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The Relationship of Body Mass Index and Blood Pressure in Iranian Children <7 Years Old

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Summary

The objective of this study was to evaluate the association between the body mass index (BMI), in healthy young children with their blood pressure (BP). The study included 3186 healthy children aged 1–6 years who were studied between March 2004 and March 2007 in different kindergartens and health centers in Tehran. Each child was classified on the basis of age- and sex-specific BMI percentile as normal weight (BMI <85th percentile), at risk for overweight (BMI >85th and <95th percentile), or overweight (BMI ≥95th percentile). Systolic BP (SBP) and diastolic BP (DBP) was compared among age–sex–BMI groups. Among children aged below 7 years in kindergartens and health centers in Tehran, 7.2% were at risk of overweight and 12.2% were overweight. These proportions were similar for boys and girls and were as follows: 6.9%, 13.9% and 7.5%, 10.5%, respectively. Analysis of variance showed that mean SBP significantly increased according to age ($p < 0.0001$) and BMI group ($p = 0.001$). Analysis of variance also showed that mean DBP significantly increased as age increased ($p < 0.0001$), but no significant difference was found between boys and girls in different age and BMI groups ($p = 0.37$). Our survey identified a high prevalence of overweight that was associated with elevated SBP among preschool-aged children in Iran. The effect of higher BMI on mean SBP is present in childhood and can be used as a predictor of high SBP even in children as young as 1–6 years.

Key words: preschool children, body mass index, blood pressure.

Introduction

Hypertension in the adult population is associated with an increased incidence of stroke, coronary heart disease, congestive heart failure and renal insufficiency [1, 2]. The origin of some cases of adult hypertension may lie in childhood or adolescence, preventive intervention begun early in life may reduce the risks of cardiovascular disease and target organ damage during later life [3–5].

Recent reports demonstrate that higher blood pressure (BP) during adolescence is associated with an increase in left ventricular mass [6] and significant thickening of carotid arterial walls in healthy young adults [7]. The marked increase in adiposity among children and adolescents over the past few decades is well established. In some studies, health statistics showed that the prevalence of overweight in very young children (age 2–5 years), rose from 7.2% to 10.4% during the most recent decade [8]. Several studies have identified the association between obesity and arterial hypertension in children and adolescents [9–11]. To date, only a few studies have examined the correlation between overweight and BP in preschool children [12].

The aim of this study was to determine whether an association between overweight, or risk of overweight, and BP could be detected in children under the age of 7 years.

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TABLE 1
Height, weight and BP according to age and sex

Age group (years)	Sex (*n*)	Height (cm)	Weight (kg)	SBP (mmHg)	DBP (mmHg)
1	Boy (336)	67.5 ± 9.55	7.5 ± 2.2	83.0 ± 10.0	54.2 ± 11.0
	Girl (288)	67.9 ± 9.7	7.5 ± 2.1	81.2 ± 9.7	55.0 ± 11.5
2	Boy (271)	85.1 ± 7.6	12.3 ± 5.0	91.8 ± 9.3	56.2 ± 10.1
	Girl (259)	85.5 ± 8.5	12.0 ± 6.9	89.7 ± 9.9	55.2 ± 10.0
3	Boy (246)	92.8 ± 6.2	13.3 ± 1.8	96.8 ± 8.3	58.9 ± 11.0
	Girl (248)	93.0 ± 6.8	13.4 ± 2.0	96.3 ± 10.0	58.5 ± 11.2
4	Boy (211)	100.6 ± 5.8	15.2 ± 2.6	101.1 ± 10.1	64.1 ± 10.3
	Girl (240)	99.5 ± 6.2	15.1 ± 2.6	99.9 ± 10.7	63.2 ± 10.6
5	Boy (259)	107.8 ± 5.3	17.5 ± 3.2	103 ± 9.7	66.2 ± 10.1
	Girl (248)	106.6 ± 5.0	16.7 ± 2.9	103.85 ± 9.5	65.9 ± 10.5
6	Boy (272)	113.1 ± 5.6	20.3 ± 3.9	107.5 ± 10.0	69.0 ± 10.6
	Girl (308)	112.7 ± 5.6	19.6 ± 3.6	107.4 ± 10.5	69.0 ± 10.4

Values are mean ± SD.

