International Journal of Biomedical and Health Sciences
Vol. 5, No. 4 December 31, 2009
Printed in Nigeria

0794-4748/2009 $12.00 + 0.00

http://www.asopah.org

IJBHS 2009127/5407

Relationship between Anthropometric Parameters and Blood Pressure in Sagamu Adolescents, Ogun State, South-West Nigeria

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(Received October 25, 2009)

ABSTRACT: **Background:** The blood pressure and anthropometric measurements are important for evaluating the health of children and adolescents, since cardiovascular abnormalities are becoming more and more common in this population. Previous studies have shown positive association between these variables but did not report the type of the relationship (whether linear or curvilinear).
Objectives: The study was to determine the relationship between anthropometric measures and blood pressure, and the kind of relationship.
Methods: A cross-sectional survey of adolescent in Sagamu was carried out. Total of 1638 apparently healthy adolescents were randomly selected. The body mass index (BMI), triceps skinfold (TSF), abdominal skinfold (ASF), and blood pressure of the participants were measured.
Results: The results showed a significant positive correlation between anthropometric measures and blood pressure in the whole population. Curvilinear (polynomial) relationship was also demonstrated between the variables. Coefficients of determination (R^2) for BMI were 12.69% and 9.3%; R^2 for SSF, 2.21% and 1.42% for systolic and diastolic blood pressure respectively ($p< 0.05$).
Conclusions: Polynomial regression of orders five and six were demonstrated between BMI, SSF and blood pressure respectively in the present study. Attention should be paid to the weight decrease in this population before cardiovascular risk becomes another burden.

Keywords: Blood pressure, Anthropometric parameters, Adolescents.

Introduction

Elevated blood pressure (BP) is associated with an increased risk of cardiovascular disease, morbidity, and mortality and this process may begin early in life[1-2]. Adolescents with essential hypertension were found to have a high prevalence of left ventricular hypertrophy, and some later developed severe hypertrophy and abnormal left ventricular geometry to a degree that would be associated with increased risk of cardiovascular disease morbidity in adults [3]. It is suspected that future hypertension may develop in children in whom BP is high for their respective age or body size [4].

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Body mass index is used by clinicians as an index of obesity and is a predictor of BP in children and adolescents [5-6]. However, the normal increase in BMI with growth and maturation generally reflects gains in fat-free mass more than fat mass, and for any given BMI, there is a range of percent body fat [7]. Total body fat measured by both skin folds and DXA are more precise than BMI. These two independent measures of body composition demonstrate that central fat distribution (trunk fat adjusted for total body fat) is an additional predictor of BP in boys only [8]. Skin fold thickness was related to a high risk profile regarding coronary heart disease (CHD), hence can be used to predict CHD [9]. In general skin fold measurement contribute only marginally to improved prediction of risk of ischaemic heart disease (IHD) as measured by BMI, but central obesity, as measured by the subscapular skin fold, is predictive of IHD independently of BMI [10]. Triceps skin fold predicted total fat content well in male children and adolescents [11].

The association between skin folds thickness in children and adolescents and elevated levels of variables considering being indicative of risk of cardiovascular diseases (CVD) in adult has been found by previous investigator[12-14]. In population based studies of children and adolescents, for example, excess subcutaneous fatness has been associated with elevated BP [12, 15]. Children and youth with triceps skin fold ≥85th percentile for age and sex are at greater risk for high BP than children with lower skin fold thicknesses [12]. Being overweight is associated with two- to six- fold increase in the risk of developing hypertension. An increase of 2-3 mmHg in systolic and 1-3 mmHg in diastolic blood pressure has been shown for each 10 kg increase in weight in western population [16]. In Brion *et al*[17] study, after full adjustment for confounders, total body fat and BMI were positively associated with systolic blood pressure (SBP) and diastolic blood pressure (DBP). Systolic blood pressure was also positively associated with lean mass, and weakly associated with trunk fat, which was robust in girls only. The association between lean mass and SBP remained even after accounting for fat mass. Systolic blood pressure in 9-year-old children is independently associated with fat mass and lean mass and, to a lesser extent, trunk fat in girls. Studies in various populations also showed strong relationship between different anthropometric indicators and blood pressure levels[18-24]. However, studies analyzing the graded relation between anthropometric measures and blood pressure in this population are scarce. The present study was therefore undertaken to examine the relationship between different anthropometric indicators and blood pressure and if this relation is linear or curvilinear.

Materials and Methods

A cross-sectional survey of adolescents in a Local Government of Ogun state, Nigeria was carried out. A total of 1638(790 male and 848 female) participants were selected by probability proportional to size from the Local Government. Their age ranged between 12 and 18 years.

