Diet intervention on obese children with hypertension in China

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Background: **Obesity has made obesity-related diseases a worldwide problem. This study was undertaken to evaluate the effects of diet-oriented intervention on obese children with hypertension in China and to determine the relationship between anthropometric indexes and hypertension.**

Methods: **A total of 469 obese children, aged 6 to 18 years, were evaluated between January 2001 and December 2005; 184 of them were diagnosed with hypertension. Hypertensive children were provided with individual diet-oriented intervention for more than 6 months. Physical exercises were recommended for obese children at least 30 minutes per day. Height, body weight, waist circumference, systolic blood pressure, and diastolic blood pressure were taken for each subject before and after intervention.**

Results: **Of the 184 children enrolled, 139 (75.5%; 86 boys) completed the study. Weight, body mass index (BMI), waist circumference, and hip circumference all decreased after a 6-month intervention, despite a 2.1 cm increase in height. Systolic and diastolic pressures decreased by 16.6 and 13.3 mmHg compared with baseline levels. Of the 139 children, 103 (74.1%) who had blood pressure in the normal range (<90th percentile for age and sex) were taken as a response group. The other 36 children who remained hypertensive showed no obvious differences in anthropometric measurements and were taken as a non-response group. Weight, BMI, BMI%, waist circumference, hip circumference and blood pressure in the 139 children showed significant differences after the intervention compared with baseline values. Weight, BMI, BMI%, waist circumference, and hip circumference were positively correlated with both systolic and diastolic blood pressures; they were correlated more strongly with systolic pressure than with diastolic pressure.**

Conclusions: **Diet-oriented intervention can decrease blood pressure in most obese children with hypertension. Weight, height, BMI, BMI%, waist circumference, and hip circumference are closely associated with blood pressure.**

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Key words: **body mass index; children; diet intervention; hypertension; obesity**

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Original article

Introduction

Obesity in recent decades has made obesity-related diseases a worldwide problem. The prevalence of obesity in children increases in both developed and developing countries.[1-6] Since hypertension is one of the chronic metabolic diseases associated with obesity,[7] the management of obesity and its complications has been the focus of investigation. Less information is available about the management of obesity and hypertension in children than in adults. Body mass index (BMI) and waist circumference (WC) are two common indexes used to screen adult obesity, but the relationship between BMI, WC, and blood pressure in children remains uncertain. This study aimed to evaluate the effect of diet-oriented intervention on obese children with hypertension in China, and to clarify the relationship between BMI, WC, and blood pressure.

Methods

Subjects

Between January 2001 and December 2005, 469 obese children, aged 6 to 18 years, were identified at an outpatient setting. Of these 469 children, 184 hypertensive ones were enrolled in this study (Fig.). Exclusion criteria were secondary obesity (known drug history of corticosteroids and antipsychotics) and known renal or endocrine disease. During each clinical visit, records were made of weight, height, WC, systolic blood pressure (SP), diastolic blood pressure (DP), and 24-hour diet recall. Only the measurements at baseline and at the end of the study were used for analysis.

Obesity was defined as BMI ≥95th percentile for age and sex.[8] Hypertension was confirmed by SP and/or DP ≥95th percentile for age and sex.[7]

The study was approved by the Ethics Committee of Ren Ji Hospital, School of Medicine, Shanghai Jiao Tong University. The children's parents/caretakers signed informed consent.

Anthropometric measurements

Body weight was measured with underwear by an electronic scale (Tanita body composition analyzer TBF-410, Japan). A standardized wall-mounted height board (SG-210.height board instrument, ZiLang Instrumrnt Corp., Ltd., Nantong, China) was used to measure height with children barefooted. BMI was calculated as body weight in kilograms divided by the square of height in meters. Because there was a wide range of 6 to 18 years, we used a valuable BMI%, which is calculated as a measurement of BMI divided by 95th percentile of age and gender BMI cut-off point for obesity × 100%.[8] WC was obtained midway between the iliac crest and the lower most margins of the ribs with bare belly and at the end of a normal expiration while the subjects were in a standing position.

Measurement of blood pressure

Blood pressure was measured in the subject's right arm after the subject had been seated in a quiet room for 15 minutes. A special cuff that fit 2/3 of the patient's arm would be chosen. Blood pressure was measured with the cubital fossa at heart level. SP was determined by the onset of tapping Korotkoff sounds. DP was confirmed by the fifth Korotkoff sound.[9] Blood pressure was measured twice between 2 pm and 5 pm for all obese children. The interval between the two BP measurements was 10 to 15 minutes, and the average value was recorded.

