ORIGINAL

Prediction of Japanese children at risk for complications of childhood obesity : gender differences for intervention approaches

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Abstract : Childhood obesity is one of the most serious public health problems in Japan, especially in Tokushima compared with other prefectures. This study was designed to clarify the life habits which predispose to development of obesity and can be modified through an appropriate intervention program to combat childhood obesity and its lifestyle-related diseases. A total of 216 school children from Itano Town, a municipality of Tokushima Prefecture, Japan, who are attending the fourth grade (9-10 years) of elementary schools, participated in the study from 2004 to 2007. The study included child's life habits questionnaire, investigating physical activity by recording the daily steps using a pedometer, anthropometric measurements, hematological examination and hemodynamometry in a cross-sectional survey during a two-month period from June to July every year. We conclude that there are considerable gender-related differences for developing obesity and other lifestyle-related diseases ; and all intervention strategies against obesity must consider such gender differences. For example, restriction of television watching hours must be intervened for controlling obesity in boys, however for girls, promotion of exercise practice or making more steps per day with adequate sleeping periods should be intervened as the proper approaches for preventing and controlling obesity and other lifestyle-related diseases. J. Med. Invest. 57 : 62-68, February, 2010

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INTRODUCTION

Childhood obesity is one of the most serious public health problems in Japan as well as other developed countries ; (1) where obese children have been frequently shown to grow into obese adults, and were accompanied with higher than expected morbidity and mortality in adult life, elevating community concerns (2-4). The prevalence of childhood obesity in Japan has been increasing in recent decades (5, 6).

Tokushima Prefecture -a rural area located in Shikoku-island in Japan, with a population of approximately 800,000- has one of the highest prevalence rates of childhood obesity among Japan's prefectures (7). Therefore, in 2000, we formed a

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Committee for Prevention Strategy against Lifestyle-related Disease within Tokushima Prefecture Medical Association. The activities of this committee include collection of data regarding weight and height of all children in Tokushima Prefecture elementary and junior high schools, to identify obese children who are eligible for intervention by primary physician (8). Obesity-related complications were defined according to the Committee for Research of Appropriate Body Build in Children (9).

The current study for school-based prevention against lifestyle-related disease began in 2004, in Itano town that is a more rural municipality in Tokushima Prefecture, where the prevalence rate of childhood obesity is higher than other municipalities. Using the cross-sectional data of Itano town school children we performed this study to predict the children at risk who should be intervened against complications associated with obesity and the appropriate intervention approaches.

METHODS

Subjects and measurements

At Itano town, of Tokushima Prefecture, Japan, we started a program for monitoring obesity development among elementary school children during the period from June 2004 till July 2007. The program included administering a child's life habits questionnaire, investigating physical activity by recording the daily steps using a pedometer, taking anthropometric measurements and performing hematological examination and hemodynamometry during a two-month period from June to July of each of the four years of the study.

We prepared a 30 item questionnaire that focused on personal data, e.g., age, sex, weight, height, etc., and information on meals, physical activity, sleeping, and how the children spend their leisure time. Questionnaires were distributed to all the children, and their parents were requested to answer the questionnaires for their children.

Among the total 524 school children in the fourth grade (9-10 years) of elementary school from 2004 to 2007 in Itano town, 291 (55.5%) children participated in the program by responding to and answering the questionnaire.

In this study we used the data of 216 (41.2%) children who completely answered the questionnaire and were subjected to the hematological examination and hemodynamometry.

From the collected data, we computed the relative body weight for every child (% of the standard weight by sex and height). The standard weight based on the median weight of each height (per cm) by sex, was calculated from Tokushima children data between 2000 and 2002 (8). Body mass index (BMI) was also calculated according to the standard method (the weight in kilograms divided by the square of the height in meters). Measurement of body fat was conducted by bioelectrical impedance method (TBF-310, Tanita Corp., Tokyo, Japan). Serum total cholesterol, high-density lipoprotein-cholesterol (HDL-C) and alanin aminotransferase (ALT) were measured in the clinical laboratory of BML, Inc., regional laboratory, Tokushima (Bio Medical Laboratories). Blood pressure was measured twice and the lower value was used for analysis. Steps counting was performed by pedometer (Lifecorder EX, Suzuken Co., Nagoya, Japan), and we used the average daily steps.

