

The Relation between Blood Pressure and Body Mass Index in Iranian School Age Children

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Abstract

Background: Association between body mass indexes (BMI) and blood pressure have been observed, but remains poorly understood. BMI is shown to be a measure of overweight status and is applicable to all populations. In this cross-sectional study we have examined the relationship between the BMI and blood pressure in school age children.

Methods: This study comprised of 486 boys and 463 girls at aged from 7 to 14-yrs. We examined the age-adjusted relationship between systolic (SBP) and diastolic (DBP) blood pressures and BMI in three age groups of 7, 11 and 14-yrs. BMI was calculated by dividing the body weight in kg by the square of height in meters (m²). At first multiple regression analyses were separately used for SBP and DBP to establish their association with BMI, age, gender and height. The analyses test was then repeated by replacing BMI by adjusted BMI.

Result: SBP and DBP were positively and significantly related to BMI ($P < 0.01$). According to multivariate regression analysis, SBP and DPB showed significant associations with age and weight with respective relation coefficient of 0.569 and 0.469 for BMI, SBP and DBP.

Conclusion: The results of this study showed that BMI was highly associated and linearly related with both systolic and diastolic blood pressures in Iranian school-age children.

Iran J Med Sci 2006; 31(1): 33-36.

Keywords • Blood pressure • BMI • obesity • children • Iran

Introduction

The prevalence of childhood overweight has increased markedly during the last three decades. Pediatric hypertension seen in association with this prevalence is a reflection of an epidemiologic shift from secondary hypertension (often caused by renal disease) to primary (essential) hypertension.¹ Childhood overweight besides increasing cardiovascular risk factors, increases risk factors such as insulin resistance and dyslipidemia.² Childhood overweight also increases the risk of adolescence obesity and hypertension.^{3,4} There are reports showing high associations between childhood obesity and hypertension in a variety of ethnic and racial backgrounds.^{5,6} Rosner and colleagues have shown the existence of diversity among race ethnic backgrounds in relation to body size and elevated blood pressure.⁷ They also mentioned that blood pressure was significantly higher for upper than

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lower percentiles of BMI.⁷ Thus prevention of childhood obesity may be important in reducing the risk of cardiovascular diseases in old age.

BMI is used as an indicator of overall adiposity, whereas, waist circumference as an indicator of central obesity is a good predictor of abdominal fat.⁸ BMI determines the level of blood pressure in children.⁹ The prevalence of overweight and hypertension among children was found to be substantially higher than what was reported in previously. For example the prevalence of hypertension in children with BMI of less than 85th percentile is only 2.6%, whereas, in children with BMI equal or more than 95th percentile, the prevalence of hypertension increases to 10.7%.¹⁰ In this cross-sectional study, therefore, we tried to find the probable correlations blood pressure and body mass index in Iranian children.

Subjects and methods

The study comprised 463 girls and 486 boys scattered in three age groups of 7, 11 and 14-yrs. One resident of pediatric, not participating in the study, measured blood pressures (mmHg), height (m) and body weight (kg) of all individuals as a routine procedure. In this context, the most recent and explicit pediatric anthropometric reference data for gender and age were used to establish height, weight and BMI percentiles.¹¹ Z scores of BMI were generated from equations provided by Centers of Disease Control and Prevention and exact BMI percentiles were calculated for each individual. Five categories of BMI percentile ($\leq 5^{\text{th}}$, 50th, 90th and 95th) were selected to obtain their associations with systolic (SBP) and diastolic blood pressures (DBP). Height and weight measurements were rounded down to the nearest 0.5cm and 0.1 kg. BMI (kg/m^2) was calculated by dividing the weight in kg by the square of height in meters. SBP and DBP were measured twice using the right arm with an appropriately sized cuff and was rounded down to the nearest two mmHg.

Statistical analyses

Data are presented as mean \pm SD. Multiple regression analyses were used separately for SBP and DBP to establish their associations with BMI, age, gender and height. Multiple regression models were also used to replace the BMI by an adjusted BMI values and $p < 0.05$ was considered as statistically significant.

Results

The interactions of blood pressures with age or gender in multivariate models are shown in

Tables 1 and 2. As shown in Table 3 BMI was higher in seven and 11-yrs-old boys than in girls with similar age. However, it was higher in 14-yrs-old girls due to their rapid growth and maturation in early adolescent.

Multivariate linear regression was used to estimate the age-adjusted slope of blood pressures with BMI. There was a positive correlation between age-adjusted slopes of BMI and the mean SBP and DBP. The correlation coefficient for SBP and DBP were equal to 0.569 and 0.469 respectively ($P < 0.01$). The following equations for SBP and DBP were obtained from Pearson correlation and linear regression analysis.

$$\text{SBP (mmHg)} = 46.3 + [\text{BMI} \times 0.292] + [\text{age (yr)} \times 3.4,2]$$

$$\text{DBP (mmHg)} = 28.012 + [\text{BMI} \times 1.905] + [\text{age (yr)} \times 1.816]$$

Table 1: Mean, median (med) and other percentiles of systolic blood pressure (mmHg) of boys and girls in the three age groups (Age; yr).