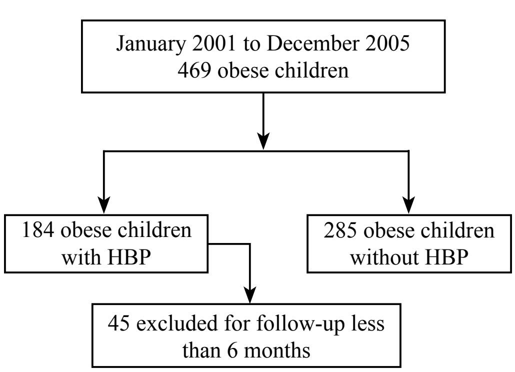

Fig. Subject selection in the study. HBP: high blood pressure.

Therapeutic protocol

Dietary protocol

A moderate energy restriction diet was designed according to Chinese dietary reference intake.[10] The diet intervention plan was composed of three periods and lasted for more than 6 months. The first stage (1 month) involved total energy intake reduction of 100 to 200 kcal per week. The second stage (4 months) involved maintenance of age-appropriate total energy intake, with 45% to 50% of calorie from carbohydrates, 20% to 25% from protein, and 25% to 30% from fat. Total energy intake was 1200 to 1500 kcal per day for children aged 6 to 9 years, 1600 to 1800 kcal per day for children aged 10 to 14, and 1800 to 2000 kcal per day for adolescents aged 15 to 18 years. The third stage (1 month or more) for all subjects, total energy intake returned to normal energy requirement, with an increase in daily intake of 100 to 200 kcal every other week. No additional food or beverage was permitted, except for water. Total energy intake was divided, with 25% for breakfast, 40% for lunch, and 35% for supper. Milk and seafood were the major recommended sources of fat and protein.

When the subjects and their parents/caretakers began the program, they were required to attend nutritional course, where they received education about nutritional requirements, composition of foods, appropriate food preparation and the complications of obesity.

Physical exercises

Physical exercises were recommended for 30 minutes per day, including walking upstairs/downstairs, swimming, jogging, running, and rope jumping.

Blood pressure assessment

Children whose blood pressure was in the recommended range (<90th percentile for age and sex) at the end of 6 months were classified into a response group; children whose blood pressure remained elevated (≥ 95th percentile for age and sex) or borderline elevated (blood pressure between the 90th and 95th percentile for age and gender) were classified into a non-response group.[7]

Follow-up schedule

The follow-up schedule was once a week during the first month, once every other week during the second month, and monthly thereafter. A diary regarding food intake, lunchtime schedule, and physical exercises were used as a reference for evaluating energy supply, modulating dietary structure, correcting behaviors, and encouraging physical activity during each follow-up.

Statistical analysis

Data were expressed as mean ± SD. The differences in BMI, WC, SP, and DP before and after intervention were compared with paired *t* tests. The difference in age was compared with independent *t* test while weight, height, BMI, WC, hip circumference, SP, and DP between high blood pressure (HBP) and non-HBP obese children were measured by multivariate analysis (age and gender for covariate). The difference between the response and non-response groups was also determined by multivariate analysis. *P* value less than 0.05 was considered statistically significant. The relationship between BMI, WC, and SP or DP was determined with partial correlation controlled for age and sex. All statistical analyses were performed using SPSS 10.0 software.

Results

Of the 469 obese children, 184 (39.2%) were diagnosed with hypertension and 285 (60.8%) without hypertension. The characteristics of these children with and without hypertension are shown in Table 1. Their mean age was similar (11.9±2.7 vs 11.6±2.8, t=-1.22, P=0.22), whereas weight, height, BMI, waist circumference, hip circumference, SP, and DP were higher in the obese children with hypertension than in those without hypertension. The prevalence of family history of hypertension was also higher in the obese children with hypertension than in those without hypertension (24.7% vs 14.7%, χ^2=6.99, P=0.01). The composition rate of boys and girls in the obese children with hypertension (male/female sex ratio=1.6) was not obviously different from that in those without hypertension (male/female sex ratio=1.3) (χ^2=1.05, P=0.31).

