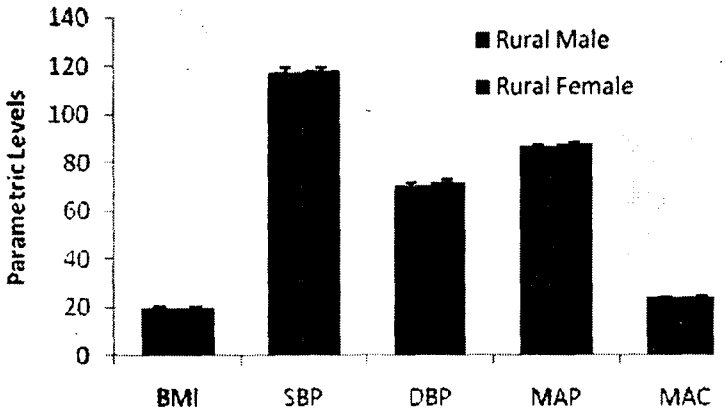

Fig. 2 Variations between rural males and females and their BMI, SBP, DBP, MAP and MAC distributions in Edo State

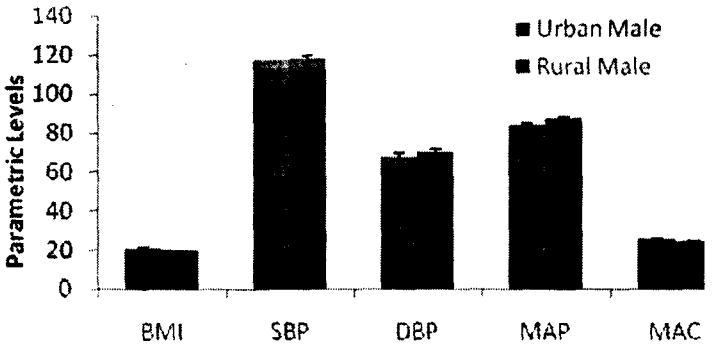

Fig. 3 Variations between urban and rural males and their BMI, SBP, DBP, MAP and MAC distributions in Edo State

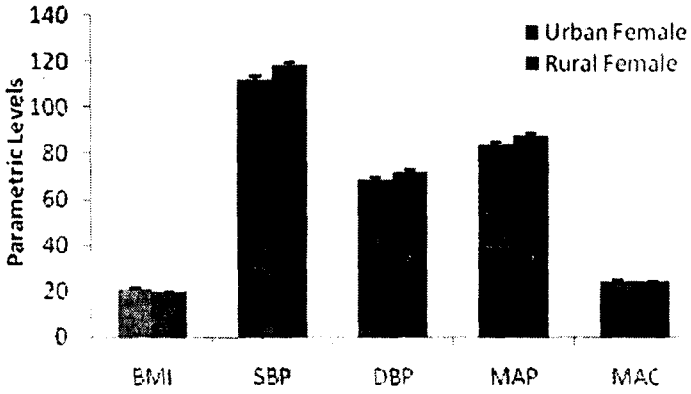

Fig. 4 Variations between urban and rural females and their BMI, SBP, DBP, MAP and MAC distributions in Edo State

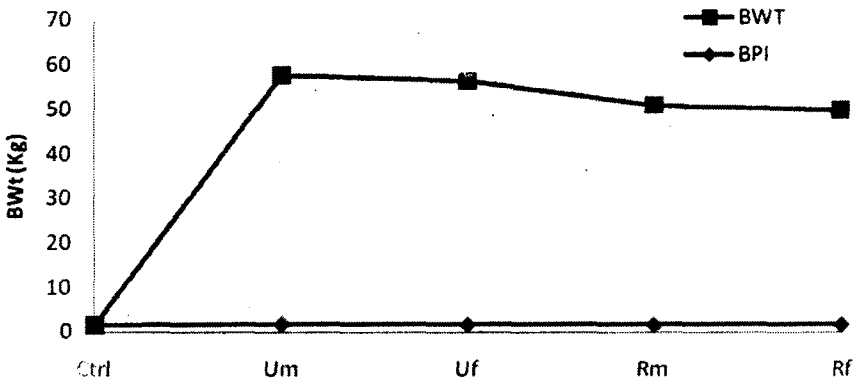

Fig. 5 Variations between body weights (BWT) and Blood pressure indices (BPI) among Urban and Rural dwellers in Edo.

heart relaxes after contraction. It is often lower than the pressure in the arteries, (systolic blood pressure), generated as the muscle of the heart beat contracts and pumps blood (Sembulingam and Sembulingam, 2006)

Just as high blood pressure increases the risk of developing hypertension and reduced life expectancy, (Vankaiah, *et al.,* 2002), low blood pressure or hypotension, may lead to a permanent damage of vital organs, such as the brain, heart and the kidney as their normal functioning become impaired due to insufficient supply of oxygen and nutrients to them.

Changes in blood pressure could be attributed to changes in body mass index and mid-arm muscle circumference among rural and urban dwellers. This study showed that the BMI correlated more significantly with the blood pressure parameters; SBP, DBP, MAP than the MAC across the gender and communities. Thus, BMI is a better indicator of overweight compared with the MAC of a person. The BMI for the female adults in both urban and rural areas were higher than their male counterparts respectively, indicating a likelihood of the females having a higher tendency for overweight than the males. In general, urban dwellers have higher blood pressure index than their rural counterparts and are therefore prone to higher incidence of high blood pressure.

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