Joint Institutional Review Committee of University of Ibadan and University College Hospital, Ibadan approved the protocol for this study. Informed consent was sought from the participants and their parents. The nature, purpose and procedure of the study were explained to the participants in detail. The biodata of each participant was taken i.e. age (as at last birth day) and sex.

Measurements

Blood Pressure: Researcher and trained personnel measured blood pressure after 5 minutes of rest in the sitting position with an aneroid sphygmomanometer (Frank Industries Inc., 9643 Great Smoky Drive, Vacon Rouge LA 70814, USA) and a cuff suitable to the subject's arm circumference according to American Heart Association guidelines[27].

Anthropometric Measurements: The triceps and abdominal skinfold thickness were measured using Skinfold caliper (FAT-O-METER, Novel products Inc., Pat. No.4.233.743) according to American College of Sports Medicine guidelines for skinfold measurement. The triceps skinfold was taken at the level of mid-point between the acromion and olecranon processes and 5cm adjacent to the umbilicus to the right side for abdominal skinfold thickness as described by ISAK [25]. Two readings were taken on each site and the average was used in the computation.

Portable weighing scale (Camry model BR9012 made in China) and height meter (Wunder, made in China) were used to measure weight and height respectively as described in previous study [26]. The BMI was then computed using a standard formula [BMI= weight (kg)/height ^{2} (m ^{2})].

Data analysis

SPSS version 15.0 statistical software package was used to carry out Statistical analysis. Descriptive statistics of mean and standard deviation were used to examine the data. Pearson moment correlation was used to find correlation between anthropometric measures and blood pressure. Regression analysis was also carried out to see relationship between the variables. The graphs were generated using Microsoft excel package. P-value < 0.05 was considered to be statistically significant.

Results

Table 1 presents descriptive data by gender. The girls were significantly ($p< 0.05$) having higher values of fatness than the boys. Table 2 shows the correlation matrix between anthropometric measures and blood pressure. There was significant ($p< 0.05$) positive correlation between the variables with exception of males' triceps skin fold. Body mass index showed strong correlation for both gender than the skin folds with blood pressure.

Figures 1-4 show the relationship between anthropometric measures and blood pressure in the whole population. The systolic blood pressure showed a significant ($p< 0.05$) curvilinear (6^{th} degree polynomial) relation with sum of skin folds (SSF). The regression equation was y = -1E-07x6 + 2E-05x5 - 0.0018x4 + 0.0737x3 - 1.5341x2 + 15.491x + 21.193 (equation 1). Sum of skin folds explained 2.21% of total variance in SBP. Diastolic blood pressure showed a significant curvilinear (6^{th} degree polynomial) relation with SSF. The regression equation was y = -8E-08x6 + 2E-05x5 - 0.0013x4 + 0.051x3 - 1.05x2 + 10.598x + 7.2645 (equation 2). The percentage contribution to the total variance from SSF was 1.42%. The systolic blood pressure demonstrated a significant curvilinear (5^{th} degree polynomial) relation with body mass index. The regression equation was y = -4E-05x5 + 0.0063x4 - 0.3414x3 + 8.7289x2 - 103.84x + 532.15 (equation 3). Body mass index explained 12.69% of total variance in SBP. Also, DBP showed a significant curvilinear (5^{th} degree polynomial) relation with BMI. The regression equation was y = -2E-05x5 + 0.0034x4 - 0.1894x3 + 5.0015x2 - 60.939x + 318.63 (equation 4). The percentage contribution to the total variance from BMI was 9.3%. **NB:** in equation 1, y=SBP and x=SSF; in equation 2, y=DBP and x=SSF; in equation3, y=SBP and x=BMI; in equation 4, y=DBP and x=BMI.

Table 1: Descriptive Statistics by Gender.

Variables	Male (n = 790)	Female (n = 848)	P
	Mean (SD)	Mean (SD)	
Age (Years)	15.1 (1.9)	14.8 (1.8)	0.001
Systolic BP (mmHg)	81.3 (14.8)	81.5 (13.8)	0.718
Diastolic BP (mmHg)	48.4 (9.6)	48.5 (9.3)	0.899
Body Mass Index (KgM^2)	18.9 (2.8)	19.2 (2.5)	0.039
Triceps Skin Fold (M)	6.4 (3.0) x 10^{-3}	14.1 (5.3) x 10^{-3}	0.000
Abdominal Skin Fold (M)	6.9 (2.6) x 10^{-3}	12.7 (4.3) x 10^{-3}	0.000
Sum of Skin Fold (M)	13.3 (5.1) x 10^{-3}	26.9 (8.9) x 10^{-3}	0.000

BP = Blood Pressure.

