



Two decades of annual medical examinations in Japanese obese children: Do obese children grow into obese adults?

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OBJECTIVE: To investigate trends in frequency of obese children in Japan over two decades, the frequency of obese children who grow into obese adults and predictive factors for adult obesity.

DESIGN: Annual cross-sectional studies for 22 y (1974-1995) with a follow-up study.

SUBJECTS: Cross-sectional: Cumulatively 13 186 obese (% of standard body weight (SBW): $\geq 120\%$) schoolchildren including 3158 extremely obese ($\geq 140\%$ of SBW) children out of 203 088 schoolchildren (age: 6-14 y) in Izumiohtsu City, Osaka, Japan. Follow-up: 151 initially obese children (initial age: 6-14 y and age at follow-up: 20-35 y) who lived in Izumiohtsu City. Control: 3552 Japanese men and 4631 Japanese women (age: 20-35 y).

MEASUREMENTS: Cross-sectional: height, weight, trunk circumference, skin-fold thickness, blood pressure and blood biochemicals. Follow-up: height, weight, trunk circumference, skin-fold thickness during childhood, and body height and weight at follow-up. Adulthood obesity: $\geq 120\%$ of the average body mass indices (BMI) of the controls.

RESULTS: Frequency of obese children increased from 5% to more than 10%, and that of extremely obese children increased from 1% to more than 2% during these 22 y. These increases were most prominent in the schoolboys aged 9-11 y. Prevalence of hyperglycemia and hyperlipidemia in the extremely obese children did not change, and that of hypertension and abnormal liver function gradually decreased during these two decades. After coming of age, 32.2% of the initially obese boys (relative risk: 5.3) and 41.0% of the initially obese girls (relative risk: 6.7) remained obese. BMI, percentage of the SBW and skin-fold thickness at the biceps during childhood were significantly larger in currently-obese girls. Positive correlations were demonstrated between these variables and percentage SBW at follow-up.

CONCLUSIONS: Childhood obesity is increasing in Japan, especially in boys aged 9-11 y. Approximately 32% of the obese boys and 41% of the obese girls grow into obese adults, and the degree of obesity is a predictive factor for adult obesity.

Keywords: obese children; frequency; follow-up study

Introduction

It is well known that obesity is often associated with hypertension and various metabolic disorders such as non-insulin-dependent diabetes mellitus (NIDDM), hyperlipidemia and hyperuricemia, and these complications have been demonstrated to accelerate atherosclerosis in obese subjects.¹⁻⁸ Furthermore, once obesity has been established in the adult, weight loss is harder to achieve with medical treatment.⁹ Many reports have also shown that children's obesity is frequently associated with metabolic complications and hypertension.¹⁰⁻¹³ We have already reported the hypo-high-density-lipoprotein (HDL)-cholesterolemia¹¹ and hypertension¹² in obese Japanese children, and hyperinsulinemia may play a key role in the development of complications in childhood obesity.¹³

Obese children have been frequently shown to grow into obese adults in North American and European countries.¹⁴⁻²⁸ However, only a few reports have been published about these phenomena from Asian countries, including Japan.

Since 1974, we have been managing annual medical examinations for the obese children in a Japanese suburban city. In the current study, trends of frequency of obesity and the prevalence of obesity-associated complications were investigated in school children. A follow-up study was also undertaken to investigate how often obese children grow into obese adults and to know the predictive factors for adult obesity.

Subjects and Methods

Annual medical examination for obese children

Since 1974, annual medical examinations of obese children have been performed in Izumiohtsu City, a

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Table 1 Number of obese, extremely obese and total of elementary and junior high school students in Izumiohtsu City

Year	Ext. obese (%)	Obese (%)	Total	Year	Ext. obese (%)	Obese (%)	Total
1974	109(1.3)	472(5.5)	8617	1985	143(1.4)	622(6.1)	10 236
1975	80(0.9)	512(5.6)	9080	1986	167(1.7)	690(7.0)	9876
1976	108(1.1)	457(4.8)	9561	1987	146(1.5)	735(7.8)	9471
1977	91(0.9)	356(3.6)	9977	1988	172(1.9)	702(7.9)	8879
1978	102(1.0)	365(3.5)	10 362	1989	151(1.8)	703(8.4)	8417
1979	118(1.1)	342(3.2)	10 615	1990	149(1.9)	699(8.8)	7962
1980	135(1.3)	554(5.2)	10 727	1991	166(2.2)	737(9.7)	7635
1981	127(1.2)	363(3.3)	10 972	1992	185(2.5)	750(10.1)	7416
1982	161(1.5)	656(5.9)	11 031	1993	185(2.6)	739(10.2)	7213
1983	147(1.4)	656(6.1)	10 783	1994	173(2.5)	693(10.0)	6961
1984	149(1.4)	646(6.2)	10 495	1995	194(2.9)	737(10.8)	6802

Ext. obese: extremely obese.

southward suburban area of the Osaka Prefecture in Japan. Every April, at the beginning of a new Japanese school year, physical examinations are made in all elementary and junior high schools in this city. All the obese and extremely obese children were selected from these students. The criterion for 'obese' was when the student's body weight exceeded 120% of the standard body weight (SBW) for Japanese children, and that for 'extremely obese' was those whose BW exceeded 140% of the SBW. There are two reasons why we chose 120% overweight as 'obese' children: First, Japan Society for the Study of Obesity (JASSO) defined 120% overweight as 'obese' in Japanese adults. Second, there are several reports from the United States²² and European countries²³ which use this criterion for the definition of children's obesity. The SBW was determined by Hibi's nomogram,²⁹ which is a weight for height and sex chart for Japanese children devised on the statistical basis from nationwide surveys. The cumulative number of the obese subjects came up to 13 186 including 3158 extremely obese children, selected from cumulatively 203 088 school children from 1974 to 1995 (Table 1).

