High Blood Pressure in Obese and Nonobese Japanese Children: Blood Pressure Measurement is Necessary Even in Nonobese Japanese Children

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ABSTRACT

Background: Although the prevalences of obesity and hypertension (HT) are increasing in children, there have been few epidemiological studies of HT in Japanese children. We evaluated the prevalences of HT and high-normal blood pressure (HNBP), and examined the relationship between blood pressure (BP) and body mass index (BMI), in Japanese children.

Methods: The subjects of this study were 2420 children living in the town of Ina, Saitama Prefecture, Japan during the period from 2006 through 2008. Body height, weight, and BP were measured. HT and HNBP were defined according to the HT criteria for Japanese children. Children with HNBP or HT were defined as having high blood pressure (HBP).

Results: The prevalences of HBP were 15.9% and 15.8% in fourth-grade boys and girls, respectively, and 11.1% and 10.8% in seventh-grade boys and girls, respectively. Irrespective of sex or grade level, a higher BMI was associated with a higher prevalence of HBP (P < 0.001). When compared with the <50th percentile BMI category, the crude odds ratios (ORs) were statistically significant for the 75th to 84th percentile category in fourth-grade boys (OR: 4.54, 95% CI: 2.36–8.76), the ≥95th percentile in fourth-grade girls (13.29, 5.93–29.77), the 85th to 94th percentile (3.16, 1.46–6.84) in seventh-grade boys, and the ≥95th percentile (7.96, 3.18–19.93) in seventh-grade girls.

Conclusions: BMI was associated with HBP in Japanese school children. In addition, some children in the lower BMI categories also had HBP.

Key words: high blood pressure; children; BMI; hypertensive family history

INTRODUCTION

In recent years, the rising obesity epidemic has been paralleled by a similar epidemic in hypertension (HT). The prevalence of childhood obesity increased from 5% to 11% in the United States from the 1960s to the 1990s. An analysis of nationwide surveys from 1963 to 2000 found that childhood HT has been increasing in US children since the late 1980s.

In Japan, there has been little opportunity to measure blood pressure (BP) among children, because BP measurement was not included in annual health check-ups of elementary and junior high school. Therefore, there have been few epidemiological studies on BP in Japanese children. Thus, the objective of the present study was to evaluate the prevalences of HT and high-normal BP (HNBP), and to examine the relationship between BP and body mass index (BMI), in Japanese children.
Data collection
The following information was collected for each child from his or her parent or guardian by using a self-administered questionnaire: age, sex, and past history of HT in the subject’s father and mother (ie, family history of HT). In the annual school health examination, all subjects were asked to remove their shoes and socks, after which their height and weight were measured in increments of 0.1 cm and 0.1 kg, respectively, while they were wearing light clothing. BMI was calculated as body weight (kg) divided by the square of height (m).

Blood pressure measurement
After instructing each subject to sit and rest, a health check-up nurse measured BP in the right upper arm using a mercury manometer and a stethoscope. The size of the cuff was 9 cm for the fourth graders and 12 cm for the seventh graders. For fourth graders whose the 9 cm cuff was too small, the 12 cm cuff was used. When systolic blood pressure (SBP) was ≥120 mm Hg or diastolic blood pressure (DBP) was ≥70 mm Hg, BP was measured 3 times, and the value at the third measurement was recorded.

Determination of HT and HNBP
According to the HT criteria for Japanese children (Japanese Society of Hypertension Guidelines Subcommittee for the Management of Hypertension; JSH2004), HT and HNBP were defined as follows. In fourth graders, an SBP ≥135 mm Hg or DBP ≥80 mm Hg was defined as HT. In seventh graders, an SBP ≥140 mm Hg or DBP ≥85 mm Hg was defined as HT in boys, while an SBP ≥135 mm Hg or DBP ≥80 mm Hg was defined as HT in girls. A BP between normal BP (NBP) and HT was regarded as HNBP (fourth graders: 125 ≤ SBP < 135 or 70 ≤ DBP < 80, seventh-grade boys: 130 ≤ SBP < 140 or 70 ≤ DBP < 85, seventh-grade girls: 125 ≤ SBP < 135 or 70 ≤ DBP < 80). Children with either HNBP or HT were considered to have high blood pressure (HBP).

