DISSERTATION

BLOOD PRESSURE PATTERN AMONG APPARENTLY HEALTHY SECONDARY SCHOOL ADOLESCENTS IN JALINGO, TARABA STATE

THIS DISSERTATION IS SUBMITTED IN PART FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE FELLOWSHIP OF THE NATIONAL POSTGRADUATE MEDICAL COLLEGE OF NIGERIA IN THE FACULTY OF PAEDIATRICS

BY

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MAY 2015
DECLARATION

I hereby declare that this dissertation is original. It has not been presented by me or any other person to another college or submitted elsewhere for publication.

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DEDICATION

This work is dedicated to my dearest wife and lovely children for their patience and understanding during this period. Above all, I dedicate it to God Almighty for sustaining me to this stage and beyond.
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LIST OF ABBREVIATIONS

ADH  Antidiuretic Hormone
ANP  Atrial Natriuretic Peptide
BMI  Body Mass Index
BP   Blood pressure
CDC  Centre for Disease Control
CVA  Cerebro-vascular accident
DASH Dietary approach to stop hypertension
DBP  Diastolic blood pressure
Ht   Height
JSS  Junior secondary school
Kg   Kilogramme
M    Meter
mmHg Millimeters of Mercury
NHBPEPWG National High Blood Pressure Education Programme Working Group
NCHS National Centre for Health Statistics
PGS  Pubertal Growth Spurt
PHC  Primary Health Care
QI   Quetelet’s index
SBP  Systolic blood pressure
SSS  Senior secondary school
SMR  Sexual maturity rating
USA  United States of America
WC   Waist circumference
WHO  World Health Organization
WHR  Waist-hip ratio
Wt   Weight
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SUMMARY

A cross sectional study of blood pressure pattern in apparently healthy secondary school adolescents aged 10-19 years in Jalingo, Taraba state was carried out over six months period from January to July 2014. One thousand three hundred and fifty (1350) students participated, comprising 628 (46.5%) boys and 722 (53.5%) girls. Variables measured included blood pressure, weight, height, waist circumference and body mass index was calculated from the weight and height.

Overall, the mean anthropometric values and blood pressure increased with age irrespective of sex. The mean weight of the students was 48.6±10.9kg with a range of 23-100kg, while the mean height was 1.6±0.1m and ranged from 1.2-1.9m. The mean waist circumference was 65.6±8.9cm and ranged from 22-100cm while the mean body mass index (BMI) was 18.9±3.1 with a range of 11.4-42.0.

The overall mean systolic blood pressure was 108.9±12.5mmHg with a range of 76-165mmHg while the mean diastolic blood pressure was 68.3±8.2mmHg and ranged from 47-95mmHg. The gender related differences in blood pressure showed mean systolic blood pressure for boys and girls to be 108.1±13.3mmHg and 109.5±11.7mmHg (t=-2.054, p=0.040) while the mean diastolic blood pressure was 67.8±8.1mmHg and 68.7±8.2mmHg (t=-2.077, p=0.038) respectively. Girls generally had a higher mean systolic blood pressure than boys from early adolescence (t=3.754, p=0.007) to middle adolescence (t=-3.025, p=0.011) but reversed during late adolescence with boys having higher mean systolic blood pressure (t=2.145, p=0.033) and these differences were statistically significant. Girls also showed dominance in the diastolic blood pressure in early and middle adolescence but only statistically significant during middle adolescence (t=-3.517, p<0.000). Adolescents from private schools had higher mean systolic blood pressure of 110.2±12.3mmHg than those
from public schools with 108.4±12.5mmHg (t=-2.22, p<0.027) and higher mean diastolic blood pressure of 70.3±8.0mmHg than those from public schools with 67.7±8.1mmHg (t=-4.61, p=0.000).

Blood pressure correlated positively with age (r=0.30-0.35, p<0.000), height (r=0.34-0.44, p<0.000), weight (r=0.38-0.51, p<0.000), body mass index (r=0.29-0.40, p<0.000) and waist circumference (r=0.23-0.31, p<0.000). The socio-economic class associated negatively with blood pressure with those from upper socio-economic classes having a relatively lower mean blood pressure than their counterparts from lower socio-economic classes but the differences were not statistically significant for both systolic (f=1.650, p=2.850) and diastolic blood pressure (f=0.193, p=0.058).

The overall point prevalence of hypertension was 4.4% (59 of 1350) with gender specific prevalence for male being 4.1% (26 of 628 boys) and 4.6% (33 of 722 girls) for females. The gender difference was not statistically significant ($\chi^2=0.831$, p=0.362). According to stages of hypertension, 1.5% (10 of 628) and 1.1% (7 of 628) males had stages 1 and 2 systolic hypertension respectively while 2.4% (15 of 628) had stage 1 diastolic hypertension and none had stage 2 diastolic hypertension. Similarly, 2.4% (17 of 722) and 1.2% (9 of 722) females had stages 1 and 2 systolic hypertension respectively while 1.2% (9 of 722) and only 0.1% (1 of 722) girls had stages 1 and 2 diastolic hypertension respectively. The overall prevalence of pre-hypertension was 22.1% (298 of 1350) with gender related prevalence of 21% (131 of 628) for males and 23.1% (167 of 722) for females. The gender difference was statistically significant ($\chi^2=4.349$, p=0.037).

In view of the high prevalence of pre-hypertension of 22.1% (298 of 1350) in this study, it is recommended that blood pressure measurement should be included as part of medical evaluation at secondary school entry and at least annually thereafter; especially for those found to be at risk of hypertension during school entry.
INTRODUCTION

Blood pressure (BP) is the pressure exerted by circulating blood volume on the walls of blood vessels.\(^1\) It is one of the vital signs measured during routine physical examination.\(^2\) Blood pressure measurement is done to screen for hypertension and other cardiovascular risk factors, determining risk for various medical procedures, identifying patients in potential or actual clinical deterioration and determining individual’s fitness for an occupation.\(^3\) Its value, as a screening tool in adults, has long been documented and is an established important component of routine paediatric physical examination.\(^4\)

The importance of BP measurement in children and adolescents is based on the fact that hypertension is now increasingly diagnosed among them.\(^5\)–\(^8\) The American Academy of Paediatrics now recommends routine screening of asymptomatic adolescents and children during preventive care visits. Such screening will identify potentially treatable and preventable causes of hypertension and initiate early treatment to prevent complications.\(^5\)

Hypertension is an important health problem all over the world\(^5\)–\(^9\) because it is usually silent and the presence of symptoms may indicate end organ damage.\(^10\) It is known to track well into adulthood; thus making BP measurements in youths valuable for identifying adolescents at risk of essential hypertension in adulthood.\(^11\) Individuals with high BP in their childhood are more likely to have high BP in subsequent years.\(^12\) The phenomenon of BP tracking into adulthood and the demonstration of the beginnings of hypertensive target organ damage during childhood, together with the increased prevalence of childhood essential hypertension, have raised concern of an impending epidemic of cardiovascular morbidity and mortality.\(^10\)

The consequences of hypertension in children range from increased morbidity from its causes, complications, or its treatment, to high mortality.\(^13\) The most frequently
and perhaps severely affected organs are the heart, kidneys, brain and the eyes leading to lowered life expectancy and premature death. In addition, hypertension is a component of the metabolic syndrome associated with similar and perhaps more severe consequences in affected individuals. Abdulrahaman and Babaoye, in a study of hypertension in Nigerian children, observed a mortality rate of 28% within the first year after diagnosis. Similar mortality of 27.5% was reported by Aderele and Seriki. Hypertension also places an excessive financial burden on the population and health system, consuming scarce resources.

Adolescence is the transitional period of development between childhood and adulthood. The World Health Organization (WHO) defines adolescents as individuals between the ages of 10 and 19 years and they account for 40% of Nigeria’s population. Adolescence is characterized by rapid biological, psychological and cognitive changes, largely dependent on hormonal and environmental influences. Many of the responses to these influences include behaviours that have direct implications on health, such as harmful dietary intake, alcoholism, smoking, substance abuse and sedentary lifestyle. These, coupled with social stresses, such as city traffic congestion, have negative health impact and predispose to obesity and increased risk of cardiovascular disease such as hypertension and metabolic syndromes. It has been shown that if preventive measures are started early in childhood and adolescence, they may lead to significant reduction in the high prevalence of hypertension and metabolic syndrome currently observed in adults.

**JUSTIFICATION FOR THE STUDY**

Hypertension is associated with high morbidity affecting major organs of the body such as the heart, kidneys and the brain, and a mortality of up to 27.5-28%, It is now diagnosed frequently in adolescents with a reported prevalence of 3.5-9.5%. The younger the age of
onset of hypertension the greater the reduction in life expectancy, if left untreated. Even asymptomatic adolescents with mild blood pressure elevations can have target organ damage. Studies have shown that early identification and intervention may lead to a significant reduction in the high prevalence of hypertension and metabolic syndrome currently observed in adults. In view of this, routine blood pressure check-ups for children and adolescents have been advocated during medical evaluations. Blood pressure is, however, not routinely measured in most paediatric clinical practices in Nigeria. Consequently, only few children will have their blood pressure measured when they fall sick or during preventive care visits. In addition, hospital and clinic BP measurements may be associated with falsely elevated BP called “white coat hypertension”. BP measurement of children outside of the hospital setting, such as in schools, will provide opportunity for apparently healthy individuals and possibly eliminate white coat hypertension. The need for surveillance for the early identification of adolescents in Jalingo who are at risk of hypertension and to initiate measures aimed at preventing its consequences is therefore the justification for this study. In addition, the study will add to the body of knowledge on adolescent blood pressure as there has been no previous study on BP from Jalingo and northeastern Nigeria as a whole. This will help inform public health policies regarding blood pressure control and prevention in Taraba State in particular and in Nigeria in general.
LITERATURE REVIEW

HISTORICAL PERSPECTIVE

Blood pressure measurement first started in the eighteenth century with the experiment of Stephen Hales, to whom its discovery can be attributed as reported by Jeremy. Accurate study of blood pressure as reported by Crile began with the introduction of a manometer by Poiseuille a century later. The first truly accurate blood pressure measurement in man was by the Surgeon Faivre in 1856 when he connected an artery to a mercury manometer to obtain direct readings. Non-invasive methods of BP measurement started with the discovery of the sphygmograph in 1855 by Vierordt as reported by Crile, and improvement by Potain in 1889 gave birth to the sphygmomanometer. In 1896, Scipione Riva-Rocci developed the method upon which present-day technique is based.

Segal reported that the use of stethoscope for BP measurement was first highlighted in 1905 by a Russian surgeon, Korotkoff who documented hearing a tapping sound using a stethoscope placed over the brachial artery as the Riva-Rocci cuff was deflated. Goodman and Howell recommended the division of the changing sounds into five distinct phases, and physicians subsequently determined blood pressure according to the point of appearance and muffling or disappearance of the sounds.