The medical examinations of the extremely obese children consisted of the following: measurement of body height and body weight; chest circumference (at nipple level); waist circumference (at the level of the umbilicus); skin fold thickness at the biceps (middle of upper arm), sub-scapular and peri-umbilical regions and blood pressure. Height, weight and trunk circumference were measured manually in the upright position to the nearest 0.1 cm, 0.1 kg and 0.1 cm, respectively, and skin-fold thicknesses were measured using Eiyoken-type calipers (Meikosha Co Ltd, Tokyo, Japan). The medical examinations also included measurement of blood pressure and blood analysis. Systolic and diastolic blood pressures (mmHg), defined by the first and fifth phase of Korotkoff sound, were measured in the supine position using a sphygmomanometer with a 12 cm cuff after 10 min rest. After measurement of blood pressure, blood samples were collected after an overnight fast, from obese children whose parents gave informed consent to the blood sampling. Serum total cholesterol and triglycerides levels were measured enzymatically, plasma glucose levels by the glucose

oxidase method, and glutamic oxaloacetic transaminase (GOT) and glutamic pyruvic transaminase (GPT) by the International Federation of Clinical Chemistry (IFCC)-recommended method.

Analysis of annual reports

Every year, annual reports were obtained of the total number of students, the obese students and the extremely obese students in each school, separated by gender and age (Table 2). Japanese children usually enter elementary schools at 6 y, and junior high schools at 12 y. Therefore, the ages of the school-children in the same grade are identical at the beginning of a new school year. The annual reports also carried the participants' personal data on the anthropometric, physical and blood biochemical examinations. The frequency of the obese and extremely obese children were calculated, as well as the prevalence of the complications caused by obesity, such as hypertension, hyperglycemia, hyperlipidemia, and abnormal liver function (most of them were fatty liver). Complications criteria for the children were; systolic BP \geq 135 mmHg or diastolic BP \geq 80 mmHg for hypertension, fasting plasma glucose \geq 110 mg/dl for hyperglycemia, total cholesterol \geq 200 mg/dl or triglycerides \geq 130 mg/dl for hyperlipidemia, and GOT $>$ 20 U/l or GPT $>$ 25 U/l for abnormal liver function.

Follow-up study

To clarify the relationship between childhood obesity and adult obesity, questionnaires asking the present body height and weight were sent to 777 subjects of the annual medical examinations whose present address could be ascertained in October 1994. Due to difficulty in ascertaining the present address of the original subjects, the number of subjects in the follow-up study became considerably smaller than the cumulative number.

Two hundred and eleven formerly obese children (age at follow-up: 15–35 y) responded to the questionnaire. However, this follow-up study was intended to investigate the transition from childhood to adult obesity, and in Japan, boys and girls of 20 y are regarded as "adults". Thus, among 211 formerly

Table 2 Number of obese, extremely obese and total of elementary and junior high school boys and girls in Izumiohtsu City (classified by age)

Boys	Aged 6-8			Aged 9-11			Aged 12-14		
	Ext. obese	Obese	Total	Ext. obese	Obese	Total	Ext. obese	Obese	Total
1974	16	50	1644	29	127	1578	9	39	1243
1975	12	59	1772	23	108	1580	6	69	1352
1976	10	55	1933	25	114	1592	17	54	1413
1977	16	44	1964	26	67	1656	16	53	1551
1978	20	49	2051	28	80	1756	8	45	1563
1979	20	46	2105	27	84	1878	22	34	1544
1980	19	75	2026	42	151	1922	28	86	1576
1981	18	42	2028	40	92	1974	22	47	1673
1982	22	80	1904	50	176	2001	31	96	1820
1983	14	74	1776	48	195	1998	31	99	1863
1984	18	65	1640	40	185	1969	33	99	1908
1985	16	63	1546	49	174	1865	30	113	1957
1986	18	68	1464	54	172	1743	39	130	1964
1987	22	84	1380	42	178	1639	34	145	1929
1988	18	74	1316	50	172	1530	45	129	1804
1989	19	85	1291	47	179	1432	32	108	1684
1990	26	107	1265	45	170	1341	25	99	1570
1991	27	108	1229	49	177	1290	22	104	1468
1992	32	116	1183	46	184	1276	31	108	1372
1993	23	110	1196	57	198	1250	28	95	1281
1994	30	124	1158	40	178	1213	30	84	1204
1995	49	128	1118	56	191	1188	19	100	1213

Girls	Aged 6-8			Aged 9-11			Aged 12-14		
	Ext. obese	Obese	Total	Ext. obese	Obese	Total	Ext. obese	Obese	Total
1974	20	71	1517	21	100	1498	14	85	1137
1975	11	62	1677	17	110	1482	11	104	1217
1976	15	55	1831	22	91	1461	19	88	1331
1977	6	42	1809	15	64	1568	12	86	1429
1978	20	38	1858	15	72	1699	11	81	1435
1979	11	32	1906	20	74	1780	18	72	1402
1980	11	62	2013	16	98	1724	19	82	1466
1981	9	57	1935	16	72	1779	22	53	1583
1982	11	90	1831	25	104	1798	22	110	1677
1983	11	70	1642	19	119	1875	24	99	1628
1984	16	74	1464	17	117	1854	25	106	1660
1985	9	57	1383	10	100	1766	29	115	1719
1986	12	61	1331	23	127	1610	21	132	1764
1987	7	75	1315	20	114	1463	21	139	1745
1988	12	76	1236	23	108	1344	24	143	1649
1989	14	86	1218	19	106	1293	20	139	1499
1990	17	94	1161	18	118	1282	18	111	1343
1991	21	110	1157	29	137	1237	18	101	1254
1992	27	105	1179	24	135	1204	25	102	1202
1993	18	97	1134	34	132	1161	25	107	1191
1994	18	82	1107	24	122	1136	31	103	1143
1995	29	99	1024	26	133	1155	15	86	1104