Of the 184 children with obesity and hypertension, 139 (75.5%; 86 boys and 53 girls) completed the study and 45 (24.5%, 45/184) were excluded due to the follow-up of less than 6 months. Weight, BMI, BMI%, waist circumference, and hip circumference decreased 5.1 kg, 2.9 kg/m^2, 10.5%, 6.6 cm, and 5.1 cm, respectively (7.2%, 9.9%, 8.7%, 7.3%, 5.7%), whereas height increased 2.1 cm after 6-month intervention. As weight and BMI decreased, blood pressure also decreased. SP and DP decreased 16.6 and 13.3 mmHg (12.9% and 15.9%) respectively compared with baseline levels (Table 2). One hundred and three (74.1%, 103/139) children showed an obvious response to diet-oriented intervention. However, 36 (25.9%, 36/139) children showed no obvious changes. The original levels of weight, BMI, BMI%, WC, hip circumference, SP, and DP were significantly higher in the non-response children than in the response children (P<0.05). Although D-values of body weight, BMI, BMI%, waist circumference and hip circumference in the response group were comparable with those in the non-response group, D-value of SP was larger in the response group than in the non-response group (17.7±11.1 mmHg vs 11.2±9.4 mmHg, F=5.66, P=0.02) but DP showed no significant difference (13.7±9.7 mmHg vs 11.4±9.8 mmHg, F=0.74, P=0.39) (Table 3).

Weight, height, BMI, BMI%, WC, and hip circumference showed a positive correlation with SP (r=0.51, 0.28, 0.50, 0.48, 0.46, 0.44, P<0.01) and DP

Table 1. Comparison of clinical data in 184 HBP obese children with 285 non-HBP obese children

Variables	HBP obese children (M/F=1.6)	Non-HBP obese children (M/F=1.3)	*F* value	*P* value
Age, y	11.9±2.7	11.6±2.8	-1.22	0.22
Weight, kg	71.3±19.6	62.1±16.2	42.38	<0.01
Height, cm	154.8±13.0	151.3±13.2	7.98	0.01
BMI, kg/m^2	29.2±4.5	26.6±3.5	48.94	<0.01
Waist, cm	90.7±11.9	84.0±9.4	41.97	<0.01
Hip, cm	96.7±12.0	90.0±9.8	34.16	<0.01
SP, mmHg	129.4±11.9	106.8±10.7	493.71	<0.01
DP, mmHg	81.1±10.0	65.9±7.8	326.40	<0.01

The difference in age was compared with independent *t* test while weight, height, BMI, WC, hip circumference, SP, DP between the two groups was tested by multivariate analysis (age and gender for covariate). SP: systolic pressure; DP: diastolic pressure; M: male; F: female; BMI: body mass index.

Table 2. Changes of clinical data in 139 obese children with hypertension

Variables	Before intervention	After intervention	*F* value	*P* value
Weight, kg	74.9±19.3	69.4±17.4	11.94	<0.01
Height, cm	156.3±12.1	158.4±12.0	3.86	0.05
BMI, kg/m^2	30.1±4.3	27.1±4.0	46.50	<0.01
BMI%	123.7±13.8	111.6±13.9	48.41	<0.01
Waist, cm	92.1±11.7	85.3±10.2	36.65	<0.01
Hip, cm	98.2±12.1	92.9±11.0	23.25	<0.01
SP, mmHg	130.1±13.1	113.5±13.8	112.64	<0.01
DP, mmHg	82.4±9.1	69.1±8.5	160.29	<0.01

The difference between the two groups was tested by multivariate analysis (age and gender for covariate). BMI: body mass index; BMI%: calculated as measurement of BMI divided by 95th percentile of age and gender BMI cut-off point for obesity × 100%; SP: systolic pressure; DP: diastolic pressure.

Table 3. D-value of anthropometric data and blood pressure in 139 children

Variables	Response	Non-response	*F* value	*P* value
Weight, kg	5.4±5.1	5.8±4.4	0.14	0.70
Height, cm	2.2±2.6	1.8±2.7	0.80	0.78
BMI, kg/m^2	3.0±2.1	2.9±1.7	0.33	0.57
BMI%	12.3±8.5	11.6±6.7	0.28	0.60
Waist, cm	6.9±5.6	6.3±4.9	0.95	0.33
Hip, cm	5.2±5.1	5.4±4.5	0.08	0.77
SP, mmHg	17.7±11.1	11.2±9.4	5.66	0.02
DP, mmHg	13.7±9.7	11.4±9.8	0.74	0.39

The difference between the two groups was tested by multivariate analysis (age and gender for covariate). BMI: body mass index; BMI%: calculated as measurement of BMI divided by 95th percentile of age and gender BMI cut-off point for obesity × 100%; SP: systolic pressure; DP: diastolic pressure.

(r=0.34, 0.14, 0.35, 0.33, 0.32, 0.29, P<0.01). The data showed that these measurements were correlated with both systolic and diastolic pressures, but that the correlation was stronger for systolic than for diastolic pressure.