DEFINITION AND REGULATION OF BLOOD PRESSURE

Blood pressure is defined as the product of cardiac output and peripheral vascular resistance. During each heartbeat, BP varies between a maximum (systolic) and a minimum (diastolic) pressure and is measured in millimeters of mercury (mmHg). Blood
pressure is regulated by different mechanisms acting either rapidly or slowly to maintain it within normal range for optimal cellular performance.\textsuperscript{31,32}

**Intrinsic Regulation**

Intrinsic factors regulating BP include stroke volume and heart rate, which both influence cardiac output.\textsuperscript{31} Stroke volume depends on the volume of blood that fills the ventricles and this depends on the preload and afterload.\textsuperscript{33} A higher afterload will decrease stroke volume causing low cardiac output and low BP and vice versa. When cardiac output increases, more volume is derived from the venous pool increasing preload. Similarly, an increased heart rate will lead to increased cardiac output and BP.\textsuperscript{31,34}

**Reflex Regulation**

The baroreceptors within the aortic arch and carotid sinuses contain sympathetic and parasympathetic nerve fibres.\textsuperscript{34,35} These are sensory nerves which run from the medulla and they respond to stretch of the tissue in which they lie by increasing or decreasing the rate of signaling\textsuperscript{36} and act fast in regulating BP.\textsuperscript{34} Sympathetic stimulation causes increased heart rate and widespread vasoconstriction to increase BP while parasympathetic stimulation produces the opposite.\textsuperscript{35,37}

**Hormonal Regulation**

Hormones regulating blood pressure include renin-angiotensin-aldosterone and antidiuretic hormone (ADH). They act slowly by responding to changes in intravascular volume and osmolality.\textsuperscript{38} Angiotensin II is a potent vasoconstrictor and stimulates the release of aldosterone from the adrenal gland.\textsuperscript{39} Aldosterone increases sodium absorption and fluid retention leading to increased BP. ADH is a potent vasoconstrictor and plasma volume regulator and its stimulation results in fluid retention and vasoconstriction.\textsuperscript{39} Other hormones regulating BP include the sex hormones, thyroid, parathyroid, cortisol and ACTH. They act on the rennin-angiotensin-aldosterone system to regulate BP.\textsuperscript{39,40}
Renal Regulation

The kidneys control blood pressure through the retention and excretion of extracellular fluid. An increase in renal fluid retention will increase extracellular volume and higher blood pressure whereas increased renal excretion leads to lower blood pressure. This is achieved through the action of ADH, aldosterone and atrial natriuretic peptide (ANP).

METHODS OF MEASURING BLOOD PRESSURE

Blood pressure can be measured by invasive and non-invasive methods.

1). Invasive (or direct) method - Blood pressure is most accurately measured invasively through an arterial line. It is the gold standard by which the accuracy of other blood pressure measuring devices and methods are assessed. Chyun compared direct and indirect blood pressure readings in 14 intensive care unit patients and found that the auscultatory method overestimates the systolic and diastolic BP especially if the VI Korotkoff sounds is used as an indicator of diastolic BP. This can often over estimate reading by as much as 20 mm Hg. This study is made up of very small sample size to make general conclusion on the differences in BP values from the two methods compared. Although the invasive method is the gold standard for true BP measurement, it is associated with serious complications related to arterial catheterization and the procedure itself may be technically difficult. It is mainly used in experimental procedures and in monitoring critically ill patients in intensive care units.

2). Non invasive (indirect) methods. These are simpler and quicker than the invasive method and are commonly used for routine blood pressure examinations. They may however yield lower accuracy and small systematic differences in numerical results. These methods include-
a). **Palpation method** - A minimum systolic value can be estimated by palpation. Deakin and Low\(^4^5\) reported that a palpable radial, femoral or carotid pulse indicates a minimum systolic BP of 80, 70 and 60 mmHg respectively. The study was carried out among adults and these values could not be applicable in children and neonate whose maximum systolic BP may be lower than the reported minimum values. **A more accurate systolic BP value** can be determined by inflating and then deflating sphygmomanometer cuff while palpating the pulse. The systolic BP corresponds to the pressure at which the radial pulse becomes palpable.\(^4^5\) Its disadvantages are that pressure obtained is usually 2-5mmHg less than those obtained by auscultation and diastolic BP cannot be measured.\(^3^2\)

b). **Auscultation method** - Also called the Korotkoff method, is the method of choice in clinical practice.\(^1^,^4^2\) It involves using a stethoscope and a sphygmomanometer.\(^4^6\) The mercury sphygmomanometer is the gold standard for BP measurement. A Riva-Rocci cuff\(^2^7\) is placed over the arm and inflated to occlude the brachial artery. It is then gradually deflated until blood flow is re-established accompanied by a tapping sound which can be detected by the stethoscope held over the artery. Five sounds are traditionally heard and classified into phases.\(^3^0\) The first phase corresponds to the systolic BP while the last or fifth phase corresponds to the diastolic BP.\(^3^0\) The fourth phase alternatively, is used to measure the diastolic pressure if a 10 mmHg or greater differences exist between the initiation of phases four and five or if the fifth sound is heard down to 0 mmHg.\(^8\) This may occur in cases of high cardiac output or peripheral vasodilatation, children or in pregnancy. This method, though the method of choice in clinical practice; may however be associated with errors arising from faulty technique and equipment,\(^4^7,^4^8\) as well as observer bias.\(^4^9\) This method was used for this study because of its widespread general usage, its reliability and accuracy. Unlike other methods, the instruments, (mercury sphygmomanometer and stethoscope) do not require any
calibration and values obtained do not require validation by other methods. The standard World Health Organization/Center for Disease Control (WHO/CDC) blood pressure reference percentile tables were generated using the mercury sphygmomanometer, hence the auscultation method is the gold standard for BP evaluation.\textsuperscript{2,5,8}

The aneroid sphygmomanometer measures BP by mechanical system of metal bellows that expand as the cuff pressure increases in a series of levers that register the pressure on a circular scale. The hybrid sphygmomanometer combines some of the features of the two and uses an electric transducer to record blood pressure.\textsuperscript{2}

c) Oscillometric technique - This uses the oscillometric device. Oscillation of pressure in a sphygmomanometer cuff is recorded during gradual deflation. The point of maximum oscillation corresponds to the mean arterial pressure.\textsuperscript{50} The oscillation begins well above systolic BP and continues below diastolic BP, so that systolic and diastolic BP can only be estimated indirectly according to some empirically derived algorithm.

d) Ultrasound method - This uses an ultrasound transmitter and receiver placed over the brachial artery under a sphygmomanometer cuff. As the cuff is deflated, the movement of the arterial wall and systolic BP cause a Doppler phase shift in the reflected ultrasound. The diastolic BP is recorded as the point of diminished arterial motion.\textsuperscript{51} Its advantage includes the ability to detect diastolic BP in atrial fibrillation and hypotension where Korotkoff sound is faint.\textsuperscript{1,52}

\textbf{FACTORS AFFECTING BLOOD PRESSURE IN ADOLESCENTS}

Several inter-related factors affect blood pressure. These include-

**Age** - A progressive BP elevation with age has been observed in several studies.\textsuperscript{21,53-55} The rate of rise varies in boys and girls.\textsuperscript{54,55} The average systolic increase ranges between
1.66 and 2.86 mmHg/yr for boys and 1.44 and 2.63 mmHg/yr for girls, while that of diastolic BP ranges from 0.83 and 1.77 mmHg/yr for boys and 0.77 and 1.48 mmHg for girls. Bugaje, Yakubu and Ogala studied blood pressure pattern among 2035 adolescents in Zaria and found a consistent rise of BP with age. The rate of rise was fairly constant until 11-13 years in boys and 12-14 years in girls when the rise became rapid. A similar study also found a BP rise with age among 650 healthy school children in Jos. In a large population studies in Lebanon and Saudi Arabia, BP was similarly reported to increase consistently with age. Rapid growth and biological maturation of organs, which are normal occurrences during adolescence, were thought to be responsible rather than the chronological age. The results of these studies showed increasing blood pressure with age despite the fact that one study used oscillometric method for their study while the standard auscultation was used in the other studies. Also, the studied sample sizes across these studies varied greatly, with sizes of 650, 2035, 5710 and 16,226. Despite this, the findings were similar.

Gender - Results of studies on the effect of gender on BP showed that sex positively affects blood pressure. Merhi, Al-Hajj and Al-Tannir et al studied BP pattern in 5,710 Lebanese school children while Al-Salloum, El-Mouzan and Al-Herbish et al studied BP pattern in 16,226 Saudi children and adolescents. The authors reported a higher BP in girls than boys at all ages. A study of BP pattern in adolescents in Zaria, Nigeria, demonstrated an initial higher BP in boys before puberty which reversed with the onset of puberty up to the age of 14-15yrs when it reversed again to be higher in boys. Akinkugbe, Akinwolere and Kayode reported no sex differences in adolescent BP in Ibadan. The reported sex difference is said to be likely due to differences in sex hormone and pattern of growth in boys and girls. Differences in age range of the study population may however be responsible for the observed BP variation. For instance, these studies.
comprised of both adolescents and pre-adolescent age groups combined in one study while the other two studies\textsuperscript{21,56} were purely adolescents.\textsuperscript{21} Blood pressure is reported to be equal in both sexes before adolescence after which the gender difference starts to manifest most likely due to physical and hormonal changes.

**Socioeconomic Factors** - Belonging to either end of the socioeconomic strata is found to be associated with elevated blood pressure.\textsuperscript{58,59} A study in Ibadan\textsuperscript{56} reported an inverse relationship between parental socioeconomic status and level of BP in adolescents. The authors suggested that this might be the result of the health behaviours and problems characteristic of the lower socioeconomic class. On the other hand Ejike, Ugwu and Ezeanyika et al\textsuperscript{60} in Lokoja and another study\textsuperscript{53} in Jos both found higher BP in children from high socioeconomic class. Colhoun, Hemminway and Poulter\textsuperscript{61} in a meta-analysis of BP and socioeconomic status in developed and developing countries found an inverse relationship of BP with socioeconomic status in developed nations and a direct correlation in developing countries. These different findings may be due to methodological differences in socio-demographic stratification. For instance, Akinkugbe and colleagues\textsuperscript{59} used father’s level of education for social classification. Parent’s educational level may however not equate well with level of family income. The other study\textsuperscript{60} used an automated device for their study whose values may require validation using the recommended auscultation method. Difference in environmental stresses may also be different, considering the level of development of the areas where the studies were carried out.

