Central adiposity and the risk of hypertension in Asian Indian girls

Jyoti Ratan Ghosh, Arup Ratan Bandyopadhyay
West Bengal, India

Background: **Elevated blood pressure during childhood is an established predictor of elevated blood pressure in adulthood. This study was undertaken to evaluate the relationship of general and central adiposity measures with hypertension and to find out the best adiposity measure in predicting hypertension.**

Methods: **A cross-sectional study was carried out in 197 girls aged 5 to 16 years. Anthropometric measurements included stature, weight, waist circumference (WC) and hip circumference. Body mass index (BMI, kg/m^2), waist hip ratio (WHR) and conicity index (CI) were calculated subsequently. Systolic blood pressure (SBP) and diastolic bold pressure (DBP) were taken and hypertension was defined as age and stature adjusted SBP and/or DBP ≥95th percentile. Linear and logistic regression analysis was made to determine the relationship of adiposity measure with blood pressure and hypertension and to find out the best adiposity measure in predicting hypertension.**

Results: **Both WC [odds ratio (OR)=2.20, 95% confidence interval, 1.32-3.69] and CI (OR=1.85, 95% confidence interval, 1.14-3.0) were significantly associated with hypertension. However, there was no significant association in BMI and WHR with hypertension.**

Conclusion: **WC is the best adiposity measure in predicting hypertension in girls.**

World J Pediatr 2013;9(3):256-260

Key words: **anthropometry;**
girls;
hypertension;
waist circumference

Author Affiliations: Department of Anthropology, Visva-Bharati University, Santiniketan-731235, West Bengal, India (Ghosh JR); Department of Anthropology, University of Calcutta, 35 Ballygunge Circular Road, Kolkata 700019, West Bengal, India (Bandyopadhyay AR)

Corresponding Author: Jyoti Ratan Ghosh, Department of Anthropology, Visva-Bharati University, Santiniketan-731235, West Bengal, India (Email: jrghosh@rediffmail.com or jrghosh@visva-bharati.ac.in)

doi: 10.1007/s12519-013-0424-2

Introduction

Hypertension is now recognized globally as a major public health problem[1] in terms of a well-known risk factor for non-communicable diseases (NCDs) like cardiovascular disease (CVD), type 2 diabetes mellitus and renal disease.[2] Prospective studies have shown that elevated blood pressure during childhood is an established predictor of elevated blood pressure in adulthood, which in turn increases the mortality of cardiovascular diseases and other NCDs.[3] Moreover, epidemiological studies[4] have also supported the hypothesis that the relationship between adiposity and risk of NCDs begins early in life. Thus, individual risk factors track reasonably well from childhood to adulthood. Therefore, identification of children and adolescents, especially girls with an elevated risk factor profile is of great importance.

It is recognized that rather than the degree of obesity, the distribution of body fat is the most important determinant of risk of NCDs and that individuals with a high proportion of abdominal adiposity have higher risk of developing NCDs including hypertension.[5,6] Accurate methods used to assess total body fat [dual-energy X-ray absorptiometry (DXA)] and its distribution (computed tomography and magnetic resonance imaging) in humans are not suitable for use in large population studies because of cost, irradiation exposure, and limited availability outside the research setting.[4,7] However, to obtain a reasonable estimation of body-fat distribution, several anthropometric parameters have been proposed including body mass index (BMI), waist circumference (WC) and waist hip ratio (WHR), which are easy to determine and have a sufficient degree of accuracy.[4] Dencker et al[8] demonstrated that anthropometric parameters are closely related to objective measurement of body fat by DXA in children.

There are few data on the relationship between body-fat distribution and cardiovascular risk factors in children, especially in Asian Indian children. Most of the studies in non Asian Indian children demonstrated a positive association of BMI, WC and WHR with hypertension risk.[4,9] Epidemiological studies[5,10,11] on adult Asian Indians have extensively used BMI, WC and WHR to analyze the association between adipose tissue distribution and CVD risk factors. Some studies[5,11] have shown that WC in adults may be a better indicator of hypertension risk than BMI and WHR. In contrast, this relationship is not fully understood in Asian Indian children.