Discussion

The importance of BMI and skin folds has been recognized for estimating cardiovascular disease risk factors, particularly due to their positive association with hypertension [28]. In the present study, we found significant positive correlation between all the anthropometric measures and systolic and diastolic blood pressure except for TSF and blood pressure of male students. Many investigators have earlier reported significant positive correlation of body mass index with systolic and diastolic blood pressure [22, 23, 29-32]. The partial correlation coefficients (r) in the whole population between BMI and SBP and DBP in the present study compared well with that of Wang *et al*[22]. Significant positive correlation between trunk skin folds and systolic and diastolic blood pressure has been also reported [8].

Table 2: Correlation matrix between anthropometric parameters and blood pressure.

Variables	BMI	TSF	ASF	SSF
Male	0.395**	0.034	0.209**	0.126**
Female	0.274**	0.228**	0.111**	0.189**
All	0.338**	0.118**	0.115**	0.122**
Male	0.332**	− 0.010	0.160**	0.075**
Female	0.239**	0.181**	0.100**	0.156**
All	0.287**	0.083**	0.093**	0.091**

SBP=systolic blood pressure, DBP=diastolic blood pressure
BMI= Body mass index   TSF= Triceps skin fold
ASF= Abdominal skin fold   SSF= Sum of skin fold
**Correlation is significant at the .01 level (2-tailed)
* Correlation is significant at the .05 level (2-tailed)