**Genetic/Familial Factors** - The effect of genetic/familial factors on BP has been demonstrated in some studies.\textsuperscript{62-64} Familial/genetic correlations, reflected in BP and other anthropometry, generally are higher among genetically close relatives such as brother-sisters or parent-offspring than among spouses.\textsuperscript{62} Levshit and Gerber\textsuperscript{63} surveyed 514
individuals from 135 nuclear families in Russia, while Budaruddoza\textsuperscript{62} studied 1400 individuals from 380 families in India and found significant genetic influence on BP. Mijinyawa, Iliyasu and Borodo\textsuperscript{65} also reported family history of hypertension as risk factor for developing high BP in a study on prevalence of hypertension among 1000 teenagers in Kano. The authors concluded that this could be due to genetic predisposition. They however did not evaluate further to determine the genetic defects. The authors did not also consider shared environmental factors known to influence blood pressure in individuals. Molecular genetic studies have identified genes as possible regulators of BP.\textsuperscript{66,67} These genes regulate the renin-angiotensin-aldosterone system involved in renal salt handling.\textsuperscript{69} Mutations that increase sodium reabsorption and salt sensitivity is associated with higher BP and vice versa\textsuperscript{68} while shared environmental risk factors may potentiate the development of such familial conditions which might have been responsible for outcome of the above studies.\textsuperscript{63,64}

**Environmental Factors** – Environmental factors greatly influence BP variation in a population.\textsuperscript{59,22,69} Akinkugbe and Ojo\textsuperscript{70} reported a consistently higher BP in Nigerian adolescents than their counterparts of similar ages in black and white American children. The authors are of the view that this could be due to different environmental factors of the study population. Obika, Adedoyin and Olowoyeye\textsuperscript{22} studied BP pattern in 2,526 children aged 1-14 years in rural, semi-urban and urban communities in Ilorin, Nigeria and demonstrated a hypertension prevalence of 9.5% in urban compared to 6.3% in rural communities. This was similar to the study\textsuperscript{59} in Ghana and Gambia.\textsuperscript{69} The authors\textsuperscript{59,22,69} argued that the differences were due to socioeconomic status which is higher in the urban than the rural areas. The BP variation could be accounted for by the nature of dietary intake since the rural communities generally consume more of natural foods, with less salt and ‘junk foods’ compared to the urban populace. This was demonstrated by one study\textsuperscript{61}
which reported higher mean BP among urban communities in developing nations due to changes in their dietary pattern. Rural areas are also less exposed to the stress and hassle of the urban cities. It is of interest to note however, that urban areas are a mixture of social classes as a result of migrant workers seeking ‘greener pastures’. Okagua, Anochie and Akani\cite{71} on the other hand reported higher mean BP among rural adolescents than their urban counter parts in Port Harcourt. The authors could not identify the reason(s) for their finding but concluded that the seemingly protective privilege of rural life may be fading gradually. The differences in the reports could however result from the sample size composition, comprising of preadolescents,\cite{22} adolescents\cite{71} and adults.\cite{69}

**Race** - Higher BP levels have been reported in African-American and Hispanic school-age children than their Caucasian counterparts and among African-Americans than the Hispanics.\cite{72,73} Akinkugbe and Ojo\cite{70} demonstrated a consistently high systolic and diastolic BP in Nigerian children compared with black and white American children of similar age. Exposure to chronic environmental stress, low socioeconomic status and high obesity rate among African American and Hispanic youths could contribute to higher BP.\cite{72-74} It can be inferred from the study that race alone may not be responsible for the observed differences but shared environmental factors and socioeconomic status may be contributory.\cite{77} Other studies\cite{74,75} however found no significant BP differences in relation to race.

**Anthropometry and blood pressure (BP)** - A positive correlation has been observed between BP and anthropometry in various studies.\cite{58-59,77} These studies\cite{58,56,78} observed a significant correlation between systolic BP and weight, height and body mass index (BMI) in boys, but only with weight in girls. Body mass index (BMI) is used as a measure of overall obesity, but it is known to be a poor indicator of actual body fat.\cite{79} Waist circumference (WC) is an aggregate measurement of the actual amount of total and
abdominal fat accumulation.\textsuperscript{80} It is therefore a better predictor of BP and other cardiovascular diseases.\textsuperscript{80,81} Guagnano, Ballone and Colagrande et al\textsuperscript{81} studied the relationship between BP, and BMI, WC and waist hip ratio (WHR) in 461 people and found WC to be the most consistent anthropometry affecting BP. It is of interest to note that the study by Guagnano et al\textsuperscript{81} was in adults population while the other studies\textsuperscript{56-59} were in children and adolescents. WC was also found to be a better predictor of BP in an Italian study,\textsuperscript{80,81} while it was not in others.\textsuperscript{56-69,82} Comparing BMI and waist circumference and their effects on BP, Arauzo, Lopes and Moriera et al\textsuperscript{83} in Brazilian children found BMI to be a better predictor of BP than waist circumference. This was similar to the study by Sebanjo and Oshikoya\textsuperscript{82} in Nigerian adolescents in Akure. Thus, waist circumference measurements may not be useful in the evaluation of obesity and/or hypertension in children and adolescents. This may partly be explained by the uniform fat distribution due to hormonal effect at puberty in adolescents compared to the disproportionate fat distribution in adults. Possible mechanisms for the positive relationship between BP and high BMI includes decreased physical activity, increased salt intake, impaired pulmonary functions and development of metabolic abnormalities such as dyslipidaemia and insulin resistance.\textsuperscript{80,84}

**Nutritional factors** - Diet has been a primary link between humans and their environment and substantial evidence supports the concept that multiple dietary factors affect BP.\textsuperscript{85} Well-established dietary modifications that lower BP are reduced salt intake, increased potassium intake, increased protein particularly plant protein, high vegetable and polyunsaturated fats.\textsuperscript{85} High sodium intake on the other hand is said to be associated with elevated blood pressure.\textsuperscript{86} A series of 3 large, controlled feeding studies tested the effects of dietary patterns on BP.\textsuperscript{86-89} Of the 3 diets studied, the dietary approach to stop hypertension (DASH) emphasized fruits, vegetables, low-fat dairy products, whole
grains, poultry, fish, nuts, potassium, magnesium, calcium and fibre as the most effective diet. Among all participants, the DASH diet significantly lowered mean systolic BP by 5.5 mm Hg and mean diastolic BP by 3.0 mm Hg, each net of changes in the control diet.

**DEFINITION AND CLASSIFICATION OF ADOLESCENCE**

Adolescence is the transitional stage between childhood and adulthood during which many life patterns are learnt and established. According to World Health Organization (WHO), adolescents are individuals between the age range of 10-19 years. The most significant feature of adolescence is puberty, characterized by an exceptionally rapid rate of biological growth and development including physical and sexual maturation. The pubertal changes have been described by Tanner and Marshal and are grouped into five stages. This utilizes definite criteria for growth and development of secondary sexual characteristics like pubic hair and breast in females and pubic hair and genitalia in males. The timing of these events and the rate of growth vary, due to genetic and environmental factors in different populations. Adolescence is divided into early, middle and late periods.

Early adolescence (10-13 years) – This is a period of rapid growth and development of secondary sexual characteristics and varies according to sex. It corresponds to Tanner stages 1 and 2. The main features of this stage are breast bud development and menarche in girls, while testicular enlargement and seminal emission occurs in boys.

Middle adolescence (14-16 years) – In this stage, rapid growth decreases and there is more cognitive development as the adolescents move from concrete thinking to formal operation and develop greater competence at abstract thinking. This corresponds to Tanner stages 3 and 4.

Late adolescence (17-19 years) – Here, slowing of physical changes continue, which permits the emergence of a more stable body image. Cognition tends to be less self-centered with
demonstration of care for others with increasing thought about concepts such as justice, patriotism and history. It corresponds to Tanner stage 5.60,92

ADOLESCENCE AND BLOOD PRESSURE

Adolescence is characteristically associated with increasing blood pressure because of the physical growth and hormonal changes associated with puberty.57,94 After the age of one year, normal BP increases more during puberty than probably at any other time in an individual’s lifetime.95 Wanzhu, Eckert and Saha et al57 examined data from a cohort of 182 normotensive children in Indiana who had blood pressure measurements taken semi-annually for up to 12 yr. The authors found that the rate of change in BP and weight peaked at the age of maximum pubertal growth spurt (PGS). This BP spurt roughly coincides with growth spurt during puberty.94 Surveys of BP patterns from childhood through adolescence shows systolic and diastolic pressures increase with age, and in adolescents the increase in males is more marked than in females, especially the systolic pressure.54,58,22,94,95

CLASSIFICATION OF BLOOD PRESSURE IN ADOLESCENTS

The National High Blood Pressure Education Program Working Group (NHBPEPWG) of the United States established guidelines for the definition of normal and elevated blood pressures in children in 1987.6 These guidelines were revised in 2004.8 The definition of childhood hypertension in the guidelines are based upon the normative distribution of blood pressure (BP) in healthy children rather than clinical outcome data as in adults. The guidelines classified BP as normal, prehypertensive or hypertensive. Hypertension is graded into stage one and two.8

Normal BP - Blood pressure <90th percentile for age, sex and height. Children and adolescents with normal BP should be followed annually from the age of 3 years.5 They
should be encouraged to maintain a healthy life style such as good dietary intake, physical activities and adequate rest.\textsuperscript{8}

Pre-hypertension - Blood pressure between the 90\textsuperscript{th} and < 95\textsuperscript{th} or if BP exceeds 120/80mmHg (even if <90\textsuperscript{th} percentile) but <95\textsuperscript{th}. It was previously called high normal BP. This new description was introduced to help identify children at risk for the development of persistent hypertension for whom targeted prevention programmes would be most beneficial.\textsuperscript{96} While recommendations for the diagnosis of hypertension in children require that BP remains elevated on three separate occasions, repeated measurements are not necessary to classify an adolescent as pre-hypertensive.\textsuperscript{11} The prevalence of childhood/adolescence pre-hypertension in US is reported to be between 12-17\%.\textsuperscript{96-98} In Nigeria, Ejeke, Ugwu and Ezeanyika\textsuperscript{99} in a study of the prevalence of point prehypertension and hypertension in 843 adolescents in Lokoja reported a prevalence of point prehypertension of 22.2\% and 25.0\% in semi urban and urban communities respectively. Ujunwa, Ikefuna and Nwokocha et al\textsuperscript{100} reported 17.5\% prehypertension prevalence among adolescents in Enugu. Among adults with prehypertension, it is reported that as much as 10\% per year develop hypertension.\textsuperscript{101} There is little information on the time course for children and adolescents with prehypertension developing hypertension. A value of between 1.1-7\% per year has been reported in US adolescents.\textsuperscript{98} There is no known study on rate of progression of prehypertension to hypertension in Nigerian adolescents. The NHBPEP recommended that children with pre-hypertension should have their BP checked after every six (6) months to monitor for progression to hypertension. They should be encouraged to engage in physical activity, healthy dietary behaviours and weight management if overweight. Pharmacologic therapy is not indicated except if there is strong evidence of renal disease, heart failure, left ventricular hypertrophiy or diabetes mellitus.\textsuperscript{8}
Hypertension: Hypertension is BP persistently equal to or above the 95th percentile for age, sex and height measured on three or more separate occasions. If the blood pressure measurement obtained is > 95th percentile, the degree of hypertension should be staged.

Stage 1 hypertension: BP value between the 95th and the 99th percentile plus 5mmHg. It is recommended that BP should be rechecked in 1–2 wks or sooner if the patient is symptomatic. If persistently elevated on 2 additional occasions, it should be evaluated or referred to source of care for pharmacologic treatment within 1 month.  

Stage 2 hypertension: BP value >99th percentile plus 5mmHg. This stage calls for more prompt evaluation and commencement of pharmacologic therapy. It is recommended that the individual be evaluated or referred to source of care within 1 wk or immediately if the patient is symptomatic.

Aetiology of hypertension

Hypertension is classified as primary (essential), when there is no identifiable cause or secondary if due to an underlying disease. Factors such as heredity, diet, stress, drugs and obesity play a role in the development of essential hypertension. Causes of secondary hypertension include umbilical artery catheterization, renal diseases, coarctation of the aorta and endocrine disorders. Aderede and Sereki, in their study of hypertension in children, reported hypertension secondary to renal pathology as the commonest cause of elevated BP in children. This study was mainly in preadolescent population in which secondary hypertension is a common finding. On the other hand, Antia-Obong and Antia-Obong reported no apparent cause in greater than 90% of the studied subjects with elevated BP and also reported proteinuria of 1% in the same population without any associated elevated blood pressure. The study did not however evaluate the etiology of the proteinuria. A study of BP in teenagers in Kano found family history of hypertension a risk factor in the study population. Another study in Enugu examined modifiable risk factors associated with
hypertension in 2694 adolescents and found only 1% and 0.6% of the hypertensive subjects to be overweight and obese respectively. The authors also found that smoking and alcohol consumption were not significant risk for hypertension. This may however be due to the shorter period of consumption of these products by the students, as a cumulative effect from long term consumption is known to be associated with adverse health outcomes.