Statistical analysis
The Mann–Whitney U-test was used to compare characteristics between boys and girls after the normality of distribution was tested for each variable. In the stratified analysis by sex and grade level, the relationship between HBP and BMI was investigated using the chi-square test and a logistic regression model. In the analysis of the association of HBP with BMI and family history of HT, BMI was analyzed as a categorical variables (<50th, 50th to 74th, 75th to 84th, 85th to 94th, and ≥95th percentile). A P value < 0.05 was considered statistically significant. Data were analyzed using SPSS statistical analysis software package (16.0J).

RESULTS
Among 2420 subjects, 35 were excluded from the analysis because of refusal to participate or school absence. Thus, data from a total of 2385 were analyzed. The rates of participation for the fourth and seventh graders were 98.7% (1297 of 1314 children) and 98.4% (1088 of 1106 children), respectively.

Table 1 shows the characteristics of the participants. Of the 2385 children, 1297 were fourth graders (661 boys and 636 girls) and 1088 were seventh graders (566 boys and 522 girls), with median ages of 9.0 years and 12.0 years, respectively. Median BMIs were 16.5 and 16.2 for fourth-grade boys and girls, respectively, and 17.9 and 18.3 for seventh-grade boys and girls, respectively. Median BMIs were 16.5 and 16.2 for fourth-grade boys and girls, respectively, and 17.9 and 18.3 for seventh-grade boys and girls. Median SBPs for fourth-grade boys and girls were 108 and 105 mm Hg, respectively, while those for seventh-grade boys and girls were 110 and 105 mm Hg; in both grades, SBP was significantly higher in boys than in girls (fourth graders: P = 0.009; seventh graders: P < 0.001). DBP was significantly higher in fourth-grade boys than in fourth-grade girls (P = 0.026), but no significant sex difference in DBP was seen in seventh graders. The proportions of children with a family history of HT were 3.6% and 4.2% for fourth-grade boys and girls, respectively, while those for seventh-grade boys and girls were 5.8% and 6.1%.

Data are expressed as a median (mean) or percentage (%).

| Table 1. Characteristics of subjects |
|-------------------------------------|
|                                    |
| **Fourth graders (age 9–10 years)** |
| **Boys (n = 661)**                  | **Girls (n = 636)**                  | **P-value** |
| Age (years)                         | 9.0 (9.2)                            | 9.0 (9.3)   | 0.082 |
| Height (cm)                         | 134.6                                | 133.8       | 0.198 |
| Weight (kg)                         | 30.0                                 | 29.2        | 0.006 |
| BMI (kg/m²)                         | 16.5                                 | 16.2        | 0.004 |
| SBP (mm Hg)                         | 108.0 (109.3)                        | 107.0 (107.7)| 0.009 |
| DBP (mm Hg)                         | 60.0 (58.3)                          | 58.0 (57.4) | 0.026 |
| Family history of HT (%)            | 3.6                                  | 4.2         | 0.869 |
| **Seventh graders (age 12–13 years)** |
| **Boys (n = 566)**                  | **Girls (n = 522)**                  | **P-value** |
| Age (years)                         | 12.0 (12.3)                          | 12.0 (12.3) | 0.433 |
| Height (cm)                         | 154.5                                | 152.7       | 0.001 |
| Weight (kg)                         | 42.9                                 | 43.3        | 0.974 |
| BMI (kg/m²)                         | 17.9                                 | 18.3        | 0.005 |
| SBP (mm Hg)                         | 110.0 (109.8)                        | 105.0 (106.7)| <0.001 |
| DBP (mm Hg)                         | 56.0 (56.6)                          | 56.0 (57.3) | 0.323 |
| Family history of HT (%)            | 5.8                                  | 6.1         | 0.898 |

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; HT, hypertension.
The prevalences of HBP in fourth-grade boys and girls were 15.9% and 15.8%, respectively, and those for seventh-grade boys and girls were 11.1% and 10.8% (Table 2). In both grades, there was no significant difference between boys and girls in the prevalence of HBP; however, the prevalence of HBP was significantly higher among fourth graders than among seventh graders (boys: \( P = 0.016 \), girls: \( P = 0.015 \); data not shown).