The present study was undertaken to determine the relationship of general and central adiposity measures such as BMI, WC, WHR and conicity index (CI) with hypertension and to find out the best adiposity measure in predicting hypertension in native Asian Indian girls.

Methods

Subjects

This cross-sectional study was carried out in an urban public school in the district of Howrah, West Bengal, India. A total of 197 apparently healthy Hindu girls from class I to VIII were evaluated. Numerically, Hindu is the largest ethnic group in West Bengal as well as in India. The age of the children ranged from 5 to 16 years. In 252 students who were enrolled into the study, 55 were excluded because of their different ethnicities and ongoing medical treatment.

Bio-social information

Bio-social information including name, date of birth, age at menarche and occupation of parents was obtained using an open-ended schedule. Age was ascertained from the school register. Information about age at menarche was obtained through interview (status quo and recall). Assents were obtained from each student and informed consent was obtained from their parents before the study.

Measurements

Stature (ST) to nearest 0.1 cm, weight (WT) to nearest 0.5 kg, and circumferences [WC, hip circumference (HC)] to nearest 0.1 cm were recorded following standard procedures.[12] BMI [WT (kg)/ST (m^2)], WHR [WC (cm)/HC (cm)] and CI=WC (m)/{0.109 × √[WT (kg)/HT (m)]} were calculated subsequently. Obesity was evaluated using age and sex specific cut-off values of BMI (kg/m^2) recommended by the World Health Organization.[13] Central obesity was defined as age adjusted WC value ≥85th percentile.

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) of the left arm were taken from each student using a sphygmomanometer. Each student was asked to sit quietly for 5 minutes before taking the measurement to relieve any possible tension. The average of two measurements was considered and used to define hypertension. Hypertension was defined as age and stature adjusted SBP and/or DBP ≥95th percentile.[14]

Statistical analysis

Descriptive analysis of anthropometric and physiological variables was made by mean and standard deviation (SD). Age adjusted linear regression analysis was used to understand the independent association between each anthropometric variable and systolic and diastolic blood pressure. To compare the independent association of different adiposity measures with hypertension, we calculated odds ratios (ORs) for each adiposity measurement in simple logistic regression analysis, with adjustment for significant effect of age and age at menarche. Statistical analyses were performed using SPSS software version 9.0 (Statistical Package for Social Science, SPSS Inc, Illinois, USA), and the significant level was set at $P<0.05$.

Results

The mean age of the subjects was 10.8 year (SD, 3.25 years), with a range of 5-16 years. Their menarcheal age ranged from 9 to 13 years, with a mean of 11.12 years (SD, 0.91 years). With regard to occupation, 88.8% of fathers were engaged in service and others (11.2%) were in business. But 84.3% of mothers were house wifes, and the rest (15.7%) engaged in service. Mean and SD of age-adjusted anthropometric and blood pressure variables are shown in Table 1. Table

Table 1. Characteristics of the study population

Variables	Total		Normotensive		Hypertensive	
	Mean	SD	Mean	SD	Mean	SD
ST (cm)	141.35	14.78	141.39	14.93	140.88	13.55
WT (kg)	39.26	10.20	39.16	10.21	40.29	10.34
WC (cm)	50.62	15.42	50.10	14.71	56.04	21.39
HC (cm)	77.38	15.73	77.32	16.36	77.99	6.28
BMI (kg/m^2)	19.43	3.18	19.38	3.23	19.96	2.67
WHR	0.67	0.21	0.67	0.21	0.72	0.27
CI	0.88	0.22	0.87	0.21	0.96	0.32
SBP (mmHg)	104.99	6.40	104.20	5.89	113.35	5.65
DBP (mmHg)	69.19	7.24	68.47	6.84	76.88	7.03

ST: stature; WT: weight; WC: waist circumference; HC: hip circumference; BMI: body mass index; WHR: waist hip ratio; CI: conicity index; SBP: systolic blood pressure; DBP: diastolic blood pressure; SD: standard deviation.