Prevalence of hypertension in adolescents

The prevalence of hypertension in adolescents varies widely due to arbitrary and imprecise definition by different researchers. It was in view of this that the National High Blood Pressure Education Program Working Group (NHBPEPWG) of the United States established guidelines for the definition of normal and elevated blood pressures in children and adolescents for uniformity.\textsuperscript{6,8} In the USA, the prevalence is about 20\% in normal weight and 50\% in their obese counterparts.\textsuperscript{108} A prevalence rate of 7.7\%,\textsuperscript{109} 10.5\%\textsuperscript{54} and 22.3\%\textsuperscript{110} has been reported in Spain, Lebanon and South Africa respectively. In Kano, Nigeria, a study\textsuperscript{65} on the prevalence of hypertension among 1000 teenagers found a prevalence of 7.2\%. Similar study in Enugu\textsuperscript{100} on the prevalence of hypertension among 2694 secondary school adolescents reported a hypertension prevalence of 5.4\%. It is of interest to note that different prevalence was reported because of the different methodology used by the authors. While the study in Kano\textsuperscript{65} applied the adult blood pressure criterion of BP greater than 140/90mmHg as hypertension, the study in Enugu\textsuperscript{100} used blood pressure greater than 95\textsuperscript{th} percentile for age and sex. Also, the study in Kano\textsuperscript{65} took a single set of measurement while the study\textsuperscript{100} in Enugu measured blood pressure of the subject three times at weekly intervals. Bugaje, Yakubu and Ogala,\textsuperscript{21} on the other hand, defined hypertension as blood pressure greater than two standard deviations from the mean, and also took six readings over thirty minutes and got a prevalence of hypertension of 3.4\%. A prevalence rate of 4.8\%\textsuperscript{107} and 9.5\%\textsuperscript{22} in Southern and Western region of the Nigeria respectively was also reported. It is obvious that, because
of the various defining criteria for hypertension in adolescents, the prevalence of adolescent hypertension remains imprecise.

**Clinical presentation** - Hypertension is usually asymptomatic unless it has been sustained or is rising rapidly. Adolescents with essential hypertension are usually detected during routine evaluation. Non-specific symptoms such as lethargy, headache, dizziness, drowsiness, visual disturbance and confusion may be present. These could also be signs of complications. Secondary hypertension may show obvious features of the underlying disease such as growth failure, heat intolerance, abdominal stria, tremors, body swelling and haematuria. Croix and Feig studied the spectrum of symptoms in 409 children aged 7-18 years newly diagnosed hypertensive in Texas, USA and reported 15 common symptoms than in the controls. The symptoms were said to resolve after commencement of antihypertensive medications. The authors concluded that hypertensive children had a variety of non-specific symptoms. The three most common symptoms reported were headache, daytime tiredness and difficulty initiating sleep. The study however, did not specify if other possible causes of these symptoms were excluded.

**Complications of hypertension** - Hypertension is usually asymptomatic in adolescents, which if left unidentified overtime, can cause serious complications. Organs commonly affected in the complication of hypertension are the heart, kidneys, brain and the eyes leading to lowered life expectancy and premature death. Left ventricular hypertrophy (LVH) is the most prominent clinical evidence of end organ damage. Studies have shown that LVH can be seen in as many as 41% of patients, even in adolescents with asymptomatic hypertension. Adolescents with severe cases of hypertension are also at increased risk of developing hypertensive encephalopathy, seizures, cerebrovascular accidents, and congestive heart failure. However, data documenting such complications in children and adolescents are generally lacking. In a study of
hypertension among teenagers in Kano, the researchers\textsuperscript{65} could not find any complications in all the 1000 teenagers studied.

**Investigations and treatment** - Basic investigations are all that may be required in adolescents who are obese and with a family history of hypertension, stage 1 disease and normal findings on physical examination.\textsuperscript{113} This is because primary hypertension is commoner in adolescents. Adolescents that are symptomatic or with stage 2 hypertension or have features of secondary hypertension should be evaluated in more detail.

Treatment of hypertension includes non-pharmacological and pharmacological methods. Non-pharmacologic management involves life style modification such as weight reduction, increased physical activities and dietary adjustment.\textsuperscript{114} In a study to evaluate the effect of diet and salt on treatment and prevention of hypertension, Sacks, Svetkey and Vollmer et al\textsuperscript{86} reported the beneficial effect of both reduced salt intake and appropriate dietary adjustment in the control of hypertension. Similar benefits were reported in other studies.\textsuperscript{87,88} Although both studies had fairly good sample size (n=412), the studies did not specify if participants were on other substances or activities other than antihypertensive that might have affected their BP. The studies were also in adults and whether it has the same effects in children and adolescents has not been evaluation. However, there is no doubt, that the outcome will be similar in adolescents as dietary modifications have been advocated as non-pharmacologic management in them. Non pharmacologic treatment is usually the initial treatment in essential hypertension and as adjuvant to drug therapy in those with secondary or complicated hypertension.\textsuperscript{101,114} Pharmacologic (drug) treatment includes diuretics, beta-blockers, calcium channel blockers, angiotensin converting enzyme inhibitors (ACEIs) and angiotensin receptor blockers (ARB) among others.\textsuperscript{106,114} They are used in those with symptomatic disease and in acute or chronic complications.\textsuperscript{106}
Prevention of hypertension may be viewed as part of the prevention of cardiovascular disease. In adolescents, approaches to prevention include reduction in obesity, discouraging cigarette smoking and alcohol intake, reduction in sodium intake and increase in physical activity through community and school-based programmes. Growth monitoring, BP check during preventive care visit, physical activity and urine screening for proteinuria and haematuria can be used starting from early childhood.
AIM AND OBJECTIVES

GENERAL AIM
To determine the blood pressure pattern of apparently healthy secondary school adolescents in Jalingo, Taraba State.

SPECIFIC OBJECTIVES
To determine:

2. The relationship, if any, between blood pressure and the anthropometric parameters of weight, height, BMI and waist circumference.
3. The association between blood pressure and parental social-economic status.
4. The point prevalence of prehypertension and hypertension in adolescents.
MATERIALS AND METHODS

Study area.

A cross-sectional survey of the blood pressure pattern of apparently healthy secondary school adolescents aged 10-19 years was conducted in Jalingo over a six month period, from January to June 2014. Jalingo is the capital of Taraba State, and lies within the savannah belt of North Eastern Nigeria. It lies between latitude 8° 54’ north and longitude 11° 21’ east and at an altitude of 360 meters above sea level. Jalingo had a population of 118,198 people. The primary inhabitants are the Konas, Mumuyes and Fulanis who are mostly farmers. Other indigenous ethnic groups include the Jukun, Kuteb, Wurkum, Tiv and host of other tribes. The Ibos, Hausas, Yorubas among others are the non-indigenous ethnic groups and are mostly civil servants and businessmen. Jalingo has a tertiary health centre, the Federal Medical Centre Jalingo and the state specialist hospital. It also has 15 private clinics/hospital and many primary health care centres. There are also tertiary education institutions including Taraba State University. As at 2013, there were 56 secondary schools in Jalingo, 24 public and 32 private, all of which were mixed schools except one which is a girls’ only school.

Study design

The study was a cross sectional descriptive study of 1350 apparently healthy secondary school adolescents in Jalingo.

Ethical approval

Ethical approval for this study was obtained from the Scientific and Health Ethics Research Committee of Ahmadu Bello University Teaching Hospital Zaria (Appendix 4). The Taraba State Ministry of Education also gave the approval and permission to conduct the study in the
selected schools. Consent was given by the students’ parents or guardian (Appendix 2). All students whose parents gave consent voluntarily participated in the study.

Sample size determination

The minimum sample size was calculated using the formula:116

\[ N = \frac{Z^2 (pq)}{E^2} \]

Where \( N \) = minimum sample size

\( p \) = Prevalence of hypertension in adolescents. A prevalence of 3.4%21 was used.

\( q = 1 - p \)

\( E \) = margin of error tolerated = 1%

\( Z = 1.96 \) at 95% confidence level

\[ N = 1.96^2 \times 0.034 \times (1-0.034) / 0.01^2 = 1262 \]

Therefore the minimum sample size was one thousand two hundred and sixty two.

Allowance for non-responders of 5%, 63 extra subjects were added to the calculated minimum sample size, bringing the total to 1325 students. To enhance representativeness of the sample and to compensate for missing information and poorly filled proforma, while maintaining the sample size, a total of 1350 was decided upon.

Inclusion criteria

1. Students (ages 10-19 years) in the selected secondary schools
2. Students whose parents gave consent to participate in the study
3. Students who gave assent to participate in the study

Exclusion criteria

1. Students who had obvious skeletal deformities of the spine and legs which can affect the height and ultimately the BMI
2. Students with known chronic disease (or history of such disease) like anaemia, chronic renal disease and cardiac disease because they are not apparently healthy and these conditions could affect their blood pressure.

3. Students with present or past history of chronic drug ingestion that can affect blood pressure such as steroids and contraceptives.

4. Students with high blood pressure already on antihypertensive

Pilot study

A pilot study was carried out in one of the schools a week before the commencement of the study. The school was selected by random sampling method using balloting and did not participate in the main study. The pilot study was carried out with the aim of assessing the competence of the research assistants in the various measurements following their training to ensure reliability. It was also used to test the questionnaire before its use during the main study and to provide information on the number of students that can be measured in a day. Consequently, twenty students had their blood pressure and anthropometry measured independently by the researcher and the research assistants, and data were compared using Students t-test. There were no statistically significant differences between the measurements. The result of the pilot study is highlighted in Table I. It was also found that some parts of the questionnaire were not well understood by most students and were adjusted appropriately in the main study (Appendix 1). The 20 students had their measurements done over a period of 3-4 hours (between 8am - 12noon) by the researcher and the research assistants.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Researcher</th>
<th>Research</th>
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Table I. Result of pilot study
<table>
<thead>
<tr>
<th></th>
<th>Mean (±SD) SBP</th>
<th>Mean (±SD) DBP</th>
<th>Mean (±SD) Weight</th>
<th>Mean (±SD) Height m</th>
<th>Mean (±SD) BMI</th>
<th>Mean (±SD) WC cm</th>
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<tr>
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<td>104(12)</td>
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<td>0.716</td>
<td>0.769</td>
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</table>

**Sampling method**

Students were selected by multistage random sampling technique. The list of secondary schools obtained from the Taraba State Post Primary Schools Board served as the sampling frame for schools. There were 56 secondary schools, 24 of which were public and 32 were private schools, a ratio of 1:1.3. Ten (10) schools were randomly selected by balloting, four (4) from public schools six (6) from private, based on the number and approximately similar ratio of private to public schools of 1:1.5 (4:6). Ten schools were selected to ensure wider coverage and even distribution of students so that it could be truly representative of the community. All the ten schools had an overall total of eight thousand, one hundred and seven (8107) students. The public schools had a total of five thousand, nine hundred and forty (5940) with nine hundred and eighty nine (989) students participating. The private schools had a total of two thousand, one hundred and sixty-seven (2167) students with three hundred and sixty one (361) participating. These number (989 and 361) was calculated based on the
relative population of each school and proportionate to number of students in each school. Thereafter, the number of students to participate per school was calculated proportionately to the number of students in each school based on the number given by the school authority. Then the number in each class was also calculated proportionately from JSS1 to SS3 to ensure fair and equal chance of participation for all age groups. The calculation was done thus: \[ n = \frac{a}{b} \times c \]

Where: 
- \( n \) = number of students per selected school 
- \( a \) = total number/population of students in the school 
- \( b \) = total number/population of students in all 10 selected schools (8107) 
- \( c \) = calculated total sample size (1350)

Students in each class, from junior secondary school (JSS) 1-3 and senior secondary school (SS) 1-3, were then randomly selected by balloting. The number of selected schools, total number of students in a school and the number of students selected per school is outlined in Table II.