Materials and Methods

The study included 3186 children aged 1–6 years who were studied between March 2004 and March 2007 in different kindergartens and health centers in Tehran as representative of pre- school children in Iran. Tehran is divided into 20 regions for administrative purposes. In each part of the city, one kindergarten and one health center was selected randomly. Clinical and demographic data, including height, weight and BP, were measured during the study. Measurements were obtained by a medical assistant or nurse trained in pediatrics. Height, weight and BP measurements were entered into the questionnaires. Height was measured without shoes on a wall-mounted stadiometer (infants in supine) and weight was measured without heavy clothing using a balance-beam scale (Seca Models 710 and 725 Germany in children older than 2 years and infants, respectively), which was calibrated daily. Informed consent was obtained from parents or guardians.

All BP measurements were performed with the child in a comfortable sitting position (infants supine) by auscultation with an appropriate-sized cuff and a mercury sphygmomanometer (Model 1002, Presameter, Riester, Germany). First Korotkoff (K1) phase was used as a measure for systolic BP (SBP) and fourth Korotkoff (K4) phase was used as a measure for diastolic BP (DBP) [13]. The mean of two readings with an interval of at least 30 s at each examination was used for data analysis.

Children were classified on the basis of age and sex-specific body mass index (BMI) percentile into three groups: BMI<85th percentile, at risk for overweight BMI ≥85th and <95th percentile and BMI≥95th percentile [14]. BMI was calculated as weight (kg)/height^2 (m^2).

Data from a total of 3186 children were analyzed. The mean BP for each age–sex–BMI group was calculated. The effect of BMI category and age and sex on mean SBP and mean DBP were analyzed by analysis of variance. Data were analyzed using STATA (8.0) statistical package.

Results

A total of 3186 children aged 1–6 years were included in this study. The sample contained a similar number of boys ($n = 1595$) and girls ($n = 1591$). Table 1 presents the mean and SD for height, weight, SBP and DBP for boys and girls according to age group. The table shows the expected increases in both mean SBP and mean DBP with age. Mean SBP was slightly lower in girls compared with boys, whereas mean DBP was approximately similar in boys and girls in each age group.

The distribution of normal weight children (BMI <85th percentile), children at risk for overweight (BMI 85th to 94th percentile) and overweight (BMI ≥95th percentile) for each age group is shown in Table 2.

Overall, 80.6% of the children had BMI<85th percentile, 7.2% were at risk for overweight and 12.2% were overweight with BMI ≥ 95th percentile. These proportions were similar for boys and girls and were as follows: 79.2%, 6.9%, 13.9% and 82.0%, 7.5% 10.5%, respectively. However, the proportion of overweight children were not similar across the age groups and between boys and girls ($p = 0.02$ and $p = 0.003$, respectively).

Mean SBP values for each BMI and age group are provided for boys and girls separately and shown in Table 3.

As Table 3 shows that the mean SBP in different BMI group is steadily increasing as age increases for both sexes. Also, the mean SBP were somewhat higher in the overweight group compared with the normal weight group, with intermediate values in the

TABLE 2
Sample size (n) and distribution (%) of overweight and 'at risk for overweight' children in different ages

Age (years)	BMI			
	<85th percentile	85th to 94th percentile	≥95th percentile	Total *n* (%)
1	546 (87.5%)	37 (5.9%)	38 (6.6%)	624 (100%)
2	366 (69.2%)	50 (9.4%)	114 (21.4%)	530 (100%)
3	400 (81%)	46 (9.3%)	48 (9.7%)	494 (100%)
4	389 (86.5%)	25 (5.5%)	37 (8.0%)	451 (100%)
5	431 (85.1%)	35 (6.9%)	41 (8.0%)	507 (100%)
6	437 (75.2%)	36 (6.1%)	107 (18.7%)	580 (100%)
Total	2569 (80.8%)	229 (7.2%)	388 (12.2%)	3186 (100%)