The associations of HBP with BMI and a family history of HT are shown in Table 3. A higher BMI category was associated with a higher prevalence of HBP regardless of sex or grade level (\( P < 0.001 \)). Among fourth graders, there was no significant association between HBP and a family history of HT in either sex; however, among seventh-grade boys, the prevalence of HBP was significantly higher in those with a family history of HT than in those without such a history (\( P = 0.022 \)). There was no significant difference among seventh-grade girls (\( P = 0.561 \)).

Logistic regression analysis was conducted using HBP as an objective variable to calculate the odds ratio (ORs) of HBP and their 95% confidence intervals (95% CIs) (Table 4). With the <50th percentile BMI category as the reference, the crude OR was statistically significant for the 75th to 84th percentile category of fourth-grade boys (OR: 4.54, 95% CI: 2.36–8.76), the ≥95th percentile of fourth-grade girls (13.29, 5.93–29.77), the 85th to 94th percentile (3.16, 1.46–6.84) of seventh-grade boys, and the ≥95th percentile (7.96, 3.18–19.93) of seventh-grade girls. The adjusted ORs were similar to the crude ORs.

### DISCUSSION

In this study, the prevalences of HBP in fourth and seventh graders were approximately 16% and 11%, indicating that there was an approximately 5% difference in HBP prevalence between fourth and seventh graders. Previous studies have shown that BP in childhood was not influenced by age, but that physiological and/or endocrinological factors do affect BP. Therefore, future study will be necessary to examine this question from the perspectives of physiology and endocrinology.
A higher BMI was associated with an increased prevalence of HBP, as was previously reported. In particular, the adjusted OR for fourth-grade boys reached statistical significance at the 75th to 84th percentile BMI category, which would be categorized as a healthy weight if the weight status categories of the Centers for Disease Control and Prevention (CDC) were applied. This suggests that BP measurement is necessary even for children who are not overweight or obese.

In this study, a statistically significant association between HBP and a family history of HT was observed in seventh-grade boys. This result was consistent with that of previous studies, which showed that BP in children was related to a family history of HT. Furthermore, a parental history of HT, which has been reported to be associated with BP, was included as a potential confounder in the logistic regression model. However, the possibility of residual confounding factors cannot be denied, it is necessary to conduct another study that adjusts for other potential confounding factors, such as diet and exercise. In addition, the subjects in this study were children from only 1 town in Japan. Therefore, it is difficult to generalize these results to all Japanese children.

A limitation of the present study was its cross-sectional design. Therefore, the direction of causality cannot be determined with respect to BMI and HBP. In the future, longitudinal research will be necessary to address this question. A family history of HT, which has been reported to be associated with BP, was included as a potential confounder in the logistic regression model. However, because the possibility of residual confounding factors cannot be denied, it is necessary to conduct another study that adjusts for other potential confounding factors, such as diet and exercise. In addition, the subjects in this study were children from only 1 town in Japan. Therefore, it is difficult to generalize these results to all Japanese children.

In conclusion, our data suggest that higher BMI is associated with higher prevalence of HBP. However, children in the lower BMI categories also had HBP. Therefore, BP measurement is necessary even for these children. To realize this hope of BP measurement for all children, it is necessary to add BP measurement as a required part of health education, because BP measurement is an excellent part of health education, because BP measurement is necessary even for children who are not overweight or obese.

Therefore, it is important to screen BP as early as possible and to begin health education at the first appearance of HNBP. However, BP can be affected by several factors. Some children are unfamiliar with BP measurement and their anxiety might affect their BP. Thus, it is important to measure BP periodically, so that children are familiar with the measurement technique and the effect of anxiety is minimized. Additionally, reported that BP measurement is an excellent part of health education, because BP measurement is noninvasive, inexpensive, and requires only a short period of time. Accordingly, lifestyle and health guidance should be provided not only to hypertensive children, but also to those with HNBP.
test in preschool and school health check-ups, so that BP measurement is available for both clinical and preventive medicine. This should facilitate early lifestyle interventions that may prevent HBP, resulting in a contribution to primary prevention for lifestyle-related diseases, including HT.

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