---

Table II. Selected schools and number of students in each of the ten schools in Jalingo

<table>
<thead>
<tr>
<th>Selected schools</th>
<th>Total no of students</th>
<th>No. of students</th>
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</table>
The study

The first contact with the students was a familiarization exercise to each of the schools during which the teachers and students were given a talk by the researcher on blood pressure and the...
importance of periodic blood pressure measurement. They were given the opportunity to ask questions which were responded to. Both the students and their teachers actively participated in the lectures.

On the second day, students were selected as described above and those selected underwent general physical examination in the presence of a chaperon to identify those who did not fulfilled the inclusion criteria. Each selected student was given a proforma (Appendix 1) in which information on their biodata, and medical history were recorded. Other information obtained was parent’s medical history and their socioeconomic status using the format described by Olusanya, Okpere and Ezimokhai\textsuperscript{117} (Appendix 3). The study was carried out in a relatively quiet and empty classroom to ensure privacy for both male and female students. The procedure for blood pressure measurement was demonstrated on one of the research assistants and sometimes on one of the teachers by the researcher to assure the students and allay their anxiety. BP and anthropometric values obtained were recorded in the study proforma. An average of 15-20 students per day were attended to over a period of 3-4 hours (between 8am - 12noon daily) by the researcher, one of the research assistants who is a medical officer, a male nurse and a lady Youth Corper (NYSC)

\textbf{Blood pressure measurement}

This was measured by the researcher and the research assistant (the medical officer). The standard auscultation method was employed using a mercury sphygmomanometer (Acosson) and a standard Littman stethoscope according to the guideline of the fourth report on the diagnosis, evaluation and treatment of hypertension in children and adolescents.\textsuperscript{8} Each student was rest-seated for 5 minutes before BP measurement. With the student seated, the right arm rested on a table at the level of the heart, an appropriate cuff size which covered
two-third (2/3rd) of the length of the arm was applied round the arm about 2cm above the antecubital fossa. Two cuff sizes were used for this study with dimensions of 10 x 24cm and 13 x 30cm, the smaller cuff for the smaller adolescents and vice versa. The bladder cuff was inflated rapidly to 20-30mmHg above the point where the brachial artery was no longer palpable. The bell of the stethoscope was then placed over the brachial artery and the cuff was deflated slowly at 2-5mmHg/second while listening to the Korotkoff sounds. Phases one and five of the Korotkoff sounds were recorded as the systolic and diastolic BP respectively. Three recordings were taken at intervals of 3-5 minutes and the average was the final BP in mmHg. BP was interpreted based on the standard set by the fourth report on the diagnosis, evaluation and treatment of hypertension in children and adolescents of the United States thus:–

Normal BP – BP value between the 5th and < 90th percentile for age, sex and height.

Prehypertension - BP value between the 90th and the <95th percentile for age, sex and height or BP of 120/80mmHg but less than the 95th percentile.

Hypertension – BP value ≥95th percentile for age, sex and height.

Students found to have prehypertension were educated and counseled on life style modifications and the need to have their blood pressure checked in six months’ time and annually subsequently. Those with hypertension were educated on the implications of the findings and were referred to the Federal Medical Center Jalingo for evaluation, management and follow-up.

**Height measurement**

Height was measured in centimeters using a locally constructed stadiometer by the research assistants. Each student was measured barefooted, standing with the heel, back and occiput
against the stadiometre. The head was held straight looking forward with the lower border of the eye socket at a horizontal plane with that of the external auditory meatus. The movable part of the stadiometre was adjusted to rest on the vertex and the corresponding value read to the nearest 0.1cm.

**Weight measurement**

The weight was measured in kilograms by the researcher and the research assistants using a bathroom scale (HANSON). Students were weighed in their approved school uniform, without caps, head ties or cardigan and with their shoes removed. The scale was checked daily for accuracy using standard calibrated weight before and midway through each session. The weight of the student was measured to the nearest 0.1 kg.

**Body mass index (BMI)**

This was calculated from the measured weight and height of the subject using the formula:\(^{118}\)

\[
\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m}^2\text{)}}
\]

**Waist circumference measurement**

WC was measured in centimeters using a measuring tape by the research assistants. The male assistant measured for boys and the lady Youth Corper measured for girls. Measurement was taken with the student standing, completely relax and breathing normally. Clothing was pulled up or down and an inelastic measuring tape was placed around the waist mid-way between the iliac crest and the lowest rib margin. The ends of the tape were pulled together lightly towards each other and the value read to the nearest 0.1cm.\(^{117,120}\)
Data analysis

Data obtained were analyzed using Epi-Info statistical software package version 7. The results obtained were presented in figures, tables, graphs and charts as appropriate. Individual mean BP levels were used as dependent variables and other measured variables as independent variables. The means and standard deviations were used to summarize quantitative variables such as BP, weight, height, waist circumference and BMI. The chi-squared test was used to test the significance of associations between categorical variables. Student’s t-test was used to compare means of any two normally distributed continuous variables. Pearson’s correlation coefficient and regression analysis were used to examine the strength of association between BP and the anthropometries. Probability level of statistical significance value was set at <0.05.

RESULTS

General characteristics

A total of 1350 students were enrolled between January and June 2014 to determine their blood pressure pattern, 628 (46.5%) were males and 722 (53.5%) were females, with male:female ratio of 1:1.1. Students enrolled in the study were drawn from both public and
private schools. The number of students from public schools was 989 (73.3%) while 361 (26.7%) were from private schools as shown in Table II. The mean age of the study subjects was 15.3±2.2 years with a range of 10-19 years. The age and sex distribution of the students is illustrated in Table III.

<table>
<thead>
<tr>
<th>Age</th>
<th>Male N (%)</th>
<th>Female N (%)</th>
<th>Total N(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>9 (1.4)</td>
<td>13 (1.8)</td>
<td>22 (1.6)</td>
</tr>
<tr>
<td>11</td>
<td>20 (3.2)</td>
<td>31 (4.3)</td>
<td>51 (3.8)</td>
</tr>
<tr>
<td>12</td>
<td>36 (5.7)</td>
<td>52 (7.2)</td>
<td>88 (6.5)</td>
</tr>
<tr>
<td>13</td>
<td>96 (15.3)</td>
<td>85 (11.8)</td>
<td>181 (13.4)</td>
</tr>
<tr>
<td>14</td>
<td>92 (14.6)</td>
<td>115 (15.8)</td>
<td>207 (15.3)</td>
</tr>
<tr>
<td>15</td>
<td>92 (14.6)</td>
<td>111 (15.4)</td>
<td>203 (15.1)</td>
</tr>
<tr>
<td>16</td>
<td>66 (10.5)</td>
<td>116 (16.1)</td>
<td>182 (13.5)</td>
</tr>
<tr>
<td>17</td>
<td>78 (12.5)</td>
<td>91 (12.6)</td>
<td>169 (12.5)</td>
</tr>
<tr>
<td>18</td>
<td>79 (12.6)</td>
<td>70 (9.7)</td>
<td>149 (11.0)</td>
</tr>
<tr>
<td>19</td>
<td>60 (9.6)</td>
<td>38 (5.3)</td>
<td>98 (7.3)</td>
</tr>
<tr>
<td>Total</td>
<td>628 (100)</td>
<td>722 (100)</td>
<td>1350 (100)</td>
</tr>
</tbody>
</table>

Table III. Age and sex distribution of 1350 study subjects in Jalingo
Socio-economic classes (SEC) – Most of the students were from the lower social classes (4 and 5) with population of 650 (415 and 235) students. The upper social classes (1 and 2) had the least population with 184 (62 and 122) students. The middle social class (3) had 516 students. The distribution of the study subjects according to individual socioeconomic class is shown in Figure I.

![Pie chart showing the distribution of students by socioeconomic class](image)

**Figure 1. Socioeconomic class distribution of students in Jalingo**

**Anthropometry**

The anthropometric characteristics of the students are displayed in Tables IV, V and VI. All the anthropometric parameters showed increasing values with age (Tables V and VI). There were significant differences in the anthropometric indices of height (p=0.000), weight (p=0.010) and body mass index (p=0.000) between boys and girls but not statistically significant for waist circumference (p=0.145) as shown in Table IV.

Weight – The mean weight of the students was 48.6±10.9kg with a range of 23-100kg (Table IV). Girls were heavier than boys up to middle adolescence after which males
were heavier than the females (Table V and VI) and this was statistically significant (t= -2.56, p=0.010)

Table IV. Overall mean anthropometric measurements of the study subjects

<table>
<thead>
<tr>
<th>Anthropometry</th>
<th>Male (n=628)</th>
<th>Female (n=722)</th>
<th>Total (N=1350)</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean(±SD)</td>
<td>47.73(11.5)</td>
<td>49.26(10.3)</td>
<td>48.55(±10.9)</td>
<td>-</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>)</td>
<td>)</td>
<td>)</td>
<td>2.5</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>23.6-84.8</td>
<td>22.7-100</td>
<td>23-100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ht (m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean(±SD)</td>
<td>1.59(0.12)</td>
<td>1.57(0.08)</td>
<td>1.58(±0.10)</td>
<td>3.5</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>)</td>
<td>)</td>
<td>)</td>
<td>5</td>
<td>*</td>
</tr>
<tr>
<td>Range</td>
<td>1.22-1.85</td>
<td>1.26-1.79</td>
<td>1.22-1.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WC (cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean(±SD)</td>
<td>65.24(9.1)</td>
<td>65.95(8.6)</td>
<td>65.62(±8.9)</td>
<td>-</td>
<td>0.145</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>22.5-90.5</td>
<td>21.5-100</td>
<td>22-100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Height**- The mean height of the study population was 1.58±0.9m and ranged from 1.22-1.85m (Table IV). Girls were taller than boys at early and middle adolescence but these reversed from 16 years in favour of the boys (Table V and VI). This differences was statistically significant (t=4.48, p=0.000)

**Waist circumference (WC)** - The overall mean waist circumference was 65.62±8.9cm and a range of 22.5-100cm. Girls had higher WC until late adolescence (18 years) when it reversed but this was not statistically significant (t=1.46, p=0.145). This is displayed in Tables IV, V and VI.

**Body Mass Index (BMI)** - Overall mean BMI was 18.9±3.1 with a range of 11.4-42. There was a statistically significant difference between girls and boys (t=-7.41, p=0.000). Tables IV, V and VI illustrate this findings.