Ext. obese: extremely obese

obese children, 151 subjects whose age at follow-up exceeded 20.0 years were adopted for the follow-up study. Table 3 shows the profiles of the subjects in this study. The initial age of the subjects was 10.5 ± 2.0 y (mean \pm s.d.) for boys and 10.3 ± 2.4 y for girls. The age at follow-up was 26.5 ± 4.1 y and 27.4 ± 4.2 y, respectively, therefore, the average follow-up interval was 16.1 ± 3.9 y and 17.1 ± 3.7 y, respectively. During the follow-up interval, their average height increased from 140.6 cm to 168.7 cm for boys and 139.0 cm to 156.7 cm for girls, and their average weight increased from 48.2 kg to 76.2 kg and 46.5 kg to 60.5 kg, respectively.

Simultaneously, the body mass index (BMI) distribution of Japanese young adults were studied as the controls. In order to match age with the subjects of the

follow-up study, 3552 men and 4631 women aged 20–35 y were selected among the registrants of the biggest life insurance in Japan (managed by Nippon Life Insurance Company). Their places of residence were distributed all over Japan, and their occupations and status of health were also randomized, so these control subjects were thought to represent the general Japanese population. Using their physical data, their BMI was calculated, and they were adopted, separated by gender as the controls for this follow-up study. The average age of the controls was 28.7 ± 4.5 y for men and 26.9 ± 6.2 y for women, and the average BMI was 23.4 ± 3.0 kg/m² and 20.1 ± 2.6 kg/m², respectively. Thus, having established that SBW (kg) for Japanese young men aged 20–35 y is 'body height(m)² \times 23.4, and that SBW (kg) for Japanese young women of the

Table 3 Profiles of the subjects in the follow-up study

	Boys (n = 90)	Girls (n = 61)
<i>Childhood</i>		
Age (y)	10.5 ± 2.0	10.3 ± 2.4
Height (cm)	140.6 ± 11.6	139.0 ± 11.3
Weight (kg)	48.2 ± 11.2	46.5 ± 11.6
Body Mass Index (kg/m ²)	24.0 ± 2.4	23.7 ± 2.9
Percentage of SBW ^a (%)	140.2 ± 11.3	137.9 ± 11.8
<i>Follow-up</i>		
Age (y)	26.5 ± 4.1	27.4 ± 4.2
Interval (y)	16.1 ± 3.9	17.1 ± 3.7
Height (cm)	168.7 ± 6.0	156.7 ± 6.1
Weight (kg)	76.2 ± 13.3	60.5 ± 12.3
Body Mass Index (kg/m ²)	26.5 ± 3.9	24.6 ± 4.6
Percentage of SBW ^b (%)	113.7 ± 16.6	122.3 ± 23.0

Plus-minus values are means ± s.d., SBW: standard body weight.
^a Determined by Hibi's nomogram³⁰; a weight for height chart for Japanese children.
^b Determined by the average body mass indices of the controls.

same age is 'body height(m)² × 20.1, the percentage of SBW (%SBW) of the initially obese children decreased from 140.2 ± 11.3% to 113.7 ± 16.6% in boys and 137.9 ± 11.8% to 122.3 ± 23.0% in girls (Table 3). We also settled the criteria for adult obesity in this follow-up study as ≥ 120% of these average BMI, which is, ≥ 28.1 kg/m² in men and ≥ 24.1 kg/m² in women.

Statistics

Results were expressed as the means ± s.d., and the significance of differences between the two groups: obese and not-obese at follow-up (shown in Table 4) was determined by two-tailed Student's *t*-test for unpaired data. Linear regression analysis was used to study the relationship between the variables. All the

Table 4 Comparison between profiles of the two groups classified by body mass index (BMI) at the end of follow-up in initially obese boys and girls

Boys	BMI at the end of follow-up	< 28.1	≥ 28.1	P value
		n = 61 (67.8%)	n = 29 (32.2%)	
<i>Childhood</i>				
	Age (y)	10.6 ± 1.9	10.1 ± 2.2	NS
	Height (cm)	140.9 ± 10.3	139.8 ± 14.2	NS
	Weight (kg)	48.1 ± 10.3	48.2 ± 13.1	NS
	Body Mass Index (kg/m ²)	24.0 ± 2.3	24.1 ± 2.5	NS
	Initial Percent of SBW (%)	140.0 ± 10.3	140.8 ± 13.3	NS
	Maximum Percent of SBW (%)	141.6 ± 11.9	146.6 ± 17.0	NS
	Circumference (cm)			
	Chest	81.8 ± 6.7	80.4 ± 8.3	NS
	Waist	77.5 ± 6.6	77.6 ± 8.7	NS
	Skin Fold Thickness (mm)			
	Biceps	22.4 ± 4.4	21.5 ± 4.6	NS
	Sub-scapular	22.0 ± 5.9	20.3 ± 5.9	NS
	Peri-umbilicus	25.2 ± 8.3	23.8 ± 7.9	NS
<i>Follow-up</i>				
	Age (y)	27.0 ± 4.2	25.5 ± 3.8	NS
	Interval (y)	16.4 ± 3.8	15.4 ± 4.2	NS
	Height (cm)	168.4 ± 5.5	169.3 ± 6.9	NS
	Weight (kg)	69.8 ± 7.8	89.7 ± 12.4	< 0.0001
	Body Mass Index (kg/m ²)	24.4 ± 2.0	31.2 ± 2.8	< 0.0001
	Percent of SBW (%)	104.4 ± 72.8	133.2 ± 11.9	< 0.0001
Girls	BMI at the end of follow-up	< 24.1	≥ 24.1	P value
		n = 36 (59.0%)	n = 25 (41.0%)	
<i>Childhood</i>				
	Age (y)	10.1 ± 2.2	10.6 ± 2.6	NS
	Height (cm)	138.4 ± 10.8	139.9 ± 12.2	NS
	Weight (kg)	44.4 ± 10.5	49.5 ± 12.8	NS
	Body Mass Index (kg/m ²)	22.9 ± 2.8	24.8 ± 2.6	0.0088
	Initial Percent of SBW (%)	134.7 ± 11.5	142.6 ± 10.7	0.0085
	Maximum Percent of SBW (%)	136.8 ± 12.2	147.3 ± 13.9	0.0081
	Circumference (cm)			
	Chest	78.6 ± 8.1	82.3 ± 8.6	NS
	Waist	71.8 ± 9.3	76.1 ± 8.8	NS
	Skin Fold Thickness (mm)			
	Biceps	21.7 ± 6.0	25.0 ± 5.9	0.0334
	Sub-scapular	22.1 ± 6.7	24.9 ± 8.9	NS
	Peri-umbilicus	23.0 ± 7.5	26.8 ± 11.8	NS
<i>Follow-up</i>				
	Age (y)	27.8 ± 4.0	26.7 ± 4.4	NS
	Interval (y)	17.8 ± 3.0	16.1 ± 4.4	NS
	Height (cm)	156.5 ± 5.6	157.0 ± 7.0	NS
	Weight (kg)	52.9 ± 5.2	71.4 ± 11.2	< 0.0001
	Body Mass Index (kg/m ²)	21.6 ± 1.6	28.9 ± 4.1	< 0.0001
	Percent of SBW (%)	107.3 ± 7.9	144.0 ± 20.1	< 0.0001