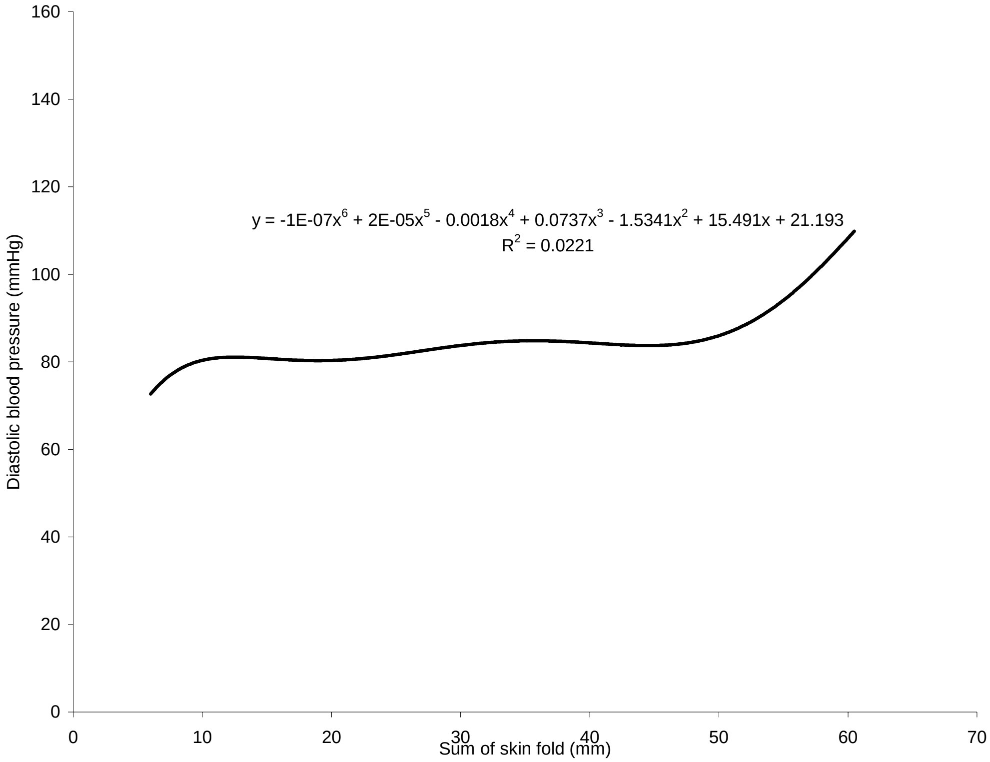

Fig 1: Graded relation between systolic blood pressure and sum of skin fold

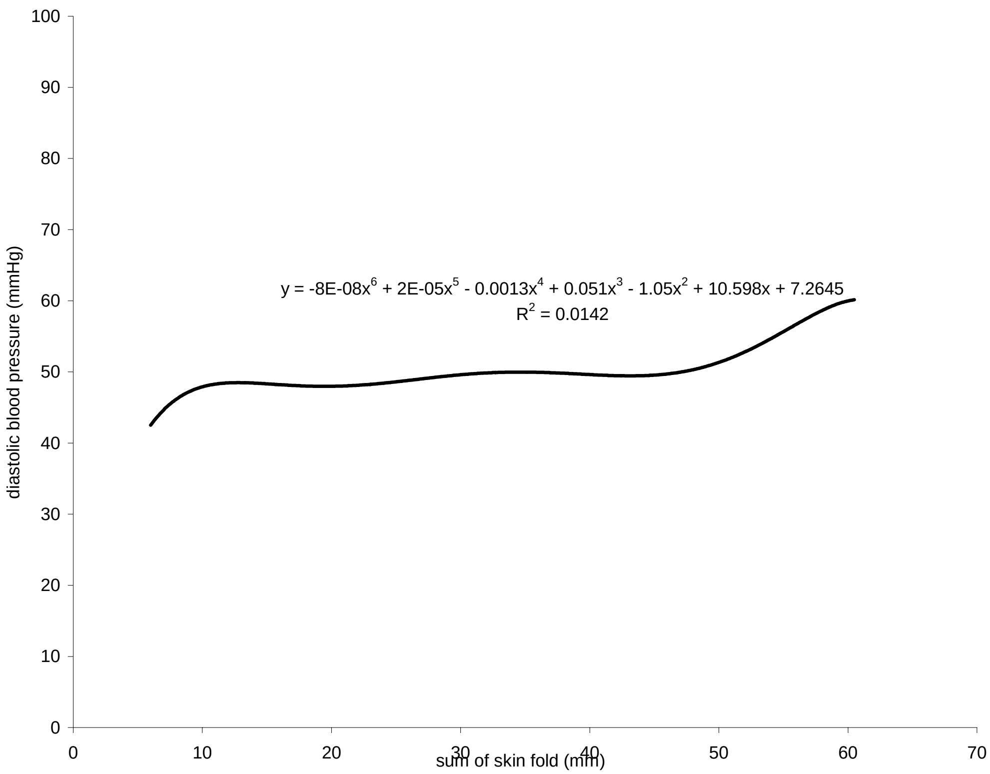

Fig 2: Graded relation between diastolic blood pressure and sum of skin fold

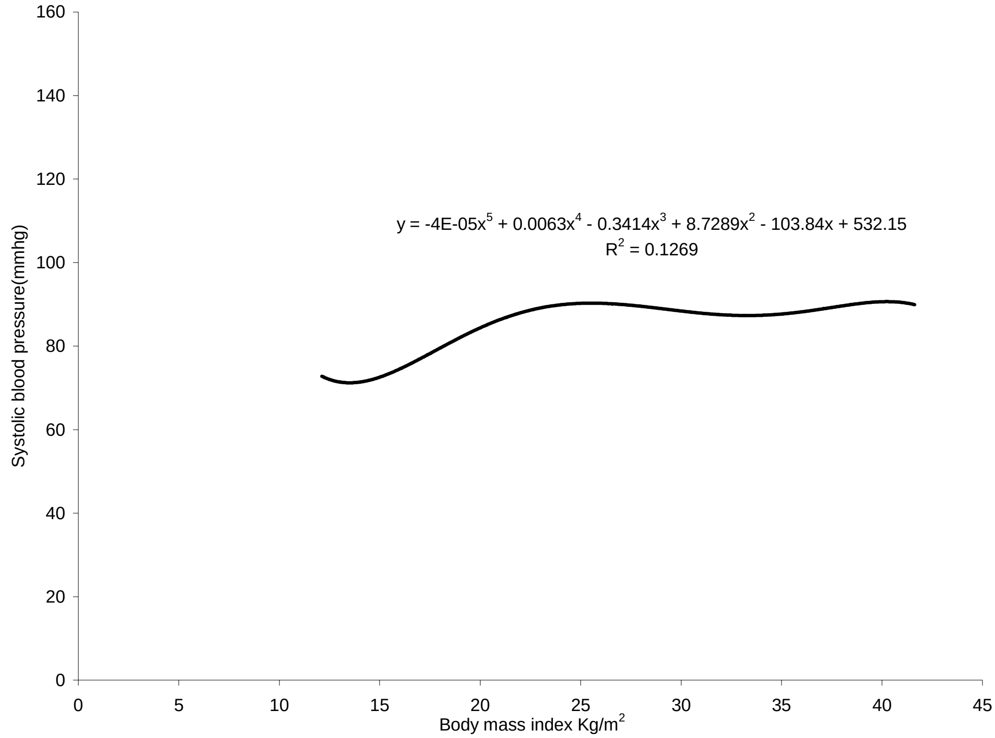

Fig 3: Graded relation between systolic blood pressure and body mass index

Some important gender differences have been found in the relationship between BP and adiposity. The partial correlation coefficients for each indicator were substantially greater in males than in females (except for TSF in relation to SBP and DBP), suggesting a greater male responsiveness of BP to a gain in relative weight or abdominal deposition. However, this was in contrast with the report of Doll *et al*[19]. In a study by He *et al* [8] involving 920 healthy children and adolescents, a sex difference was demonstrated in the relationship between BP and body fat distribution in that a significant positive relationship between trunk fat and BP was present in boys only. This sex difference was not influenced by race (African-American, Asian, or Caucasian) or stage of sexual maturation and was independent of height and total body fat [8].

The present study results show a strong graded relation between blood pressure and anthropometric measures (body mass index and sum of skin folds), and the relation was curvilinear (polynomial). The fifth and sixth degree term of the BMI