### Table V. Mean anthropometric measurements of 628 boys

<table>
<thead>
<tr>
<th>Age</th>
<th>No of students</th>
<th>Wt(±SD) Kg</th>
<th>Ht(±SD) m</th>
<th>WC(±SD) cm</th>
<th>BMI(±SD) Kg/m²</th>
</tr>
</thead>
</table>

*Statistically significant p values at 0.05 level of significance. Wt=Weight, Ht=Height, WC=Waist Circumference, BMI=Body Mass Index, SD=Standard Deviation
<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>9</td>
<td>34.9(5.0)</td>
<td>1.43(0.01)</td>
<td>61.3(0.6)</td>
<td>16.9(0.1)</td>
</tr>
<tr>
<td>11</td>
<td>20</td>
<td>35.4(2.5)</td>
<td>1.43(0.02)</td>
<td>61.7(1.3)</td>
<td>17.0(0.7)</td>
</tr>
<tr>
<td>12</td>
<td>36</td>
<td>36.3(5.1)</td>
<td>1.46(0.02)</td>
<td>61.6(1.4)</td>
<td>16.7(0.6)</td>
</tr>
<tr>
<td>13</td>
<td>96</td>
<td>37.9(5.1)</td>
<td>1.50(0.03)</td>
<td>60.2(4.0)</td>
<td>16.5(0.8)</td>
</tr>
<tr>
<td>14</td>
<td>92</td>
<td>41.2(5.0)</td>
<td>1.54(0.03)</td>
<td>62.3(3.2)</td>
<td>16.9(0.8)</td>
</tr>
<tr>
<td>15</td>
<td>92</td>
<td>47.1(6.0)</td>
<td>1.60(0.03)</td>
<td>63.4(3.9)</td>
<td>17.8(0.8)</td>
</tr>
<tr>
<td>16</td>
<td>66</td>
<td>52.5(5.2)</td>
<td>1.64(0.02)</td>
<td>67.2(2.4)</td>
<td>19.2(0.9)</td>
</tr>
<tr>
<td>17</td>
<td>78</td>
<td>55.5(5.1)</td>
<td>1.67(0.02)</td>
<td>68.0(3.1)</td>
<td>19.7(0.8)</td>
</tr>
<tr>
<td>18</td>
<td>79</td>
<td>57.6(6.1)</td>
<td>1.69(0.02)</td>
<td>70.7(1.8)</td>
<td>20.0(0.8)</td>
</tr>
<tr>
<td>19</td>
<td>60</td>
<td>59.0(5.7)</td>
<td>1.70(0.02)</td>
<td>71.6(1.6)</td>
<td>20.3(0.7)</td>
</tr>
<tr>
<td>Total</td>
<td>628</td>
<td>47.7(11.5)</td>
<td>1.6(0.1)</td>
<td>65.2(9.1)</td>
<td>18.3(2.7)</td>
</tr>
</tbody>
</table>
Table VI. Mean anthropometric measurements of 722 girls

<table>
<thead>
<tr>
<th>Age</th>
<th>No of students</th>
<th>Wt(±SD) Kg</th>
<th>Ht(±SD) m</th>
<th>WC(±SD) cm</th>
<th>BMI(±SD) Kg/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>13</td>
<td>31.3(3.4)</td>
<td>1.39(0.01)</td>
<td>58.2(0.5)</td>
<td>15.6(0.2)</td>
</tr>
<tr>
<td>11</td>
<td>31</td>
<td>36.1(5.3)</td>
<td>1.44(0.02)</td>
<td>61.1(1.2)</td>
<td>17.0(0.5)</td>
</tr>
<tr>
<td>12</td>
<td>52</td>
<td>40.3(6.4)</td>
<td>1.49(0.02)</td>
<td>62.5(2.1)</td>
<td>17.8(0.9)</td>
</tr>
<tr>
<td>13</td>
<td>85</td>
<td>45.8(6.6)</td>
<td>1.54(0.02)</td>
<td>65.7(2.2)</td>
<td>18.8(1.2)</td>
</tr>
<tr>
<td>14</td>
<td>115</td>
<td>47.8(7.4)</td>
<td>1.57(0.03)</td>
<td>62.7(4.8)</td>
<td>18.7(1.0)</td>
</tr>
<tr>
<td>15</td>
<td>111</td>
<td>50.8(6.5)</td>
<td>1.59(0.02)</td>
<td>66.6(3.4)</td>
<td>19.9(1.3)</td>
</tr>
<tr>
<td>16</td>
<td>116</td>
<td>52.1(6.0)</td>
<td>1.59(0.02)</td>
<td>67.8(2.8)</td>
<td>20.1(1.1)</td>
</tr>
<tr>
<td>17</td>
<td>91</td>
<td>54.1(6.2)</td>
<td>1.61(0.02)</td>
<td>68.1(2.8)</td>
<td>20.3(1.1)</td>
</tr>
<tr>
<td>18</td>
<td>70</td>
<td>55.6(6.3)</td>
<td>1.61(0.02)</td>
<td>69.6(2.1)</td>
<td>21.1(1.1)</td>
</tr>
<tr>
<td>19</td>
<td>38</td>
<td>54.0(4.8)</td>
<td>1.58(0.02)</td>
<td>68.8(1.4)</td>
<td>20.8(0.6)</td>
</tr>
<tr>
<td>Total</td>
<td>722</td>
<td>49.3(10.3)</td>
<td>1.6(0.10)</td>
<td>65.1(2.3)</td>
<td>19.0(0.9)</td>
</tr>
</tbody>
</table>

Wt=Weight, Ht=Height, WC=Waist circumference, BMI=Body Mass Index, SD=Standard Deviation

Blood pressure (BP) measurements
Table VII shows mean blood pressure distribution of the study population for all ages.

The highest SBP and DBP were 165mmHg and 95mmHg at 18 years and 15 years respectively. Table VIII displays mean BP distribution in relation to age and sex. The tables show that both systolic and diastolic blood pressure increased with age. This is also depicted in Figure 2.

<table>
<thead>
<tr>
<th>Age</th>
<th>No of students</th>
<th>Systolic Blood Pressure (mmHg)</th>
<th>Diastolic Blood Pressure (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean(±SD)</td>
<td>Range</td>
</tr>
<tr>
<td>10</td>
<td>22</td>
<td>93.6(7.4)</td>
<td>80-107</td>
</tr>
<tr>
<td>11</td>
<td>51</td>
<td>99.2(10.6)</td>
<td>76-120</td>
</tr>
<tr>
<td>12</td>
<td>88</td>
<td>103.6(11.0)</td>
<td>80-140</td>
</tr>
<tr>
<td>13</td>
<td>181</td>
<td>104.2(10.8)</td>
<td>80-143</td>
</tr>
<tr>
<td>14</td>
<td>207</td>
<td>107.0(11.5)</td>
<td>83-150</td>
</tr>
<tr>
<td>15</td>
<td>203</td>
<td>109.0(11.9)</td>
<td>80-150</td>
</tr>
<tr>
<td>16</td>
<td>182</td>
<td>112.2(12.4)</td>
<td>80-150</td>
</tr>
<tr>
<td>Age</td>
<td>Male</td>
<td>Female</td>
<td>Systolic BP (mmHg)</td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
<td>--------</td>
<td>-------------------</td>
</tr>
<tr>
<td>17</td>
<td>169</td>
<td>108.9(12.5)</td>
<td>90-165</td>
</tr>
<tr>
<td>18</td>
<td>149</td>
<td>113.8(12.1)</td>
<td>90-165</td>
</tr>
<tr>
<td>19</td>
<td>98</td>
<td>113.1(12.7)</td>
<td>90-143</td>
</tr>
<tr>
<td>Total</td>
<td>1350</td>
<td>108.9(12.5)</td>
<td>76-165</td>
</tr>
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</table>

Table VIII. Mean blood pressure in relation to age and sex.
<p>| | | | | | | | |</p>
<table>
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<th></th>
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<th></th>
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<td>10</td>
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<td>0.3</td>
<td>61.9(4.6)</td>
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<td>0.1</td>
</tr>
<tr>
<td></td>
<td>00</td>
<td>02</td>
<td>20</td>
<td>3.2</td>
<td>4.6</td>
<td>36</td>
<td>91</td>
</tr>
<tr>
<td>11</td>
<td>98.5(5.5)</td>
<td>99.7(9.2)</td>
<td>0.0</td>
<td>0.6</td>
<td>64.8(61.7)</td>
<td>1.0</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>05</td>
<td>02</td>
<td>42</td>
<td>80</td>
<td>3.9</td>
<td>5.7</td>
<td>56</td>
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<td>-</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>09</td>
<td>01</td>
<td>84</td>
<td>06*</td>
<td>2.9</td>
<td>5.2</td>
<td>07</td>
</tr>
<tr>
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<td>107.5(7.3)</td>
<td>04</td>
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<td>64.9(67.2)</td>
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<td>0.0</td>
</tr>
<tr>
<td></td>
<td>03</td>
<td>00*</td>
<td>03</td>
<td>03</td>
<td>4.3</td>
<td>5.9</td>
<td>01*</td>
</tr>
<tr>
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<td>109.8(7.8)</td>
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<td>01*</td>
<td>4.4</td>
<td>5.8</td>
<td>90</td>
<td>01*</td>
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</tr>
<tr>
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<td>110.5(8.7)</td>
<td>02</td>
<td>0.0</td>
<td>66.5(68.9)</td>
<td>-</td>
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<tr>
<td></td>
<td>00</td>
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<td>42*</td>
<td>5.8</td>
<td>5.6</td>
<td>2.37*</td>
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<tr>
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<td>00</td>
<td>00</td>
<td>03</td>
<td>10</td>
<td>5.1</td>
<td>6.1</td>
<td>15</td>
</tr>
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<td></td>
<td>115.2(8.7)</td>
<td>111.5(7.7)</td>
<td>2.04</td>
<td>43*</td>
<td>69.8(5.9)</td>
<td>69.8(5.8)</td>
<td>02</td>
</tr>
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<td>----</td>
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<td>-----</td>
<td>----------</td>
<td>----------</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>114.1(9.6)</td>
<td>113.5(7.4)</td>
<td>0.27</td>
<td>0</td>
<td>70.4(6.2)</td>
<td>72.1(6.3)</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>114.6(9.7)</td>
<td>110.8(8.0)</td>
<td>0.27</td>
<td>0</td>
<td>73.3(6.3)</td>
<td>71.4(4.3)</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>108.1(13.3)</td>
<td>109.5(11.7)</td>
<td>2.05</td>
<td>0</td>
<td>67.8(8.1)</td>
<td>68.7(8.2)</td>
<td>02</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Statistically significant p values at 0.05 levels of significance
Figure 2. Blood pressure distribution in relation to age and sex.

SBP = Systolic blood pressure, DBP = Diastolic blood pressure

Blood pressure and stages of adolescence

Table IX displays mean blood pressure according to stages of adolescence. Girls had a higher mean SBP than boys from early adolescence (t=3.754, p=0.000) to middle adolescence (t=-3.025 p=0.003) and this was statistically significant. This dominance was also demonstrated in the DBP and was statistically significant in middle adolescence (t=-3.517, p<0.000). Adolescents from private schools had higher mean SBP (t=-2.22, p<0.027) and mean DBP (t=-4.61, p=0.000) than those from public schools and these differences were statistically significant.

Table IX. Mean blood pressure according to sex and stages of adolescence
<table>
<thead>
<tr>
<th>Stages of adolescence (years)</th>
<th>Mean(±SD) systolic blood pressure (mmHg)</th>
<th>Mean(±SD) diastolic blood pressure (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Early (10-13)</td>
<td>100.0(9)</td>
<td>104.0(1)</td>
</tr>
<tr>
<td></td>
<td>0.6</td>
<td>1.8</td>
</tr>
<tr>
<td>Middle (14-16)</td>
<td>107.5(1)</td>
<td>110.5(1)</td>
</tr>
<tr>
<td></td>
<td>2.9</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late (17-19)</td>
<td>114.0(1)</td>
<td>112.1(1)</td>
</tr>
<tr>
<td></td>
<td>2.8</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>108.2(1)</td>
<td>109.2(1)</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Statistically significant p values at 0.05 level of significance, SD=Standard Deviation

Table X shows blood pressure pattern according to stages of adolescence. Prehypertension and hypertension were more prevalent in late adolescence than early and middle adolescence ($\chi^2=49.054$, $p=0.000$) and ($\chi^2=10.305$, $p=0.006$), both of which were statistically significant.