TABLE 3
Mean SBP in BMI, age and sex groups

	BMI		
	<85th percentile	85th to 94th percentile	≥95th percentile
SBP (mmHg)			
Boys			
1 y	82.8 ± 10.1 (291)	84.7 ± 7.6 (20)	85.3 ± 10.6 (25)
2 y	92.5 ± 9.7 (170)	92.1 ± 9.6 (28)	90.0 ± 8.0 (73)
3 y	97.1 ± 8.6 (198)	95.5 ± 7.3 (27)	95.6 ± 6.0 (21)
4 y	100.7 ± 10.2 (189)	103.5 ± 6.7 (10)	106. 4 ± 11.1 (12)
5 y	102.7 ± 9.4 (217)	106.6 ± 10.0 (16)	107.1 ± 11.0 (26)
6 y	107.2 ± 9.4 (199)	108.6 ± 9.7 (9)	108.5 ± 11.8 (64)
Girls			
1 y	80.8 ± 9.7 (255)	82.1 ± 6.2 (17)	85.5 ± 12.0 (16)
2 y	90.0 ± 9.2 (196)	92.8 ± 13.1 (22)	86.4 ± 10.5 (41)
3 y	96.2 ± 9.4 (202)	94.3 ± 7.4 (19)	98.8 ± 14.8 (27)
4 y	99.3 ± 10.7 (200)	98.4 ± 5.7 (15)	105.6 ± 11.6 (25)
5 y	103.7 ± 9.4 (214)	103.5 ± 10.4 (19)	106.5 ± 10.0 (15)
6 y	107.1 ± 10.4 (238)	107.7 ± 9.4 (27)	108.9 ± 11.9 (43)

'at risk for overweight group'. Almost in all age-BMI groups mean SBP is slightly lower in girls compared with boys.

Analysis of variance showed that mean SBP significantly increased according to age ($p < 0.0001$) and BMI group ($p = 0.001$), and was significantly ($p = 0.004$) higher in boys than in girls. On the other hand, there was evidence of some more increase in mean SBP values among overweight and older children ($p = 0.001$, interaction of age and BMI level).

In Table 4, the mean DBP values for each BMI and age group are provided for boys and girls separately.

Table 4 shows that mean DBP in different BMI group is increasing as age increases for boys and girls. However, there is no difference in mean DBP between boys and girls. Analysis of variance showed that mean DBP significantly increased as age increases ($p < 0.0001$) but no significant difference was found between boys and girls in different age and BMI groups ($p = 0.37$). Also, there is no evidence of increase in the mean DBP values in the overweight group compared with the other BMI groups ($p = 0.24$).

Discussion

Many studies have highlighted the association between excess weight and elevated BP. [15, 16] However, the mechanisms by which obesity induces hypertension are poorly understood. Although the relationship between BMI and BP has been well studied in all age groups including older children and adolescents, information on toddlers and in young children has been limited [12]. To our knowledge this is the first report on this subject among Iranian children aged <7 years. An examination of clinical data for 3186 children aged 1–6 years in different kindergartens and health centers in Tehran identified high rate of both overweight and risk of overweight.

Data from the 1999–2000 National Health and Nutrition Examination Survey (NHANES) reported

TABLE 4
Mean DBP in BMI, age and sex groups

	BMI		
	<85th percentile	85th to 94th percentile	<95th percentile
DBP (mmHg)			
Boys (age in years)			
1 y	54.3 ± 11.1 (291)	53.9 ± 7.6 (20)	53.7 ± 12.0 (25)
2 y	56.6 ± 10.6 (170)	57.6 ± 10.5 (28)	54.7 ± 8.47 (73)
3 y	59.8 ± 11.2 (198)	54.6 ± 9.7 (27)	55.3 ± 8.43 (21)
4 y	63.8 ± 10.4 (189)	67.5 ± 5.3 (10)	66.0 ± 12.5 (12)
5 y	66.1 ± 10.3 (217)	68.3 ± 11.0 (16)	65.9 ± 8.7 (26)
6 y	69.5 ± 10.2 (199)	66.4 ± 11.6 (9)	67.9 ± 12.0 (64)
Girls (age in years)			
1 year	54.9 ± 11.5 (255)	57.2 ± 9.4 (17)	53.5 ± 13.6 (16)
2 y	54.9 ± 8.8 (196)	57.9 ± 15.2 (22)	54.7 ± 11.9 (41)
3 y	58.4 ± 11.2 (202)	59.5 ± 10.4 (19)	58.0 ± 11.8 (27)
4 y	63.1 ± 10.7 (200)	59.7 ± 7.1 (15)	66.0 ± 11.3 (25)
5 y	65.7 ± 10.1 (214)	67.3 ± 11.0 (19)	67.0 ± 14.8 (15)
6 y	69.6 ± 10.0 (238)	67.5 ± 10.7 (27)	66.6 ± 12.1 (43)