Original article

2 shows the age adjusted regression analysis between adiposity measures and blood pressures. The results of the analysis revealed a positive correlation of WC with SBP (r=0.315, P<0.01) and DBP (r=0.219, P<0.01), followed by CI (r=0.292, P<0.01 for SBP; r=0.209, P<0.05 for DBP) and WHR (r=0.291, P<0.05 for SBP; r=0.144, P<0.05 for DBP). However, BMI was not a significant (P>0.05) predictor of SBP and DBP. The age and ST adjusted prevalence of systolic and/or diastolic hypertension in the subjects was 8.6%. The overall prevalence of obesity and central obesity was 24.87% and 14.72%, respectively. The adjusted (age and age at menarche) ORs along with 95% confidence intervals of BMI, WC, WHR and CI for hypertension are shown in Table 3. The OR associated with one unit (1.0 cm) increase in WC was 2.20 (95% confidence interval, 1.32-3.69). The value for one unit (0.1) increase in CI was 1.85 (95% confidence interval, 1.14-3.00). In contrast, BMI (OR=1.32, 95% confidence interval, 0.78-2.21) and WHR (OR=1.38, 95% confidence interval, 0.90-2.10) were not significantly (P>0.05) related to hypertension. Thus, the higher risk of hypertension was associated with increasing WC.

Discussion

In the present study, we elucidated the relationship of different adiposity measures with hypertension in Asian Indian children. We found that the prevalence of hypertension was 8.6% in the studied subjects. According to Buch et al,[15] the prevalence of hypertension in Surat school girls was 6.1%, while Prabhjot et al[16] found that the prevalence of hypertension in Amritsar school girls was 6.5%. Thus, comparison with these studies[15,16] revealed a higher prevalence of hypertension in the present study. Moreover, the results of the present study showed that general adiposity measure, i.e. the BMI was not a significant predictor of hypertension. However, WC as a measure of central adiposity was the best adiposity measure in predicting hypertension.

Although BMI was widely used as a measure of general adiposity and related to disease risk, the present study in Asian Indian girls revealed no significant relation of BMI with hypertension. It was also reported that BMI had the lowest predictive value for the detection of CVD risk factors in children of Greek-Cypriot origin.[17] Ellis et al[18] compared the BMI of children with the fat mass measured by DXA and concluded that the accuracy of BMI in predicting fatness was poor in an individual child. A recent study also revealed a higher prevalence of high blood pressure in Pakistan children with lower BMI.[3] This may be due to the fact that BMI not only measures fat mass, it measures both fat and fat free mass without distinguishing between them.[19] Thus, individuals with the same BMI may have different proportions of fat mass. However, the lack of association between BMI and hypertension in South Asian children may be a reflection of lower birth weight. Tamakoshi et al[20] reported that a 1 kg increase in birth weight was associated with a 1.46 mmHg decrease in SBP and the association was pronounced in subjects with lower BMI. Another study[21] revealed that Asian Indians have a high percentage of body fat relative to BMI and muscle mass, which is associated with a proportionate increase in visceral fat. This is more important in girls, because, in contrast to boys, earlier sexual maturation is positively related to excess body fat and the likelihood of persistence of excess body fat from childhood into adulthood is also higher among them.[22]

Different central adiposity measures in the present study revealed that WC was the best predictor of hypertension, followed by CI. In contrast, WHR was not a significant predictor of hypertension. WC, the most widely used indicator of abdominal adiposity in children, was also better than WHR and CI in identifying children with high trunk fat measured with DXA.[7] de Ridder et al[23] reported that WC was a better measure for trunk fat in girls. Moreover, WC was an effective indicator of excess visceral fat in young people,[24] which exhibits higher lipolysis rates than subcutaneous fat and leads to the development of components of metabolic syndrome (hypertension, insulin resistance, and unfavorable lipid levels).[25,26] In contrast, WHR was largely influenced by skeletal structure and correlated poorly with central