Statistics

In this study, we used hematological analysis results and blood pressure measurement to detect the complications related to obesity. The criteria for deciding the presence or absence of complications were defined according to "the Committee for Research of Appropriate Body Build in Children" (9) as follows :

-Hypercholesterolemia : Serum total cholesterol$\geqq$ 220 mg/dl

-Low serum HDL-C : Serum HDL-C level$<$40 mg/dl

-Liver dysfunction : ALT$>$30 IU/L

-Hypertension : (SBP : systolic blood pressure, DBP : diastolic blood pressure) SBP$\geqq$130 mmHg, and/or DBP$\geqq$80 mmHg

Those children who had at least one abnormal value of the above five variables were assigned to the complications group and those without any abnormal values to the non-complications group.

Then, a threshold value for each anthropometric index for predicting metabolic complications was calculated using receiver operating characteristic (ROC) curve analysis. The cutoff point on the ROC curve was identified as the closest point to the upper left corner.

Moreover, total z scores were used to summarize the 4 metabolic complications (10). First, each of the 5 variables (total cholesterol, HDL-C, ALT, SBP and DBP) was standardized to a mean of zero and variance of 1 (z score), separately by sex. The higher of SBP z score or DBP z score, and multiplied HDL-C

z score by minus were used as z score, then the 4 z scores were summed for each child.

The data *were* analyzed with SPSS 16.0 statistical package for social sciences (SPSS Inc., Tokyo, Japan). Data are presented as means and SD. Mann-Whitney test was used to correlate variables with sex. Spearman's correlation coefficients were used to assess the level of associations between anthropometric indices and other variables.

For this study, written informed consents were obtained from all participants' parents ; and the study was approved by the ethical committee of Tokushima University Hospital.

RESULTS

The number of subjects in this study was 216 (105 boys and 111 girls) elementary school children, 4th grade (9-10 years), who participated in preventive program against childhood lifestyle-related disease from 2004 to 2007.

Table 1 shows the characteristics of the participants, where there were no significant differences between males and females regarding any of the anthropometric measurements, obesity or metabolic indices, except for the liver enzyme s of Alanine Transaminases (ALT), which was higher in boys than girls. However, in regard to the life habits questionnaire, there were significant gender differences in sleeping, exercise, and television watching periods. The mean sleeping, exercise and television watching hours of boys were more than those of girls. Moreover, the physical activity presented by the number of daily steps recorded by pedometer was significantly more in boys than girls.

Table 2 shows the prevalence and number of children who matched any of the variables representing obesity complications as recommended by "the Committee for Research of Appropriate Body Build

Table 1 Comparison between Japanese 9~ 10 years old boys and girls regarding obesity indices, metabolic factors and life habits

	Boys (n=105)		Girls (n=111)		p value
Height (cm)	134.7± 5.3		135.3± 7.0		0.921
Weight (kg)	33.9± 8.2		34.0± 9.5		0.673
BMI (kg/m^2)	18.5± 3.5		18.3± 3.7		0.596
Relative body weight (%)	108.6± 19.2		107.6± 18.8		0.643
Body fat (%)	19.4± 7.0		19.8± 8.1		0.972
Systolic blood pressure (mmHg)	104.6± 11.0		104.6± 11.1		0.962
Diastolic blood pressure (mmHg)	62.4± 7.5		61.5± 7.5		0.530
ALT(IU/l)	19.0± 25.4		14.5± 4.8		0.020
Total cholesterol (mg/dl)	174.8± 25.0		178.6± 24.7		0.384
HDL-C (mg/dl)	62.9± 11.6		62.0± 11.6		0.557
Sleeping (hr/day)	9.0± 0.6	(n=102)	8.8± 0.6	(n=110)	0.006
Exercise (hr/week)	10.9± 8.3	(n=98)	8.2± 6.3	(n=104)	0.025
Television watching (hr/day)	1.9± 1.1	(n=104)	1.6± 1.1	(n=111)	0.014
Physical activity (steps/day)	14929± 4030		12389± 2946		< 0.001

BMI, body mass index
ALT, alanine aminotransferase
HDL-C, high-density lipoprotein cholesterol

Table 2 Prevalence of metabolic complications and its distribution among Japanese 9~ 10 years old boys and girls