Table X. The pattern of normal BP, Prehypertension and hypertension according to stages of adolescence
<table>
<thead>
<tr>
<th>Blood pressure pattern</th>
<th>Stages of adolescence</th>
<th>( \chi^2 )</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early n(%)</td>
<td>Middle n(%)</td>
<td>Late n(%)</td>
</tr>
<tr>
<td>Normal</td>
<td>290(84)</td>
<td>428(72)</td>
<td>275(66)</td>
</tr>
<tr>
<td></td>
<td>.8)</td>
<td>.3)</td>
<td>.1)</td>
</tr>
<tr>
<td>Prehypertension</td>
<td>43(12.)</td>
<td>135(22)</td>
<td>120(28)</td>
</tr>
<tr>
<td></td>
<td>6)</td>
<td>.8)</td>
<td>.8)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>9(2.6)</td>
<td>29(4.9)</td>
<td>21(5.1)</td>
</tr>
<tr>
<td></td>
<td>05</td>
<td>05</td>
<td>05</td>
</tr>
</tbody>
</table>

*Statistically significant p value at 0.05 level of significance

**Relationship between blood pressure and the measured anthropometry**

There was a positive correlation between SBP and DBP with age and the anthropometric variables of weight, height, waist circumference and BMI (Table XI). SBP showed a stronger correlation with the anthropometries than the DBP and was stronger for weight \((r=0.51)\) and height \((r=0.44)\). The waist circumference, though statistically significant, showed the weakest correlation.

**Table XI. Correlation between blood pressure, age (yrs) and anthropometry**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Systolic Blood Pressure</th>
<th>Diastolic Blood Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation coefficient</td>
<td>p</td>
</tr>
</tbody>
</table>

56
Age (yrs) & 0.35 & <0.000* & 0.30 & <0.000* \\
Height (m) & 0.44 & <0.000* & 0.34 & <0.000* \\
Weight (Kg) & 0.51 & <0.000* & 0.38 & <0.000* \\
WC (cm) & 0.40 & <0.000* & 0.29 & <0.000* \\
BMI (Kg/m²) & 0.31 & <0.000* & 0.23 & <0.000* \\

*Statistically significant p values at 0.05 level of significance, Wt=Weight, Ht=Height, WC=Waist circumference, BMI=Body Mass Index,

Blood pressure distribution and socio-economic classes

Table XII shows mean blood pressure according to socio-economic class of the subjects. Lower social classes had higher mean SBP (t=1.650, p=2.850) and DBP (t=0.193, p=0.058) but these were not statistically significant.

Table XII. Mean Blood pressure in relation to socioeconomic classes

<table>
<thead>
<tr>
<th>Blood pressure</th>
<th>Upper (1 &amp; 2) n=184</th>
<th>Middle (3) n=516</th>
<th>Lower (4 &amp; 5) n=650</th>
<th>f(anova)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD)</td>
<td>108.57(12.6)</td>
<td>108.66(12.8)</td>
<td>110.40(10.9)</td>
<td>1.650</td>
<td>2.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
SBP

Mean  68.20(8.3)  67.91(8.3)  69.57(7.6)  0.193  0.05

(DBP)

SEC= Socioeconomic class  SBP=Systolic Blood Pressure  DBP=Diastolic Blood Pressure  SD=Standard Deviation

Table XIII shows blood pressure pattern in relation to socioeconomic classes of the subjects. The percentage of students with prehypertension was higher in the upper social class ($\chi^2=3.067$, $p=0.216$), while the percentage of hypertension were higher in the lower socioeconomic classes ($\chi^2=1.037$, $p=0.568$), but these differences were not statistically significant.

Table XIII. Blood pressure pattern in relation to socioeconomic status

<table>
<thead>
<tr>
<th>Blood pressure pattern</th>
<th>Socioeconomic classes</th>
<th>n(%)</th>
<th>n(%)</th>
<th>n(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upper (1 &amp; 2)</td>
<td>Middle (3)</td>
<td>Lower (4 &amp; 5)</td>
<td>Total N(%)</td>
</tr>
<tr>
<td>Normal</td>
<td>127(69)</td>
<td>383(74.</td>
<td>483(74.</td>
<td>993(73.</td>
</tr>
<tr>
<td>Prehypertension</td>
<td>52(28.</td>
<td>108(20.</td>
<td>138(21.</td>
<td>298(22.</td>
</tr>
<tr>
<td>Hypertension</td>
<td>5(2.7)</td>
<td>25(4.8)</td>
<td>29(4.5)</td>
<td>59(4.4)</td>
</tr>
</tbody>
</table>
Prevalence of Hypertension and Prehypertension

Table XIV shows the prevalence of hypertension in the study population. The total number of students with hypertension was 59 giving an overall prevalence of 4.4%. Thirty four students (2.5%) had systolic hypertension, sixteen (1.2%) had diastolic hypertension and nine students (0.7%) had both systolic and diastolic hypertension. Systolic hypertension was more prevalent in the females and was more at the age of 16 years while diastolic hypertension was higher in males and this also occurred at 16 years. Among those with hypertension, 27 and 16 subjects had stage 1 and 2 systolic hypertension respectively. With regard to diastolic hypertension, 24 and 1 subjects had stage 1 and 2 hypertension respectively. The gender difference in the prevalence of hypertension is not statistically significant ($\chi^2=0.831$, $p=0.362$).

The number of students with pre-hypertension was 298 giving an overall prevalence of 22.1%. Of this, 131 were males and 167 are females. This is illustrated in Table XIV. Prehypertension is more prevalent in females than males and this was statistically significant ($\chi^2=4.349$, $p=0.037$).
Table XIV. Overall Blood pressure pattern and prevalence of hypertension and prehypertension of 1350 students in Jalingo

<table>
<thead>
<tr>
<th>Blood pressure pattern</th>
<th>Males n(%)</th>
<th>Females n(%)</th>
<th>Total N(%)</th>
<th>$\chi^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>471(75.0)</td>
<td>522(72.3)</td>
<td>993(73.5)</td>
<td>2.619</td>
<td>0.106</td>
</tr>
<tr>
<td>Prehypertension</td>
<td>131(20.9)</td>
<td>167(23.1)</td>
<td>298(22.1)</td>
<td>4.349</td>
<td>0.037*</td>
</tr>
<tr>
<td>Hypertension</td>
<td>26(4.1)</td>
<td>33(4.6)</td>
<td>59(4.4)</td>
<td>0.831</td>
<td>0.362</td>
</tr>
</tbody>
</table>

628(100) 722(100) 1350(100) 1.260 0.533

*statistically significant p value at 0.05 level of significance
DISCUSSION

The findings of this study showed that the BP of secondary school adolescents in Jalingo was similar in terms of mean values, range and trend of progression with age to that of other adolescents from Ibadan \textsuperscript{63} and Kogi \textsuperscript{60} (Nigeria), Ashanti (Ghana) \textsuperscript{59} and Lebanon. \textsuperscript{54}

The mean value was however, lower than the mean BP of adolescents from Zaria (Nigeria), \textsuperscript{21} Belgrade (Serbia) \textsuperscript{78} and Fortaleza-Ceará (Brazil) \textsuperscript{83} who had higher mean BP in both sexes and at all ages. The lower mean BP in this study compared to that of adolescents from Zaria, \textsuperscript{21} Belgrade \textsuperscript{78} and Brazil \textsuperscript{83} could be due to lower mean anthropometry of weight, height and BMI in adolescents from Jalingo resulting in lower mean BP. The sample sizes of these studies \textsuperscript{78,83} were also different and could have affected the mean BP of the study population. For instance, the sample size in the Brazilian study \textsuperscript{83} is 151 compared to the study in Lebanon \textsuperscript{54} with 5710 subjects. The use of the fifth Korotkoff sounds as DBP in this study \textsuperscript{21} could also have accounted for the lower mean BP in contrast to a similar study in Zaria \textsuperscript{21} where the fourth Korotkoff sound was used as the DBP.

A progressive increase in blood pressure with age was found in this study. This was similar to most findings by researchers in Nigeria \textsuperscript{21,53,58-60,65,66,107} and worldwide. \textsuperscript{54,55,59,61} The peak age of rise in BP in this study was in middle adolescence between 15-16 years in boys but much earlier in girls for both systolic and diastolic BP. This was similar to the study by Akinkugbe, Akinwolere and Kayode \textsuperscript{56} in Ibadan and Ejeke, Ugwu and Ezeanyika et al \textsuperscript{60} in Lokoja. This age group is usually the period of onset of puberty. The chronologic age is not the main factor responsible for BP increase.
with age but rather, the progressive increase in size of the individual. Increase in body size with growth and maturity of organs associated with the physical and hormonal changes during puberty potentially lead to increasing BP. The simultaneous increase in weight, height and other anthropometric indices alongside BP with age seen in this study and others is in agreement with that. The implication of this increase in blood pressure with age is that those with prehypertension/hypertension in childhood may continue into adulthood hence further increasing the high prevalence of hypertension in the adult population with its attendant morbidity, disability and mortality.

Overall, significant higher mean BP was recorded in girls than boys in this study. This was seen from early to middle adolescence after which it reversed in favour of the boys. Reports on the relationship between BP and sex have been inconsistent. Some have reported higher mean BP in females,\textsuperscript{54-56} others higher in males\textsuperscript{58,83} while yet another reported no sex differences.\textsuperscript{22} The findings of this study were similar to those of Bugaje, Yakubu and Ogala\textsuperscript{21} and Ujunwa, Ikefuna and Nwokocha\textsuperscript{100} who reported a consistently higher mean blood pressure in female adolescents up to 16 years compared to their male counterparts of similar ages. Early female predominance in mean blood pressure was also reports by Agyemang, Redekop and Owusu-Dabo et al\textsuperscript{59} in Ashanti adolescents in Ghana and Obika, Adedoyin and Olowoyeye\textsuperscript{22} in Ilorin. The finding was however in contrast with the study in Calabar\textsuperscript{58} where higher mean BP was found in boys than girls at all ages. The reason for the higher mean BP in females than boys could be because of earlier onset of puberty in girls. The differences in blood pressure between boys and girls in this study could also be accounted for by variation in the anthropometric variables of the individuals as girls were seen to be heavier and taller up to middle adolescence.

This study demonstrated a consistently positive relationship between blood pressure and the anthropometric variables of weight, height, body mass index and waist
circumference as widely reported in other studies.\textsuperscript{54,55,58-61,65,107,100} Weight is reported to correlate positively with blood pressure in several studies.\textsuperscript{53,56,58,71} Body mass index (BMI) also showed a positive relation with BP in this study as reported in other studies.\textsuperscript{59,78-81} This is in-keeping with the findings in Port Hacourt,\textsuperscript{71} Abeokuta,\textsuperscript{83} the Gambia,\textsuperscript{69} Brazil,\textsuperscript{82} and Belgrade\textsuperscript{77} children. Some of these studies however were made up of younger and older age groups. Even in lean populations, BMI is known to correlate positively with BP. Waist circumference was also found in this study to correlate positively with BP. This was similar to reports from other studies.\textsuperscript{79-81,83} It was found to be a better predictor of BP in two Italian study,\textsuperscript{80,81} while it was not in another.\textsuperscript{82} Comparing BMI and waist circumference and their effects on BP, Arauzo, Lopes and Moriera et al\textsuperscript{82} in Brazilian children found BMI to be a better predictor of BP than waist circumference. This was similar to the report by Sebanjo and Oshikoya\textsuperscript{83} in Nigerian adolescents in Akure. Guagnano, Ballone and Colagrande et al\textsuperscript{81} however found waist circumference to be better than BMI. The study\textsuperscript{81} however involved adults and may not be applicable in children and adolescents. The present study demonstrated BMI and WC to be significant, but found BMI to be a better determinant of BP than waist circumference. BMI and waist circumference measure obesity in an individual. Whereas BMI is a measure of overall obesity, WC measures central/abdominal fat accumulation and thus said to be more predictive of adverse health risk.\textsuperscript{79} Obese individuals may be prone to such condition as dyslipidaemia, insulin resistance and hypertension with reduction in the quality of life. Weight, BMI and or waist circumference affects blood pressure through decreased physical activity, increased cardiac output, insulin resistance, impaired pulmonary function and other hormonal abnormalities.\textsuperscript{80,84} It seems therefore that BMI is a better predictor of BP in adolescents than waist circumference. The reason
for this is not obvious but it may be because of the nature of uniform fat distribution in adolescents associated with growth and hormonal changes at puberty.