Table 2. Regression analysis between adiposity measures and blood pressures

Variables	SBP*			DBP*		
	r	r^2	P	r	r^2	P
BMI (kg/m^2)	0.035	0.001	0.62	0.044	0.002	0.53
WC (cm)	0.315	0.099	0.01	0.219	0.048	0.01
WHR	0.291	0.085	0.01	0.144	0.021	0.05
CI	0.292	0.085	0.01	0.209	0.044	0.01

*: adjusted for age. WC: waist circumference; BMI: body mass index; WHR: waist hip ratio; CI: conicity index; SBP: systolic blood pressure; DBP: diastolic blood pressure.

Table 3. Odds ratios of adiposity measures for hypertension

Variables	OR	95% confidence interval		P
		Lower bound	Upper bound	
BMI (kg/m^2)	1.32	0.78	2.21	0.30
WC (cm)	2.20	1.32	3.69	0.01
WHR	1.38	0.90	2.10	0.14
CI	1.85	1.14	3.00	0.01

BMI: body mass index; WC: waist circumference; WHR: waist hip ratio; CI: conicity index; OR: adjusted odds ratio.

adiposity.[7,21] Moreover, HC changes reflected changes in the bones and muscles more than changes in fat.[27] Similarly, CI was also revealed limitation as an indicator of central adipose tissue distribution in youths.[7] Compared with WHR, however, it was advantageous in calculating adiposity without measurement of HC.[28] This is due to the performance of CI superior to WHR in predicting hypertension.

Other investigations also reported WC as a better predictor of CVD risk factors in children as compared with other adiposity measures.[6,7,17,29,30] Maffeis et al[4] found that WC adjusted for age, gender and BMI was independently correlated with CVD risk factors. Similar results were also observed in Hong Kong Chinese adolescents[31] and in Northern Italian children.[32] Al-Sendi et al[27] reported that girls in the uppermost tertile of WC were seven times more likely to have hypertension than those in the lowest tertile. Furthermore, WC tracks reasonably well from childhood to adulthood. Katzmarzyk et al[33] found that 25%-90% of children and adolescents who were in the highest quintile of WC at baseline remained in that quintile 7 years later.

Comparing the findings of the present study with the studies done in adult Asian Indians, we found that adult Asian Indians have a tendency towards more centralized adipose tissue deposition; WC as a measure of central adiposity is a better marker for adiposity related metabolic risk than a measure of general adiposity indicated by BMI.[5,10] Comparable trends have also been observed in young girls of the present study. The importance of this point was emphasized when adult Asian Indians were particularly predisposed to CVD.[3] Thus, earlier assessment of hypertension risk could plays an important role in prevention and control of hypertension as well as CVD risk in adulthood. Since adiposity and CVD risk factors track from childhood into adulthood,[7,30] elevated blood pressure during childhood is an established predictor of adult hypertension, which in turn increases mortality from CVD.[3] Therefore, WC could be a better option for the prevention and management of hypertension risk in childhood. Recently, Koulouridis et al[34] demonstrated that WC was not only a better predictor of hypertension, but even better than biochemical variables such as fasting blood insulin, glucose, cholesterol, cholesterol-HDL, cholesterol-LDL, triglycerides and uric acid levels in children. Another study[29] also suggested that WC may be reasonably included in clinical practice as a simple tool that may help to identify girls at higher metabolic risk.[4]

The main limitation of the present study is the relatively small sample, and it is not representative of the Indian population. Because of vast ethnic and cultural heterogeneity in Asian Indians, it is imperative to study other ethnic groups to see if the trends observed also exist among them. The results obtained from such studies could be used to prevent CVD risk in adulthood.

