A potential limitation of our study is the relatively small sample size ($n = 62$). Although a relationship between the ability to recognize energy expenditure and the status of DM control was suggested, it did not attain statistical significance, which may be due to the small size of our study sample. Additional studies are needed to confirm our findings, preferably using larger sample sizes.

There was a study that assessed the validity of accelerometer (Life Corder)-recorded energy expenditure by comparing to those measured by the whole-body indirect calorimetry method in a respiratory chamber [3]. The total energy expenditure estimated by the accelerometer was significantly correlated to that measured by the indirect calorimetry (correlation coefficient, $r = 0.928$, $P < 0.001$) and there was a strong correlation between the activity levels and MET while walking ($r = 0.93$, $P < 0.001$) [3]. Thus, the device is likely to detect not only ambulatory movements, but also spontaneous low-level activities [3]. Other studies also reported high correlations between energy expenditure recorded by the accelerometer and that estimated by other methods ($r = 0.90$, $P < 0.01$ versus time-motion study [8]; $r = 0.90$, $P < 0.001$ versus breath gas analysis [6,8]). However, the respiratory chamber-based validity study [3] also suggested that the accelerometer underestimated total energy expenditure by 8.1% as compared to those measured by the indirect calorimetry. The accelerometer underestimated the energy expenditure especially for arm activity, pushing or carrying objects, walking uphill, or stair climbing. This is a limitation when attempting to use pedometers to qualify daily physical activity energy expenditure [28,29]. Since our study subjects were unlikely to make these specific motions so frequently, the underestimation may be small and the values estimated by the accelerometer would be appropriate. To further clarify the relationship between the ability to estimate energy expenditure and the control status of DM, additional studies are expected to measure the energy expenditure more accurately, for example, by using the doubly labeled water method.

The WHO classifies diabetic prevention into three levels: primary, secondary, and tertiary levels [30]. Diet is an important strategy for subjects at any level of the WHO classification system. Subjects classified in the primary prevention category are people who do not have DM [30]. To educate individuals in the primary prevention category regarding proper diet and lifestyle, and to instruct them how to estimate their individual energy intake and energy expenditure in advance of DM onset is one of the most useful measures for the prevention of DM. A good diet is important not only for DM patients, but also for anyone who wishes to have a long and healthy life [27]. In particular, excessive caloric intake and the consequent obesity cause various serious diseases. It would be interesting to examine whether the ability to recognize the amount of an individual's energy intake and physical exercise is related to the development of these diseases in future studies. If this proves true, a dietary educational program should incorporate a training procedure to improve an individual's ability to recognize his/her daily caloric intake.

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Trends in Childhood Obesity in Japan over the Last 25 Years from the National Nutrition Survey

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Abstract
MATSUSHITA, YUMI, NOBUO YOSHIIKE, FUMI KANEDA, KATSUSHI YOSHITA, AND HIDEMI TAKIMOTO. Trends in childhood obesity in Japan over the last 25 years from the National Nutrition Survey. *Obes Res.* 2004;12:205–214.
Objective: To describe the 25-year changes in BMI (measured in kilograms per meters squared) and the prevalence of obesity in Japanese children with special reference to urban-rural differences.
Research Methods and Procedures: We used the data sets from the cross-sectional annual nationwide surveys (National Nutrition Survey, Japan) conducted from 1976 to 2000 and comprising 29,052 boys and 27,552 girls between 6 and 14 years of age. We carried out the trend analyses with the data on sex and age groups and on residential areas according to the size of the municipality (metropolitan areas, cities, and small towns).
Results: The mean (age-adjusted) BMI increased by +0.32 kg/m^2 per 10 years in boys and by +0.24 kg/m^2 per 10 years in girls, increases that were remarkable in small towns. The prevalence of obese boys and girls increased from 6.1% and 7.1%, respectively, in the time-period 1976 to 1980, to 11.1% and 10.2% in 1996 to 2000. The increasing trend was most evident in 9- to 11-year-old children of both sexes living in small towns, whereas no changes were observed in girls in metropolitan areas.
Discussion: Our data clearly show increasing trends in obesity prevalence in Japanese school children. Degrees of the increasing trends, however, differed across sex and age groups and residential areas, demonstrating a particular phenomenon that girls in metropolitan areas were unlikely to become obese. These epidemiological aspects indicate the priorities for intervention in population strategies to control obesity in children.