Plus-minus values are means ± s.d., NS; not significant, SBW: standard body weight

statistical analyses were performed by StatView vers 4.5J (Abacus Concepts, Inc. Berkeley, CA, USA).

Results

Trends of obese children and complications of obesity

Figure 1 shows the trends of frequency of obese (body weight $\geq 120\%$ of SBW) and extremely obese (body weight $\geq 140\%$ of SBW) children in Izumiohtsu City. The frequency of obese children decreased from 5 to 3% between 1974 and 1979, then increased from 3 to 11% between 1979 and 1995. Although the occurrence of extremely obese children remained stable around 1% during the period 1974–1979, it gradually increased from 1 to 3% between 1979 and 1995. Overall, occurrences of obese and extremely obese children have approximately doubled during these two decades.

To analyze these changes more precisely, the obese and the extremely obese children were classified into 6 subgroups by gender and age (6–8 y, 9–11 y, or 12–14 y) and are shown in Table 2. The results of analysis in the obese children are demonstrated in Figure 2a. From 1974 to 1979, the occurrence of obese children in all the subgroups decreased similarly. However, after 1979, obese boys aged 9–11 y showed a more prominent increase than the other 5 subgroups. Similarly, the occurrence of the extremely obese boys aged

9–11 y showed a more marked increase after 1979 (Figure 2b).

We also analyzed the trends of the prevalence of complications in the extremely obese children, such as hypertension, hyperglycemia, hyperlipidemia, and abnormal liver function (Figure 3). The prevalence of hyperglycemia and hyperlipidemia did not change throughout the years studied, however the prevalence of hypertension and abnormal liver function gradually decreased in the last 11 y.

Follow-up Study

BMI distribution at follow-up in the initially obese boys and girls are demonstrated and compared with those in the controls (Figure 4). In the control men, the peak BMI was 22 kg/m^2 and the average BMI was $23.4 \pm 3.0 \text{ kg/m}^2$, and 6.1% (217 out of 3552) of them were obese ($\geq 120\%$ of the average BW of the control men, that is, $\text{BMI} \geq 28.1 \text{ kg/m}^2$). On the other hand, the distribution of present BMI in initially obese boys showed the peak value shifted to the right (BMI at 26, Figure 4a). The average BMI was $26.6 \pm 3.9 \text{ kg/m}^2$ and approximately one-third of them (32.2%) belonged to the obese. The relative risk for adult obesity in initially obese boys was 5.3.

In the control women, the peak BMI was 19 kg/m^2 , the average BMI was $20.1 \pm 2.6 \text{ kg/m}^2$ and 6.1% (281 out of 4631) were found to be obese ($\geq 120\%$ of the average BW of the control women, that is, $\text{BMI} \geq 24.1$). On the other hand, the distribution of