	Criteria	Boys (n=105)		Girls (n=111)	
		n	(%)	n	(%)
Hypercholesterolemia	Total cholesterol≧ 220 mg/dl	2	(1.9)	9	(8.1)
Low serum HDL-C	HDL-C < 40 mg/dl	0	(0.0)	3	(2.7)
Liver dysfunction	ALT > 30 IU/l	7	(6.7)	2	(1.8)
Hypertention	SBP≧ 130 mmHg, and/or DBP≧ 80 mmHg	2	(1.9)	2	(1.8)
Some metabolic complications		10*	(9.5)	16	(14.4)

HDL-C, high-density lipoprotein cholesterol
ALT, alanine aminotransferase
SBP, systolic blood pressure
DBP, diastolic blood pressure
*, A boy has two metabolic complications

in Children"(9). The prevalence of hypercholesterolemia in girls was the highest (8.1%) among the four metabolic complications. On the other hand, in boys, the prevalence of liver dysfunction was the highest (6.7%). The percentage of subjects with metabolic complications in boys and girls was 9.5% and 14.4%, respectively.

ROC analysis results for the boys and girls who have complications or without complications are shown in Table 3. The cutoff values of relative body weight for boys and girls are 120.1% and 109.5%, respectively. When we used these cutoff points, the sensitivity and specificity for relative body weight were 100.0% and 88.4%, respectively, for boys and 81.3% and 65.3%, respectively, for girls. The AUC, sensitivity and specificity of all indices among boys were higher than those of girls.

In Table 4, it is clear that most of the obesity indices were significantly correlated with metabolic variables except for the total cholesterol. Elevated liver transaminases (ALT) and high systolic blood pressure showed significant moderate correlations with obesity indices (BMI, relative body weight and body fat), while HDL-C was negatively correlated with the same obesity indices.

Furthermore, we investigated the associations between obesity indices and life habits (Table 5). For boys, body fat was significantly correlated with

Table 3 Receiver operating characteristic (ROC) curve analysis for obesity indices for Japanese 9~10 years old boys and girls

	Boys (n=105)				Girls (n=111)			
	Criteria	Sensitivity (%)	Specificity (%)	AUC	Criteria	Sensitivity (%)	Specificity (%)	AUC
Relative body weight	120.1 (%)	100.0	88.4	0.964	109.5 (%)	81.3	65.3	0.713
BMI	21.2 (kg/m^2)	100.0	81.1	0.955	20.1 (kg/m^2)	62.5	76.8	0.677
Body fat	26.3 (%)	90.0	91.6	0.915	20.1 (%)	75.0	66.3	0.682

BMI, body mass index
AUC, area under the curve

Table 4 Spearman's correlation coefficients of associations between obesity indices and metabolic factors in Japanese 9~10 years old boys and girls (Boys ; n=105, Girls ; n=111)

		Total cholesterol	HDL-C	ALT	SBP	DBP	Total z score
BMI							
	Boys	-0.040	-0.453 **	0.465 **	0.382 **	0.458 **	0.577**
	Girls	0.073	-0.383 **	0.298 **	0.420 **	0.191 *	0.547**
Relative body weight							
	Boys	0.063	-0.465 **	0.445 **	0.382 **	0.451 **	0.569**
	Girls	0.158	-0.327 **	0.323 **	0.351 **	0.135	0.542**
Body fat							
	Boys	0.072	-0.281 **	0.398 **	0.346 **	0.440 **	0.565**
	Girls	0.111	-0.355 **	0.272 **	0.393 **	0.135	0.514**

BMI, body mass index
HDL-C, high-density lipoprotein cholesterol
ALT, alanine aminotransferase
SBP, systolic blood pressure
DBP, diastolic blood pressure
Total z score, sum of each metabolic factors' z score
*p<0.05, **p<0.01

Table 5 Spearman's correlation coefficients of associations between obesity indices and life habits in Japanese 9~10 years old boys and girls

	Sleeping (hr/day) (Boys ; n=102, Girls ; n=110)	Exercise (hr/week) (Boys ; n=98, Girls ; n=104)	Television watching (hr/day) (Boys ; n=104, Girls ; n=111)	Physical activity (steps/day) (Boys ; n=105, Girls ; n=111)
BMI				
Boys	-0.178	-0.093	0.278 **	-0.258 **
Girls	-0.278 **	-0.291 **	0.095	-0.434 **
Relative body weight				
Boys	-0.165	-0.076	0.243 *	-0.225 *
Girls	-0.236 *	-0.309 **	0.091	-0.393 **
Body fat				
Boys	-0.219 *	-0.320 **	0.282 **	-0.286 **
Girls	-0.245 **	-0.300 **	0.123	-0.470 **

BMI, body mass index
*p<0.05, **p<0.01

sleeping, exercise and television watching periods, and physical activity represented by the number of steps recorded by the pedometer. For girls, all obesity indices were significantly correlated with sleeping and exercise periods, as well as the physical activity (steps recorded by pedometer) but not for the television watching periods.