Key words: trends analysis, school children, Japan, BMI, geographic difference

Introduction

There are limited reports about the changes in the prevalence of obesity in Japanese children (1,2). Publications in English are scarce; moreover, all of these have used data only from selected areas in Japan (2). Although the annual reports of school health statistics from the former Ministry of Education have shown numerous measurement values for body height and weight among large representative samples of school children (3), no further analyses on the data sets for descriptive epidemiology of childhood obesity have been made, mainly because of the limited accessibility to the original data sets. Therefore, no detailed epidemiological aspects of obesity in children have been shown using a nationwide representative sample in Japan.

Turning to the situations in other countries, although numerous reports have documented trends in childhood obesity over extended periods of time in various counties or regions (4–9), to our knowledge, very few of these studies have analyzed longer-term changes in childhood obesity at a national level (4–6).

In the present study, we used the data sets of the National Nutrition Survey, Japan (NNS-J)[1] (10), conducted by the former Ministry of Health and Welfare from 1976 to 2000. Using the large (~57,000 Japanese children 6 to 14 years of age) representative samples, we described changes in anthropometric indices and obesity prevalence of Japanese children.

Received for review June 9, 2003.
Accepted in final form December 10, 2003.
The costs of publication of this article were defrayed, in part, by the payment of page charges. This article must, therefore, be hereby marked "advertisement" in accordance with 18 U.S.C. Section 1734 solely to indicate this fact.
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[1] Nonstandard abbreviations: NNS-J, National Nutrition Survey, Japan; IOTF, International Obesity Task Force; CI, confidence interval.

Research Methods and Procedures

Data Collection in NNS-J

Details of sampling frames and data-collection procedures in the NNS-J have been described previously (11,12). Therefore, here we will only briefly explain relevant data collection methods. This annual survey was carried out in the local public centers under supervision of the central government. Three hundred survey areas were randomly selected from enumerated districts based on the population census; these areas, comprising ~6000 households and 15,000 individuals who were 1 year of age and older, were independently selected every year. The sampling areas were classified according to the size of municipality of residence (metropolitan: ≥1,000,000 people; large cities: 150,000 to <1,000,000 people; medium-sized cities: 50,000 to <150,000 people; small cities and small towns: <50,000 people).

The survey consisted of three components: 1) household- and individual-based dietary surveys (semi-weighed method for 1 day); 2) physical examinations of the household members; and 3) a questionnaire survey on dietary habits and lifestyle. The household members were asked to undergo measurements of both body weight and height (with light indoor clothes but no shoes) using a spring scale and a stadiometer at a local community center near their residence.

Data Sources and Analyses

With the permission of the Ministry of Health Labour and Welfare, we used NNS-J data sets obtained between 1976 and 2000 (a 25-year period) stored in magnetic tapes. Data sets for 29,052 boys and 27,552 girls 6 to 14 years of age were included in a secondary data set for the analyses. Table 1 details the number, age, and gender of the subjects in the study group. For subgroup analyses, the subjects were divided into three age groups, corresponding to lower grades (6 to 8 years of age) and higher grades (9 to 11 years of age) in primary schools and junior high school (12 to 14 years of age).

As a demographic factor, we classified five categories of residential areas in the original data set into three groups to avoid the small sample size in selected subgroups: metropolitan, cities (combining the three groups of large, moderate, and small cities), and small towns.

We calculated BMI (measured in kilograms per meters squared) using the recorded body weight and height in the data set. The criterion for "obese" was +20% excess of children's body weight from the standard body weight. The standard body weight was determined by Hibi's monogram (2,13), which is a weight-for-height chart by sex for Japanese children based on the school health statistics.

To define childhood and adolescent overweight and obesity, mainly for the purpose of international comparisons, we also used the International Obesity Task Force (IOTF) reference with age- and sex-specific BMI cutoff points. The IOTF reference consists of sex-specific curves that show equivalent values of BMI of 25 and 30 kg/m^2 at the age of 18 years for boys and girls, respectively (4,14).