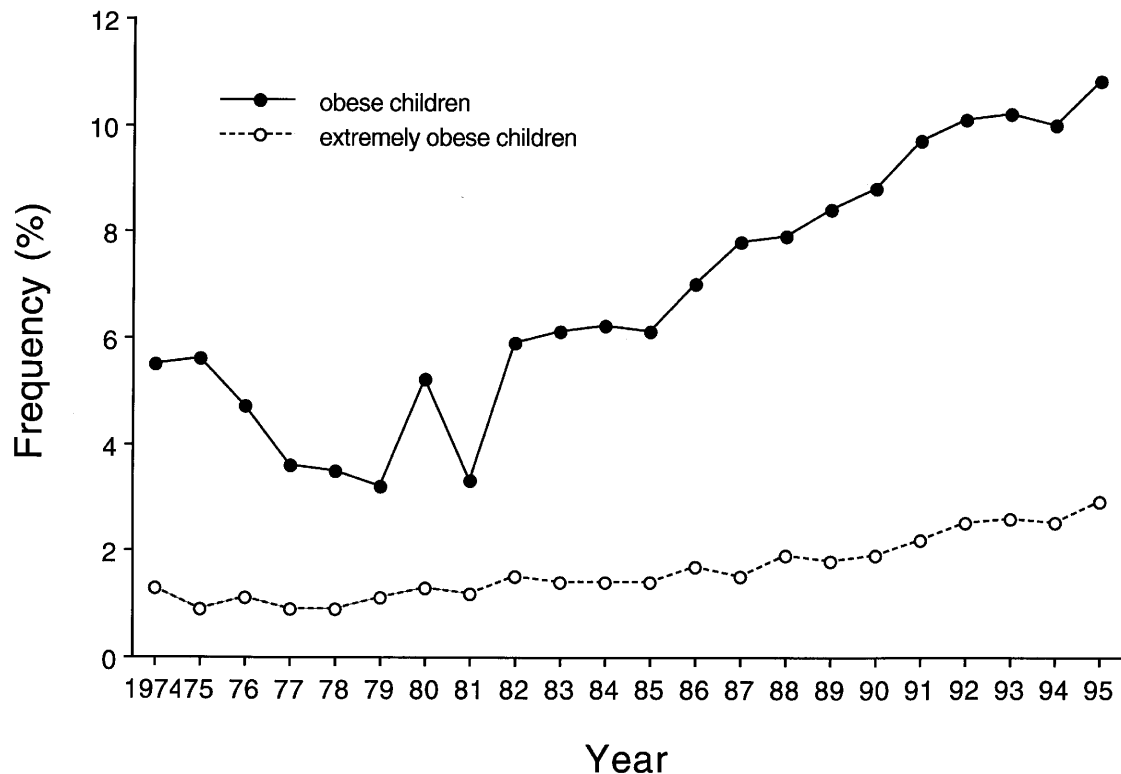
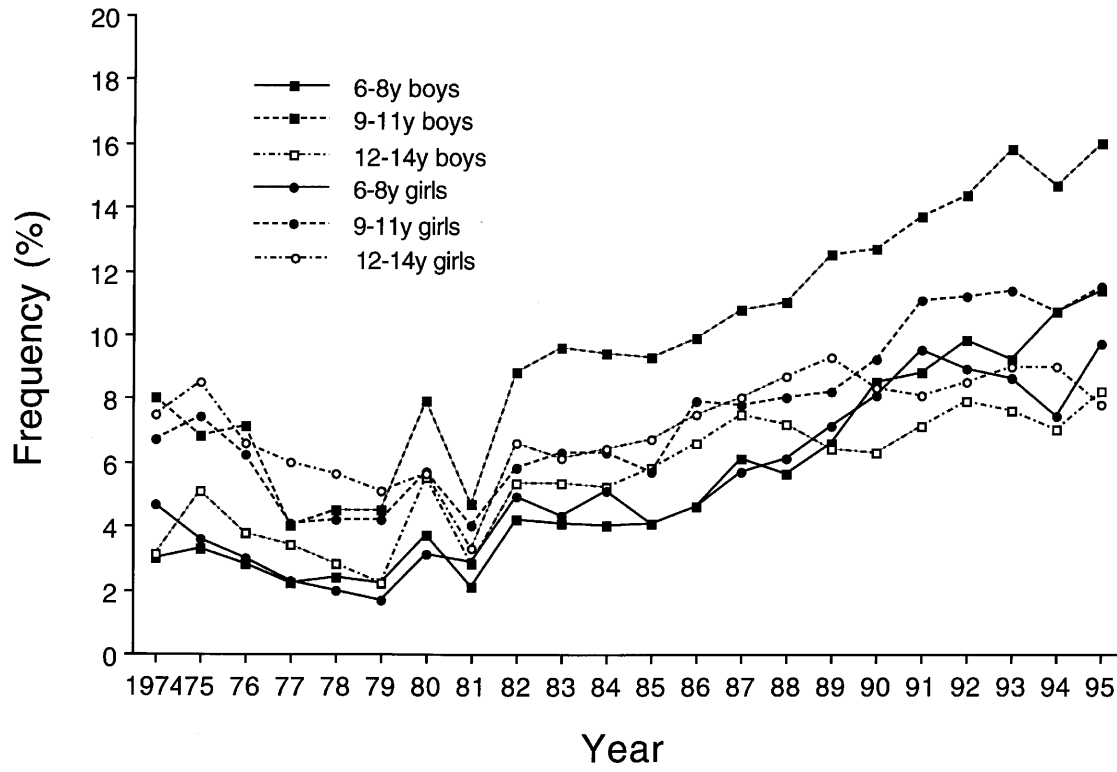
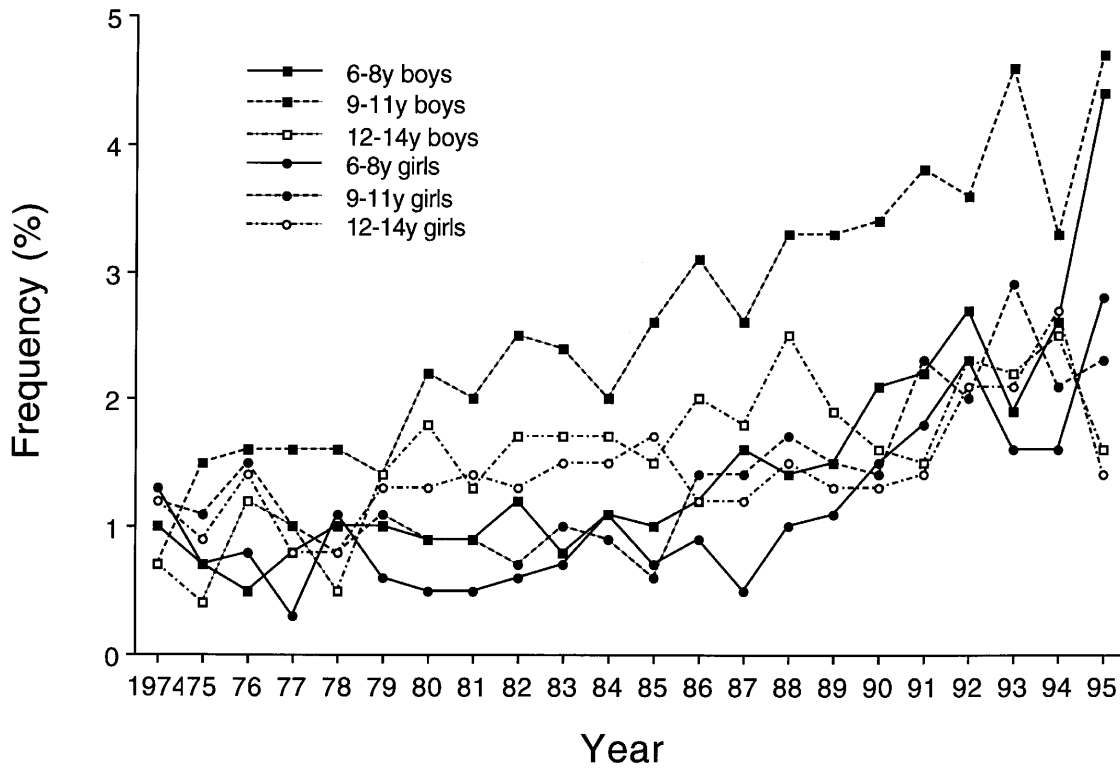