Values are mean ± SD and number of children are given in parenthses.

a prevalence of overweight of 15.3% in both children and adolescents [17].

We demonstrated that according to the BMI percentiles, 7.2% of the children were at risk of overweight and 12.2% were overweight which shows an elevated prevalence of children above the normal weight range. The prevalence of overweight, detected in this series is slightly higher than the prevalence of childhood overweight derived from the NHANES [17].Approximately 19.4% of pre-school children have BMI>85th percentile. These data demonstrate a significant association between age, BMI and SBP in children aged 1–6 years.

This study analyzed data from different kindergartens and health centers from Tehran (capital city of Iran), which could be taken as a nationally representative sample of very young Iranian children. In general, our findings are in accordance with observations of Preece (personal communication, 1994) that, in the developing world, capital cities tend to include people drawn from all parts of the country; thus the data could be representative of the health profile of children under the supervision of primary care in kindergartens and health centers.

Numerous longitudinal reports have demonstrated that the excessive levels of BMI are strongly associated with high BP in children and adolescents [18, 19]. It is also known that both SBP and DBP increase with BMI [13, 20]. Compared with children with BMI<85th percentile, mean SBP was higher in children with higher BMI levels ($p = 0.001$) as was observed by Falkner *et al*. [12] and others [20].

However, in the present study we found no significant association between mean DBP and BMI in both genders ($p = 0.37$) and this observation was the same for different BMI levels.

This finding was in accordance with results as reported by Rankinen *et al*. [21], and Burke *et al*. [22] Bose *et al*. [23], also reported that BMI had a strong impact on systolic, but its impact on DBP and mean arterial pressure were weak.

The SD for SBP and DBP in each age group of our children compared with the SD for SBP and DBP in the national childhood BP dataset provided in the Working Group report [24]. These national childhood BP data, report SDs for SBP of 10.7 mmHg for males and 10.5 mmHg for females and SD of DBP of 11.6 mmHg for males and 11.0 mmHg for females. As shown in Tables 3 and 4 the SD of BP values in our series are nearly identical.

In the present study, SBP was significantly ($p < 0.004$) higher in boys than in girls adjusted for BMI, which is in agreement with some previous studies [21, 25, 26]. Jafar *et al*., revealed that these differences persisted even after adjustment for sociodemographic factors [26]. The mechanisms responsible for the sex differences in BP levels are not clear, although it is speculated that interactions between sex hormones and the kidneys could play a protective role in females [27]. However, the potential role of female sex hormones on BP needs to be determined.

Obesity during childhood has been reported to be strongly associated with SBP in children and in adults [28]. We observed significant relationships between SBP and BMI in children.

It was worth mentioning that using the proportion of overweight in children in the United States

as reference; the prevalence of overweight in children in Iran would be 12.6%. This is >5% predicted prevalence of overweight in children in the United States based on same criteria. The reasons for higher overweight levels in Iranian children vs. those in the United States need further exploration. However, this would not affect the general findings on association between SBP and DBP, and age and BMI for boys and girls in our study.

Conclusion

Our survey identified a high prevalence of overweight that was associated with elevated SBP among preschool-aged children in Iran. The effect of higher BMI on mean SBP is present in childhood and can be used as a predictor of high SBP even in children as young as 1–6 years. Public health policies, for preventing childhood obesity and its hemodynamic consequences beginning early in life are required.

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