DISCUSSION

Obesity is a multifactorial and multidimensional disease that encompasses, genetic background, environmental conditions as well as familial, life habits and socioeconomic risk factors. Any successful preventive interventions to overcome and control obesity and its-related disorders must take into considerations all the risk factors dimensions and decide the suitable approaches and factors to be intervened. Therefore, we performed this current study to predict the children at risk who should be intervened against complications associated with obesity and to clarify obesity-related life habits that need appropriate intervention approaches.

The Committee for Prevention Strategy against Lifestyle-related Disease in Tokushima Prefecture Medical Association had established a program "Health management system for obese children", in 2003(8). This medical intervention system recommends obese children (RBW≧150%) to consult with their primary physician after obtaining their school health check results. In the regular school health checks, blood sampling and measuring the blood pressure are not included since they are not mentioned and not mandated by the school health law, besides, it will add additional cost from the children. For this current study we performed hematological testing, measured blood pressure together with anthropometric measurements and evaluated the life habits by questionnaires for all the participating children.

It is hypothesized that there must be a possible high prevalence rate of metabolic disorders in children of Itano town since its children show a higher prevalence rate of overweight compared to children from other districts in Japan. Our results showed that among the 216 school children who participated in this study at Itano Town, of Tokushima Prefecture, 26 (12.0%) children were found to have metabolic complications according to the criteria mentioned in the methodology section of the Committee for Research of Appropriate Body Build in Children.

In previous studies, the threshold values for detecting metabolic complications in Japanese obese children had been reported, using the analysis of ROC curve (11, 12). Those values for RBW were more than 150% in both sexes, as the subjects included in those studies were all obese children. The cutoff values set by our study for obesity indices can be used for classifying school children into two groups : one group that should receive further medical examination or intervention and another group which will not. ROC characteristics analysis for obesity indices shows that there was differences between boys and girls, as for RBW, 120.1% and 109.5%, respectively ; and the AUC of each of the obesity variables (RBW, BMI and body fat) in girls was smaller than that of boys. These results suggest that the relationship between metabolic complications and anthropometric measurements "obesity level" is stronger in boys than girls.

Considering the meaning of obesity as excessive body fat, the body fat percentage was thought as the best index for obesity, however, our results shows a consistency among the three obesity indices indicating that all of them are important and can be used together or separately as indicators for obesity. Our results showed that the use of RBW and BMI are not inferior to using the body fat as the cutoff values for diagnosing obesity with metabolic complications.

As shown in Table 4, most of the metabolic variables are significantly correlated with obesity indices. These results are consistent with previous reports (13, 14) ; and these correlation coefficients were also nearly comparable among three obesity indices. Our results had also, shown that there were no significant relationships between life habits and present metabolic disorders.

Furthermore, we investigated the relationships between life habits and obesity indices to find out the appropriate variables for intervention against lifestyle-related disease in future. Gender differences were found in sleeping and television watching periods. Sleeping hours were shorter in girls than boys (Table 1), showing a significant mild negative correlations with obesity indices of BMI, RBW and body fat, which is consistent with the findings of previous (15, 16). On the other hand, boys' television watching hours were longer than those of girls, and had a significant moderate positive correlation with obesity indices.

The self-reported exercise hours and physical activity monitored objectively, by pedometer's steps counting data were negatively correlated with

obesity indices in both sexes ; however, girls' physical activity showed significant stronger negative correlations with obesity indices. These findings are also similar to previous studies that had shown variable degrees of association between obesity and life habits, such as exercise, watching television, etc (17, 18).

Based on our findings, we conclude that there are considerable gender-related differences for developing obesity and other lifestyle-related diseases ; and all intervention strategies against obesity must consider such gender differences. For example, restriction of television watching hours must be intervened for controlling obesity in boys, however for girls, promotion of exercise practice or making more steps per day with adequate sleeping hours should be intervened as the proper approaches for preventing and controlling obesity and other lifestyle-related diseases.

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