Figure 1 Trends in frequency of obese (—●—, $\geq 120\%$ of standard body weight) and extremely obese (---○---, $\geq 140\%$ of standard body weight) children in Izumiohtsu City, Japan.



(a)



(b)

Figure 2 Trends in frequency of obese children (a) and that of extremely obese children (b) classified by gender and age. (Squares indicate boys and circles indicate girls, and closed symbols indicate elementary school students and open ones indicate junior high school students; —■—: boys aged 6–8y, ---■---: boys aged 9–11y, - -□- - : boys aged 12–14y, —●—: girls aged 6–8y, - -●- - : girls aged 9–11y, -○- : girls aged 12–14y.)

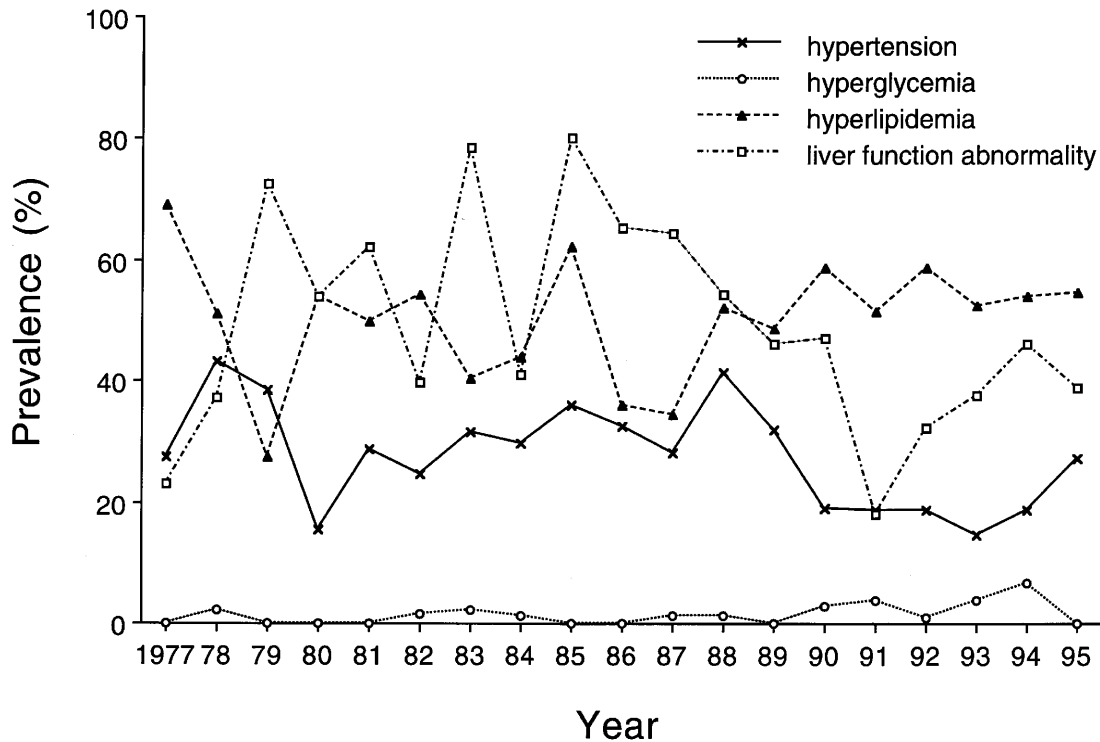


Figure 3 Trends in the prevalence of hypertension (—x—), hyperglycemia (—o—), hyperlipidemia (---▲---), and abnormal liver function (---□---) in extremely obese children.

present BMI in initially obese girls showed the peak value shifted to the right (BMI at 21) with a long tail to the right side (Figure 4b). The average BMI was $24.6 \pm 4.6 \text{ kg/m}^2$, and approximately 41.0% continued to be obese. The relative risk in initially obese girls was 6.7.