and SSF variables respectively, which could indicate a more complex association than a second order polynomial, was significant for both SBP and DBP in the whole population and BMI only explained 12.69% and 9.3% of the variation in SBP and DBP respectively while percentage contribution of SSF to the total variance was 2.21% and 1.42% respectively. Body mass index shows strongest relation than the SSF which was similar to the observation of Reich et al[33]. Body mass index is used by clinicians as an index of obesity and is a predictor of BP in children and adolescents [5-6].

The recognition of significant correlation and graded association between anthropometric measures and blood pressure in Nigerian adolescents in the present study may help target prevention towards high-risk individuals in this age group. Decrease in adiposity is one of the most effective preventive measures not only in decreasing the overall cardiovascular risk but also the blood pressure [34]. Therefore, attention should be paid to the decreasing fatness in this population before cardiovascular risk becomes another burden. This is especially important in the light of evidence linking adolescent obesity with metabolic abnormalities and risk of cardiovascular diseases in adulthood.

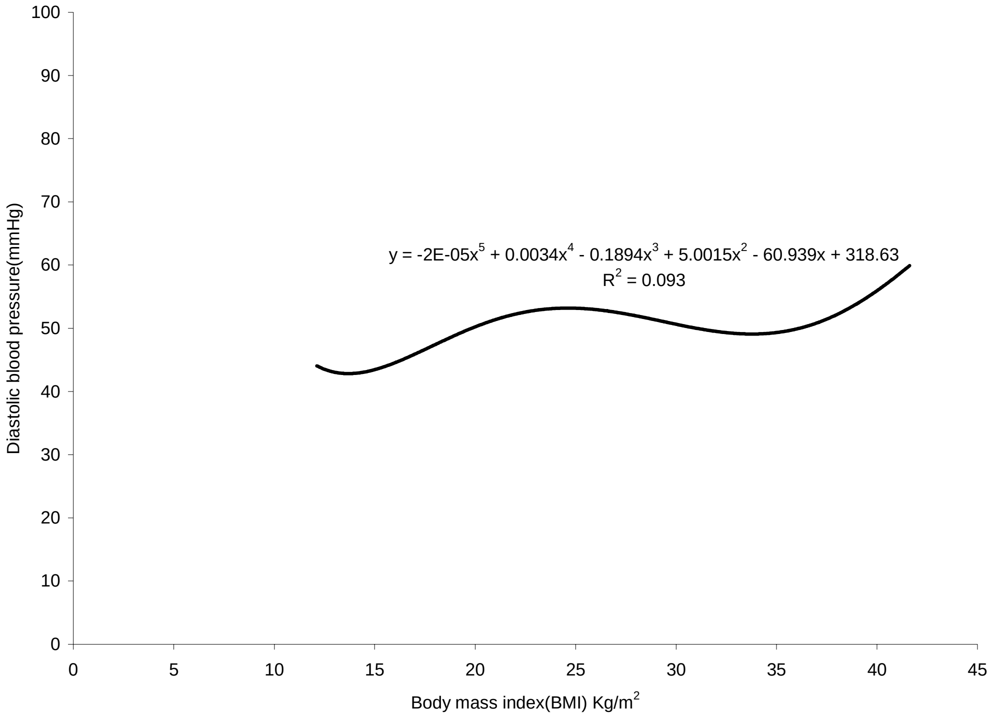

Fig4: Graded relation between diastolic blood pressure and body mass index

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