Discussion

A variety of chronic diseases associated with obesity are now known to affect children as well as adults.[11,12] Obese children are at three-fold risk of hypertension compared to non-obese children.[13,14] School-based hypertension screening performed in Houston, USA showed a prevalence of elevated blood pressure of 4.5%.[15] A retrospective, case-control study by Boyd[16] of 497 overweight (BMI ≥95th percentile) patients aged 2 to 18 years showed elevated blood pressure in 34.7% of the sample. Invitti et al[17] showed that the prevalence of hypertension was 24.7% in obese children (BMI ≥97th percentile) aged 6-16 years. Among a sample of elementary school children in Taiwan, China the prevalence of hypertension was 12.9% for obese boys and only 0.3% for normal weight boys.[18] The prevalence of hypertension (39.2%) in this study was similar to the results found by Boyd, though it was higher than that found in other studies. Differing definitions of hypertension and obesity may have contributed to the difference in results; ethnicity may also have played a role.[15]

Dietary intervention has been emphasized in adult obesity but is still not routinely recommended for obese children.[19–22] Comprehensive treatment based on diet control, including physical exercise and establishing healthy lifestyle and eating habits, is preferable to managing obesity with hypertension. Figueroa-Colon et al[23] reported that a restricted diet (600-900 kcal per day) could be useful to treat obese children. Daily energy intake increased by 100 kcal per 2 weeks until 1200-1600 kcal was reached. Protein, fat, and carbohydrate comprised 20%, 30%, and 50% of calories, respectively. Compared with Figueroa-Colon's design, total energy intake is higher in our study, with increased fat and decreased carbohydrates; we recommend more milk, eggs, and sea food as sources of fat and protein, because the food is rich in protein, polyunsaturated fatty acids, monounsaturated fatty acids, and phospholipids, which are essential for the development of children. Our study showed that diet-oriented intervention played a crucial role in decreasing blood pressure in obese children. Mean blood pressure and average weight and BMI decreased for most children after a 6-month intervention. However, blood pressure for one-quarter of the children did not show this obvious response to the dietary intervention. Possible causes for this difference include: (1) The original levels of body weight, BMI, BMI%, SP and DP were higher in these children. Although the decline of body weight, BMI, BMI%, waist circumference and hip circumference was comparable with that in children who responded, blood pressure was still at a high level. (2) Physical exercise may have improved vascular function, but different type and intensity of the exercise have different effects on blood pressure. Training at an intensity of 70%–80% of maximal fitness for 30–40 minutes per day, 5 days per week was associated with a significant 6–10 mmHg reduction in systolic blood pressure of hypertensive adolescents.[24] Training at low-intensity (55%–60%) aerobic exercise during an 8-month intervention, the magnitude of blood pressure reduction was significantly less (about 2 mmHg).[25] In our study, physical exercise was not monitored. We encouraged a daily 30-minute physical exercise, but we did not know if the exercise occurred, and we did not know the duration or intensity of the exercise either.

It is important to identify children at high risk of developing hypertension. Because hypertension is strongly associated with excess weight, BMI is widely used in evaluating obesity in children. Children with BMI greater than the 85th percentile for age and sex are at higher risk for hypertension than children whose BMI is in a normal range.[8] Savva et al[26] evaluated a total of 1037 boys and 950 girls (mean age, 11.4±0.4 years). Dependent variables for the study were total cholesterol, triglyceride, high density lipoprotein-cholesterol, low density lipoprotein-cholesterol, SP, and DP; independent factors were WC and BMI. WC was the most significant predictor for all variables both for boys and girls, whereas BMI had the lowest predictive value for the detection of cardiovascular disease risk factors. In another study, Genovesi et al[27] found that both weight class and waist circumference showed a significant effect on absolute values of systolic and diastolic blood pressure. Other anthropometric data, such as hip circumference and waist-to-hip ratio were also associated with hypertension.[28,29] The results of our study indicated that body weight, BMI, waist circumference, and hip circumference were associated with blood pressure.

When obesity in children is recognized by health professionals, instructions for the child and family should begin. Discussion of risks of obesity, information about nutrition, and ways of establishing healthy eating habits should be introduced. Family has the greatest responsibility for the success of the treatment and for creating good eating habits and a healthy lifestyle.[30] The key point for successful treatment is collaboration among doctors, obese children, and their families.

In conclusion, hypertension is prevalent in obese children in China and may be treated successfully by diet-oriented intervention. Hypertension is closely associated with excess body weight and anthropometric indexes including BMI, WC, and hip circumference. Blood pressure should be routinely measured in all obese children.

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Ethical approval: The study was approved by the Ethics Committee of Ren Ji Hospital, School of Medicine, Shanghai Jiao Tong University.

Competing interest: None.

Contributors: Wan YP proposed the study and wrote the main body of the article, Xu RY analyzed the data and further draft. Wu YJ and Chen ZQ provided advice on medical aspects and collected the data. Cai W is the guarantor.

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