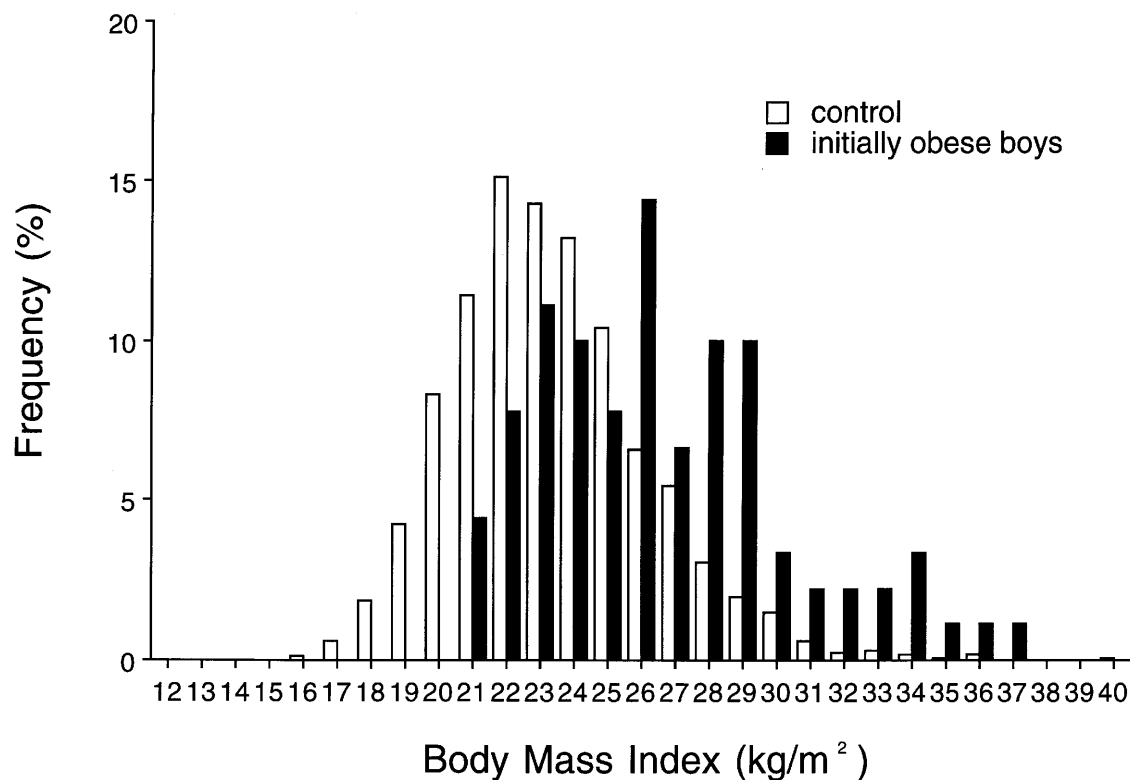
Next, to clarify the predictive factors for adult obesity, the anthropometric childhood data of two subgroups, 'obese' and 'non-obese' (at the end of follow-up), were compared. The two subgroups were classified by the average BMI of the controls: 28.1 kg/m^2 in men and 26.1 kg/m^2 in women. Table 4 shows the profiles of these subgroups. There were no significant differences in the initial age, height, weight, age at follow-up nor interval between two subgroups in both genders. In the initially obese boys, weight, BMI and %SBW at follow-up were, as a matter of course, larger in the obese group, but no other indices during childhood showed any differences between two subgroups. In initially obese girls, BMI, initial and maximum %SBW, waist circumference and skin-fold thickness at biceps during childhood were significantly larger in the presently obese girls, than those in the presently non-obese ones.

To investigate the relationship between the predicting factors during childhood and %SBW at follow-up by another statistical way, linear regression analyses were performed. In initially obese boys, although no differences were found between the data during childhood in the comparative study, a positive correlation was found ($r = 0.231$, $P = 0.0283$) between the maximum %SBW during childhood and %SBW at follow-up. On the other hand, in initially obese girls, many

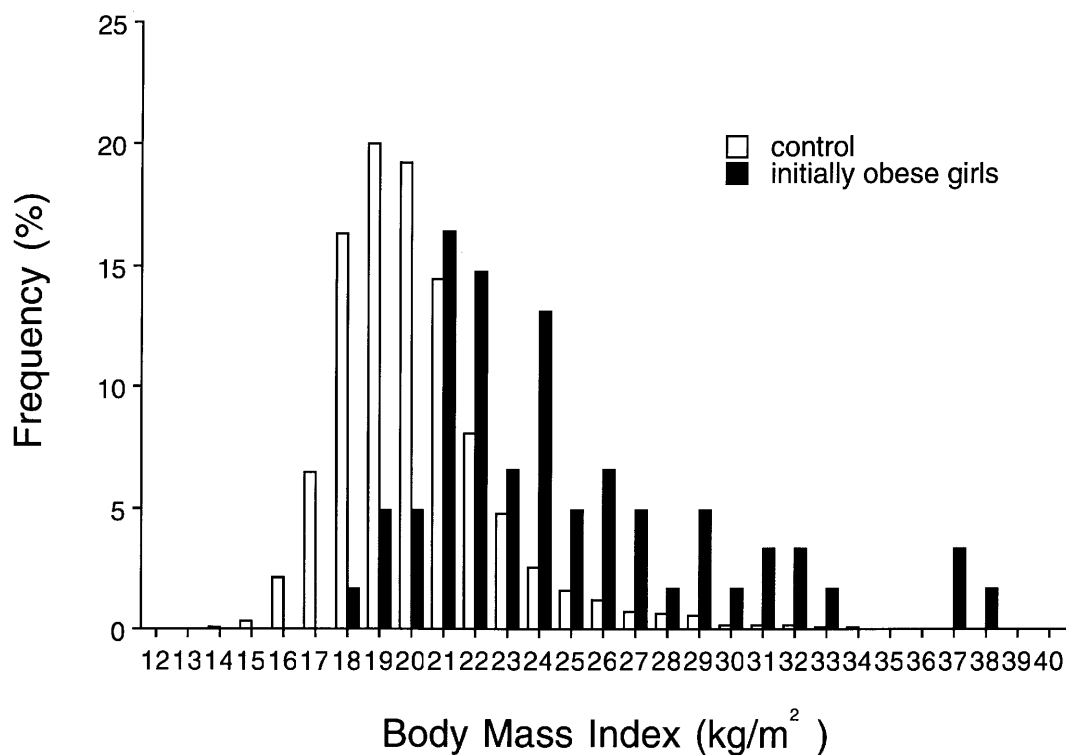
significant correlations were observed between %SBW at follow-up and: initial BW ($r = 0.268$, $P = 0.0370$); initial BMI ($r = 0.406$, $P = 0.0012$); initial percent of SBW ($r = 0.409$, $P = 0.0011$); maximum %SBW ($r = 0.441$, $P = 0.0004$); waist circumference ($r = 0.371$, $P = 0.0035$); chest circumference ($r = 0.295$, $P = 0.0208$); skin-fold thickness at biceps ($r = 0.352$, $P = 0.0054$), at sub-scapular ($r = 0.279$, $P = 0.0295$) and at peri-umbilicus ($r = 0.268$, $P = 0.0369$). In short, the more obese a schoolgirl was, the more obese she will become when she grows up. Thus, all, the strongest predictor for adult obesity was 'the maximum %SBW during childhood, in both genders, and in both statistical ways.