Blood pressure distribution in relation to the parental socio-economic class in this study showed that students from low socio-economic classes had higher mean blood pressure than those from upper socioeconomic classes but this was not statistically significant. A study in Ibadan\(^{56}\) reported a statistically significant negative relation between blood pressure and parental socio-economic status. It was also similar to the study\(^{58}\) in Calabar. In contrast, other studies found the reverse.\(^{53,60,22}\) The reasons for the inverse relationship between BP and socioeconomic includes exposure to chronic environmental stress with sustained sympathetic nervous system stimulation. Others are poor health seeking behaviours due to low income and/or inadequate health knowledge, high low birth weight rate and inadequate healthy diets among others.\(^{97,101}\) In the same environment, individuals from a high social class are believed to be more educated with high income.\(^{61}\) They have easy access to health education and awareness on hypertension prevention and control and better accessibility and adherence to medical treatment.\(^{61,73,74}\) The former might be responsible for the finding of this study as Jalingo is a semi urban community. Most of its inhabitants are subsistent farmers, civil servants and traders with low income. The high number of students in the lower socioeconomic class lays credence to that.

The overall point prevalence of hypertension in this study was 4.4% while that of pre-hypertension was 22.1%. This prevalence of hypertension is similar to the prevalence of 4.8% by Antia-Obong and Antia-Obong,\(^{107}\) but higher than the prevalence rate of 3.7% reported in Zaria\(^{21}\) and lower than the prevalence of 5.8% reported in Ibadan\(^{56}\), 5.4% in Enugu\(^{100}\) and the 7.2% reported in Kano.\(^{65}\) The prevalence of pre-hypertension was lower than that reported by Ejeke, Ugwu and Ezeanyika\(^{99}\) who found a prehypertensive
prevalence of 25% among adolescents in Lokoja. It is higher than the 17.3% reported by Ujunwa, Ikefuna and Nwokocha et al.\textsuperscript{100} in Enugu and 12%-17% by Redwine and Daniels\textsuperscript{96} among US adolescents. The differences in the reported prevalence of hypertension and prehypertension in adolescents could have resulted from the different criteria applied by the various researchers in defining hypertension. For instance, whereas this study used BP greater than 95\textsuperscript{th} percentile as hypertension, a study in Kano\textsuperscript{65} used the adult hypertensive value of BP>140/90mmHg as hypertension and got a prevalence of 7.2%. The prevalence in that study\textsuperscript{65} could have been higher if the percentile or the statistical definition was used as many children with BP 140/90mmHg would probably be at stage 2 hypertension. This was demonstrated in the study by Bugaje, Yakubu and Ogala\textsuperscript{21} who found a prevalence of hypertension in their study to be 0.6% when the adult cut off value of >140/90mmHg was used but it increased to 3.7% when the statistical definition of BP> 2 standard deviations was used.

The number of times blood pressure is taken could affect the outcome as repeated measurements over a time interval is known to give lower BP values than if BP is taken once. This study used the average of three blood pressure values taken at one sitting but Ujunwa, Ekefuna and Nwokocha\textsuperscript{100} took three readings at five minutes interval with two other readings at a week interval. In that study,\textsuperscript{100} the prevalence of prehypertension dropped from 74.5% during the first set of readings to 17.3% after the third week readings. The prevalence of hypertension also dropped from 13.5% to 5.4% over the same period. Similar decrease in the prevalence of both prehypertension and hypertension was reported by Redwine and Daniels\textsuperscript{96} in US adolescents when blood pressure was taken over time interval. Another factor which might have affected the overall prevalence is the Korotkoff sound used for diastolic pressure.\textsuperscript{2,3} The 4\textsuperscript{th} or 5\textsuperscript{th} Korotkoff sounds has been used by different researchers resulting in different diastolic BP. The study\textsuperscript{21} in Zaria used
the 4th Korotkoff sound while most other researchers\textsuperscript{22,65,100} used the 5th. About 5-10mmHg difference is said to exist between the 4th and 5th Korotkoff sounds.\textsuperscript{2,30} In this study, the 5th Korotkoff sound was used, thus giving a higher prevalence of hypertension in the studied population than in those where the 4th sound was used.

The implication of the outcome of this study is that 4.4\% of adolescents in Jalingo are already hypertensive while 22.1\% of them are at risk of developing hypertension as they are pre-hypertensive. Since 85.6\% (255 of 298) of the prehypertensives were in the middle and late adolescence, these individuals are likely to be adults with high blood pressure. Therefore, regular screening of this group of individuals who were assumed to be a healthy population is highly important for early detection of hypertension and intervention such as life style changes and treatment.
CONCLUSIONS

The following conclusions can be made from this study

1. The mean and range of blood pressure of adolescents in Jalingo was similar to those of other adolescents in Nigeria and other parts of the world. Blood pressure increased progressively with age.

2. All measured anthropometry of weight, height, body mass index and waist circumference correlated positively with BP but weight was the most significant variable in BP determination.

3. Socioeconomic status was not significantly related with blood pressure.

4. The point prevalence of hypertension and pre-hypertension was 4.4% and 22.1% respectively using a recommended definition.

RECOMMENDATIONS

1. In view of the high prevalence of prehypertension in this study, it is recommended that students should have their blood pressure measured at school entry as this will
help identify those with abnormal BP for early intervention. Thereafter, BP check should be offered at least once a year at the beginning of a new session especially for those found with abnormal BP at school entry.

2. Physical and health education should be revived in all the schools. This will lead to increased physical activity and reduced risk of obesity and its consequences.

3. School health programmes should be strengthened in schools where it already exist and effort made to establish same in schools where it is yet to exist. The programme should include measures to detect early prehypertension and hypertension and other health related needs of the students.

LIMITATIONS

The following limitations were encountered in the course of the study

1. Exclusion and inclusion of students that were based on volunteered information and physical evaluation. This could have led to inclusion and/or exclusion of adolescentss
with or without background renal diseases which could have affected the result of this study.

2. Home blood pressure measurement especially early morning measurement for those with high blood pressure to possibly eliminate the effect of stress, traffic and/or trekking and other school related stresses which may affect blood pressure during the day.

LINES OF FUTURE RESEARCH

This study was questionnaire based and time bound. Consequently, students were not investigated for background diseases, co-morbid conditions, target organ damage or risk factors for high blood pressure. They were also not followed up. In view of this, future research on blood pressure in adolescents should include-
1. Investigations such as urinalysis, electrolytes, urea and creatinine, random blood sugar (RBS), lipid profile and echocardiography as part of blood pressure evaluation in adolescents.

2. A long period of study to allow for follow-up over months or years to identify those that are truly hypertensive considering the definition of hypertension. It will also reveal the rate of progression from pre-hypertension to hypertension.


REFERENCES


APPENDICES

Appendix 1

PROFORMA ON BLOOD PRESSURE PATTERN IN APPARENTLY HEALTHY SECONDARY SCHOOL ADOLESCENTS IN JALINGO

PUBLIC SCHOOL [ ]

Serial No.

83
PRIVATE SCHOOL [ ]

A. BIODATA

1. Age (years). 10[ ] 11[ ] 12[ ] 13[ ] 14[ ] 15[ ] 16[ ] 17[ ] 18[ ] 19[ ]

2. Gender M [ ] F [ ]

3. Class. JSS 1-3 [ ] SS1-3 [ ]


1. Have you ever passed blood in your urine? [ ]

2. Have you ever had your face or legs swollen? [ ]

3. Are you on any drug for long time (such as pills, steroids, marijuana, codeine NSAIDs, containing drugs, tramal, and others)? [ ]

If yes, specify………

C. SOCIO-ECONOMIC CLASSIFICATION

Father’s occupation

Score: 1. Professionals, top civil servants, politicians and top businessmen.

2. Middle-level civil servants, technicians, skilled-artisans and well-to-do traders

3. Unskilled workers and those in general whose income would be at or below the national minimum wage.

Mothers educational level

Score: 0. Education up to University level

1. Secondary or tertiary level below the University

2. No formal education or up to primary level only

D. ANTHROPOMETRY

i. Weight (Kg) – 1……. 2……… Average…………

ii. Height (m) – 1……. 2……… Average…………

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iii. Body mass index = weight/height (kg/m²)

v. Waist circumference (cm) – 1…… 2……… Average…………

iv. Blood Pressure (mmHg) - 1…… 2….. 3…… Average…………

Appendix 2

AUTHORIZATION AND CONSENT TO PARTICIPATE IN A RESEARCH

I, Dr Peter Teru Yaru of the Department of Paediatrics, Ahmadu Bello University Teaching Hospital (ABUTH) Zaria, I’m conducting a research on the blood pressure pattern among secondary school adolescents in Jalingo.

The aim of the study is to know the level of blood pressure among their age groups. Those with high blood pressure (or hypertension) will be identified, appropriately advised and referred for further care. The study will involve taking their weight, height, blood pressure and waist circumference. Female assistants shall be responsible for
measuring waist circumference of female students. Students will also be given a questionnaire on some of their activities, drug use among others, all aimed at looking for factors which can affect their blood pressure. Information obtained shall be treated with utmost confidentiality and for this research work only. Please note that participation is voluntary. I will be glad if you give consent for your child/ward to participate in the study.

**Statement by parents:** I’ve read and understood this consent form and agreed for my child to be included in the study.

**Parents name:**

**Parents phone no if any:**

**Parents sign/thumb print:**

**Researcher’s name and sign:**

**Date:**

**Phone no**
Appendix 3

SOCIO-ECONOMIC SCORE

The classification of socio-economic scores based on father’s occupation and mother’s education by Olusanya et al.:

A. Husband (father’s occupation)

Score: 1. Professionals, top civil servants, politicians and businessmen.
2. Middle-level bureaucrats, technicians, skilled-artisans and well-to-do traders.
3. Unskilled workers and those in general whose income would be at or below the national minimum wage.

B. Mothers educational level

Score: 0 Education up to University level
1. Secondary or tertiary level below the University
2. No formal education or up to primary level only

The socio-economic class of the child’s mother is obtained by adding the scores from A and B above and graded I-V as appropriate, for example:

- Score (1) from A plus score (0) from B = social class I
- Score (2) from A plus score (0) from B = social class II
- Score (2) from A plus score (1) from B = social class III
- Score (2) from A plus score (2) from B = social class IV
- Score (3) from A plus score (0) from B = social class III
- Score (3) from A plus score (1) from B = social class IV
- Score (3) from A plus score (2) from B = social class V