In summary, WC is the best predictor of hypertension, and intervention programs designed to reduce WC may significantly reduce the incidence of hypertension in children.

Funding: Partial financial assistance from Visva-Bharati, Govt. of India.

Ethical approval: The DC committee of the Department of Anthropology accepted the study. An informed consent was obtained from the parents of the children.

Competing interest: None.

Contributors: Ghosh JR contributed to the conception of the study, analysis and interpretation of data. Bandyopadhyay AR made the interpretation and critical review of the work.

Original article

References

1 Wan YP, Xu RY, Wu YJ, Chen ZQ, Cai W. Diet intervention on obese children with hypertension in China. World J Pediatr 2009;5:269-274.

2 Monyeki KD, Kemper HCG, Makgae PJ. The association of fat patterning with blood pressure in rural South African children: the Ellisras longitudinal growth and health study. Int J Epidemiol 2006;35:114-120.

3 Jafar TH, Islam M, Poulter N, Hatcher J, Schmid CH, Levey AS, et al. Children in South Asia have higher body mass–adjusted blood pressure levels than White children in the United States: a comparative study. Circulation 2005;111:1291-1297.

4 Maffeis C, Pietrobelli A, Grezzani A, Provera S, Tato L. Waist circumference and cardiovascular risk factors in prepubertal children. Obes Res 2001;9:179-187.

5 Deepa M, Farooq S, Deepa R, Manjula D, Mohan V. Prevalence and significance of generalized and central body obesity in an urban Asian Indian population in Chennai, India (CURES: 47). Eur J Clin Nutr 2009;63:259-267.

6 Botton J, Heude B, Kettaneh A, Borys JM, Lommez A, Bresson JL, et al. Cardiovascular risk factor levels and their relationships with overweight and fat distribution in children: the Fleurbaix Laventie Ville Sante II study. Metabolism 2007;56:614-622.

7 Taylor RW, Jones IE, Williams SM, Goulding A. Evaluation of waist circumference, waist-to-hip ratio, and the conicity index as screening tools for high trunk fat mass, as measured by dual-energy X-ray absorptiometry, in children aged 3-19 y. Am J Clin Nutr 2000;72:490-495.

8 Dencker M, Thorsson O, Linden C, Wollmer P, Andersen LB, Karlsson MK. BMI and objectively measured body fat and body fat distribution in prepubertal children. Clin Physiol Funct Imaging 2007;27:12-16.

9 Hujova Z, Alberty R, Ahlers I, Ahlersova E, Paulikova E, Desatnikova J, et al. Cardiovascular risk predictors in central Slovakian Roma children and adolescents: regional differences. Cent Eur J Public Health 2010;18:139-144.

10 Snehalatha C, Viswanathan V, Ramachandran A. Cutoff values for normal anthropometric variables in Asian Indian adults.