Discussion

The current study has demonstrated that the frequency of obesity in schoolchildren is increasing in Japan and during these 22 years it has approximately doubled. These results are consistent with the previous reports from other countries. In the United States (US), Gortmaker *et al*¹⁶ reported that the prevalence of obese children increased by 54% and that of super obesity increased by 98% from 1964–1978, and Tiwary *et al*¹⁷ reported that the prevalence of grossly obese children increased from 5.5% (in 1978) to 9.0% (during 1986–1990). Regarding the data in Asian countries, Mosuwan *et al*¹⁸ reported the prevalence of obesity rose from 12.2% (in 1991) to 15.6% (in 1993) in Thailand,



(a)



(b)

Figure 4 Distribution of present body mass index (BMI) in initially obese boys (a) and girls (b) with that of Japanese adults. (■, initially obese children and □, adults).

a transitional country. Thus, the increase in the frequency of obese children seems to be a world-wide trend today. However, the frequency of the obese children demonstrated a definite decrease during the first 5 y of our study (1974–1979), which we speculated was the effect of the nationwide campaign. In

those days, Japanese television programs and newspapers frequently emphasized the risk of childhood obesity, and parents and school teachers became very aware of this problem.

We further investigated the changes in frequency of obesity separately by gender and age, and clarified

that this increase was most prominent in the schoolboys aged 9–11 y. There are several possible causes that may bring about these phenomena: 1) The change in playing style of schoolboys. Recently, outdoor games (such as baseball, which require considerable energy expenditure) have declined and instead, indoor games (such as computer games, that demand little physical energy) have become very popular. 2) The spread of private schools, which are more popular for boys than girls in Japan and have deprived the boys of their playing time after school. 3) The flood of cheap and high-caloric snacks among schoolboys, which are easily available. The boys aged 9–11 y are thought to be most susceptible to these environmental changes. Thus, to make a strategic approach to prevent the increase of obese children in the future, we should carefully analyze the changes in life-style of the boys in the higher grades of elementary schools.

We also revealed that the prevalence of hyperglycemia and hyperlipidemia in the extremely obese children did not change during these two decades, and that of hypertension and abnormal liver function gradually decreased. However, as mentioned above, the prevalence of extremely obese children has been increasing. Taken together, the overall prevalence of the complications of obesity, such as hyperglycemia and hyperlipidemia, seem to be increasing in schoolchildren. Therefore, the difference in trends for the various complications deserves further investigation.

The current study also revealed that obese children frequently grow into obese adults. 32.2% of the initially obese boys and 41.0% of the initially obese girls still remained obese after coming of age and the relative risks are 5.3 in boys and 6.7 in girls. In the previous literature¹⁵ published from the US and European countries, 42–63% of obese school-age children were found to have developed into obese adults. Although there might be some methodological differences, Japanese obese school-age children are less likely to become obese adults than Caucasian obese children. Some possible reasons can be suspected. One possible reason may be the genetic differences between populations, another is the recent yearning for lean bodies in the young generations in Japan. Another possibility is the selective loss of the subjects from the tracking study. That is to say, the people who are still obese may be unwilling to answer our questionnaires and as a result, the percentage body weight of the formerly obese children may be regarded as smaller than the real values.

The biggest result which ran counter to our expectation was, 'obese girls are more likely to be obese adults than obese boys'. Generally speaking, young girls yearn for 'slender' bodies more than boys. In the US, Casey *et al*¹⁹ reported that BMIs before maturity were poor predictors of middle-aged BMI status in females but were good predictors in males. Freedman *et al*²⁰ reported that white females show a weak tracking of obesity than white males and black peo-

ples because of intentional dieting. Taken together, most Japanese girls have already begun to make efforts to reduce their body weight before they enter senior high schools. In other words, Japanese obese school-age girls may be a group who have already given up being thin.

The current study also revealed that the probability of becoming an obese adult depends on the extent of obesity during childhood. That is to say, the higher the degree of obesity in childhood, the more probable it was that one will become an obese adult. This result is consistent with many previous reports which demonstrated that the more extreme the obesity of the child, the higher the risk for obesity on becoming an adult.^{15,22–24}

Conclusion

Although the prevalence of complications in the obese children did not change, the frequency of obesity among schoolchildren is increasing in Japan, especially in boys aged 9–11 y. Approximately one-third of the obese boys and two-fifths of the obese girls grow into the obese adults, and the degree of obesity during childhood is the predictive factor for the adulthood obesity.

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