Age	N	Mean \pm SD	5th	med	90th	95th
Boys						
7	157	87 \pm 9	70	90	100	105
11	170	104 \pm 13	81	105	120	130
14	159	117 \pm 11	100	120	130	135
Girls						
7	152	89 \pm 11	70	90	108	110
11	160	108 \pm 13	90	107	130	133
14	151	119 \pm 11	100	120	130	137

Table 2: Mean, (mean) median and other percentiles of diastolic blood pressure (mmHg) of boys and girls in the three age groups (Age; yr).

Age	N	Mean \pm SD	5th	Med	90th	95th
Boys						
7	157	55 \pm 11	36	51	70	73
11	170	64 \pm 13	40	65	80	85
14	159	71 \pm 8	57	70	80	85
Girls						
7	152	56 \pm 11	34	60	70	75
11	160	68 \pm 14	40	70	85	86
14	151	74 \pm 9	60	75	85	90

Table 3: Mean, median, and other percentiles of BMI (kg/m^2) values of boys and girls in the three age groups (Age; yr)

Age	N	Mean \pm SD	5th	med	90th	95th
Boys						
7	157	14.0 \pm 1.3	12.0	13.9	16.5	16.9
11	170	16.1 \pm 2.6	13.0	15.5	21.9	22.8
14	159	17.6 \pm 3.2	13.1	16.9	24.1	25.1
Girls						
7	152	13.9 \pm 1.7	11.7	13.7	16.4	16.9
11	160	15.9 \pm 2.8	12.7	15.1	21.1	21.6
14	151	19.2 \pm 3.3	15.1	18.6	24.8	25.7

*BMI distribution is usually positively skewed; therefore, mean \pm SD may not be an appropriate estimate for variation

Discussion

According to the previous reports, obese children have significantly higher blood pressures than non-obese ones.^{12,13} Some studies have also pointed to the presence of a direct rela-

relationship between BMI and SBP but not DBP.^{10,14} There is an association between blood pressure and height of school age children.¹⁵ In a study performed on boys and girls living in Belgrade, Vlajinac and colleagues demonstrated that in boys both SBP and DBP were extensively associated with age, BMI and sub-scapular skin fold. SBP in girls was greatly associated with weight and DBP with triceps skin fold.¹⁶ They also revealed that in girls, SBP was usually associated with BMI, suprailiac and sub scapular skin fold.¹⁶ Higher systolic and diastolic blood pressures were found during routine checkups in obese children with ages ranging from five to 11 yrs.¹⁷ Bose et al. reported that BMI had a strong impact on SBP, but its impact on DBP and mean arterial pressure (MAP) were weak, whereas, waist circumference had a significant association with SBP, DBP and MAP, even after being adjusted for age.¹⁸ Eisenmenn and colleagues, reported that overweight status was significantly associated with high blood pressure and overall (high BMI) and central obesity (high waist circumference) are important determinants of resting blood pressure in young children.¹⁹ In our study, SBP and DBP were somewhat higher in girls than in boys but their differences were not statistically significant. This was in contrast to the previous studies where systolic and diastolic blood pressures were higher in boys than girls.^{10,20}

Most studies have demonstrated the prevalence of elevated blood pressure or hypertension with successive the increased BMI percentile, even within normal range of BMI.^{9,13,14,20-22} Reports of Paradis and colleagues indicated that BMI was consistently associated with SBP and DBP in all age and gender groups.²³ A cohort study demonstrated that those children who were somewhat overweight but had a normal BMI at age of five-yrs but were obese at age of 14-yrs had higher blood pressures than those of similar ages with normal BMI at bodyweight.²⁴

Chen et al. reported that age significantly modifies the relations of BMI with DBP in both sexes, with the prevalence of high blood pressure being more pronounced in females.²⁵ The results of the present study indicated that after adjustment for age and gender there was a positive and significant correlation between BMI and blood pressures in all age groups of children and adolescent participated in this study ($P < 0.001$). In these groups the correlation coefficients (r) between BMI, SBP and DBP were 0.569 and 0.469 respectively, whereas, in the study of Bose et al. no correlation was found between BMI, SBP and DBP.¹⁸ This result was in agreement with several previously studies.^{8,13,14,20-22,26}

Our study showed an approximate linearity in regard to relationship between blood pressures and BMI in children. However, in some studies, this association was plateaued out at the middle and the upper levels of BMI for systolic blood pressures with the exception of aged over 70 yrs. In a cohort study including middle aged men a linear relationship was found between BMI and both SBP and DBP.²⁷ Kerry SM et al. reported that the relationship between BP and BMI in thin rural and semi-urban adult subjects in West Africa were not linear and was possibly sigmoid, which probably varied between subgroups.²⁸

Conclusion

Body mass index seems to be conclusively associated with blood pressure in school age children; therefore, it may be used as a predictor of high blood pressure.

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