Diabetes Care 2003;26:1380-1384.
11 Bose K, Ghosh A, Roy S, Gangopadhyay S. Blood pressure and waist circumference: an empirical study of the effects of waist circumference on blood pressure among Bengalee male jute workers of Belur, West Bengal, India. J Physiol Anthropol Appl Human Sci 2003;22:169-173.
12 Lohman TG, Roche AF, Martorell R. Anthropometric standardization reference manual. Illinois: Human Kinetic, 1988.
13 de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ 2007;85:660-667.
14 National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. Pediatrics 2004;114:555-576.
15 Buch N, Goyal JP, Kumar N, Parmar I, Shah VB, Charan J. Prevalence of hypertension in school going children of Surat city, Western India. J Cardiovasc Dis Res 2011;2:228-232.
16 Prabhjot A, Kaur N, Kumari K, Sidhu S. Variation in blood pressure among school children of Amritsar (Punjab). Anthropologist 2005;7:201-204.
17 Savva SC, Tornaritis M, Savva ME, Kourides Y, Panagi A, Silikiotou N, et al. Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. Int J Obes Relat Metab Disord 2000;24:1453-1458.
18 Ellis KJ, Abrams SA, Wong WW. Monitoring childhood obesity: assessment of the weight/height index. Am J Epidemiol 1999;150:939-946.
19 Garn SM, Leonard WR, Hawthorne VM. Three limitations of the body mass index. Am J Clin Nutr 1986;44:996-997.
20 Tamakoshi K, Yatsuya H, Wada K, Matsushita K, Otsuka R, Yang PO, et al. Birth weight and adult hypertension: cross sectional study in a Japanese workplace population. Circ J 2006;70:262-267.
21 Banerji MA, Faridi N, Atluri R, Chaiken RL, Lebovitz HE. Body composition, visceral fat, leptin and insulin resistance in Asian Indian men. J Clin Endocrinol Metab 1999;84:137-144.
22 Wang Y. Is obesity associated with early sexual maturation? A comparison of the association in American boys versus girls. Pediatrics 2002;110:903-910.
23 de Ridder CM, de Boer RW, Seidell JC, Nieuwenhoff CM, Jeneson JA, Bakker CJ, et al. Body fat distribution in pubertal girls quantified by magnetic resonance imaging. Int J Obes Relat Metab Disord 1992;16:443-449.
24 Fernandes RA, Rosa CS, Buonani C, de Oliveira AR, Freitas-Junior IF. The use of bioelectrical impedance to detect excess visceral and subcutaneous fat. J Pediatr (Rio J) 2007;83:529-534.
25 Ferreira AP, Oliveira CE, Franca NM. Metabolic syndrome and risk factors for cardiovascular disease in obese children: the relationship with insulin resistance (HOMA-IR). J Pediatr (Rio J) 2007;83:21-26.
26 Sinaiko A. Obesity, insulin resistance and the metabolic syndrome. J Pediatr (Rio J) 2007;83:3-4.
27 Al-Sendi AM, Shetty P, Musaiger AO, Myatt M. Relationship between body composition and blood pressure in Bahraini adolescents. Br J Nutr 2003;90:837-844.
28 Valdez R, Seidell JC, Ahn YI, Weiss KM. A new index of abdominal adiposity as an indicator of risk for cardiovascular disease. A cross population study. Int J Obes Relat Metab Disord 1993;17:77-82.
29 Maffeis C, Corciulo N, Livieri C, Rabbone I, Trifiro G, Falorni A, et al. Waist circumference as a predictor of cardiovascular and metabolic risk factors in obese girls. Eur J Clin Nutr 2003;57:566-572.
30 Sung RY, Yu CC, Choi KC, McManus A, Li AM, Xu SL, et al. Waist circumference and body mass index in Chinese children: cutoff values for predicting cardiovascular risk factors. Int J Obes (Lond) 2007;31:550-558.
31 Leung LC, Sung RY, So HK, Wong SN, Lee KW, Lee KP, et al. Prevalence and risk factors for hypertension in Hong Kong Chinese adolescents: waist circumference predicts hypertension, exercise decreases risk. Arch Dis Child 2011;96:804-809.
32 Genovesi S, Antolini L, Giussani M, Brambilla P, Barbieri V, Galbiati S, et al. Hypertension, prehypertension, and transient elevated blood pressure in children: association with weight excess and waist circumference. Am J Hypertens 2010;23:756-761.
33 Katzmarzyk PT, Perusse L, Malina RM, Bouchard C. Seven-year stability of indicators of obesity and adipose tissue distribution in the Canadian population. Am J Clin Nutr 1999;69:1123-1129.
34 Koulouridis E, Georgalidis K, Kostimpa I, Kalantzi M, Ntouto P, Koulouridis I, et al. Factors influencing blood pressure control in children and adolescents. Int Urol Nephrol 2008;40:741-748.

Received February 1, 2012
Accepted after revision May 24, 2012