To avoid year-to-year fluctuations in the survey results, we calculated mean BMI values and obesity prevalence for five time periods (1976 to 1980, 1981 to 1985, 1986 to 1990, 1991 to 1995, and 1996 to 2000) by sex, and these data were further classified by three age groups and the three residential areas.

For trend analyses, we adopted general linear models to determine the degrees of changes in the average BMI during the 25-year period from 1976 to 2000. We calculated regression coefficients of BMI for successive survey years that were coded as follows: 0, 0.1, 0.2, etc., up to 2.4, for the years 1976, 1977, 1978, etc., up to 2000. The results are shown as coefficients in units of kilograms per square meter per 10 years with a 95% confidence interval (CI). Age-adjusted data were used in all analyses, except for the age-specific data in the multiple regression models.

In addition, by means of multiple logistic models with age-adjusted data, we described trends in the prevalence of obesity expressed as an odds ratio for a 10-year period. An odds ratio with a lower CI that was >1.0 indicated a statistically significant increase by year, whereas an odds ratio with an upper CI <1.0 implied a significantly declining yearly trend. All statistical analyses were performed using SAS software (Version 8.2; SAS Institute Inc., Cary, NC) (15).

Results

In Tables 2 and 3, we show body height, weight, and BMI of children by age and sex in the five time-periods: 1976 to 1980, 1981 to 1985, 1986 to 1990, 1991 to 1995, and 1996 to 2000. For boys and girls, increasing trends were observed in body height, weight, and BMI throughout the period.

Table 4 shows BMI changes in Japanese children for all age groups in the five time periods. The age-adjusted changes in mean BMI, estimated by the linear regression models, were +0.32 and +0.24kg/m^2 per 10 years for boys and girls, respectively. Both of these results were statistically significant. The increased BMI trends were remarkable, especially in those living in small towns. The largest coefficient was observed in the 9-to-11-year-old age group living in small towns (+0.60kg/m^2 and +0.46kg/m^2 per 10 years, for boys and girls, respectively). In contrast, no such change was observed in 9- to 11-year-old girls living in metropolitan areas.

Table 5 shows the changes in the prevalence of obesity over the 25-year period from 1976 to 2000 using Hibi's monogram. The prevalence of obesity in the earliest study period (1976 to 1980) was 6.1% (boys) and 7.1% (girls).

Table 1. Number and sex of subjects included in the analyses

Sex	Year of surveys				
	1976 to 1980	1981 to 1985	1986 to 1990	1991 to 1995	1996 to 2000
Boys					
Age (years)					
6	1002	781	606	447	299
7	965	813	677	489	319
8	956	826	696	478	343
9	936	866	685	451	362
10	909	811	640	530	327
11	853	892	713	497	356
12	856	896	632	490	334
13	819	743	676	496	380
14	793	789	715	545	363
Total	8089	7417	6040	4423	3083
Girls					
Age (years)					
6	922	755	587	423	336
7	914	765	610	450	325
8	953	832	625	499	303
9	829	835	679	420	351
10	830	856	637	462	305
11	814	853	618	425	330
12	845	787	689	463	346
13	766	762	625	462	342
14	715	752	629	468	358
Total	7588	7197	5699	4072	2996
Combined					
Total	15677	14614	11739	8495	6079
Boys					
Metropolitan	1378	1114	943	803	480
Cities	4475	4264	3500	2442	1778
Small towns	2236	2039	1597	1178	825
Girls					
Metropolitan	1309	1042	916	698	479
Cities	4219	4171	3217	2287	1741
Small towns	2060	1984	1566	1087	776

These figures have gradually increased and, in the most recent period of 1996 to 2000, 11.1% and 10.2% of boys and girls, respectively, were found to be obese.

The increasing trends were statistically significant, with odds ratios for a 10-year-change of 1.38 (95% CI: 1.30 to 1.46) for boys and 1.21 (95% CI: 1.14 to 1.29) for girls, after age adjustment. Across the three age groups of boys, the largest odds ratio was observed in the 6-to-8-year-old age group, in which the prevalence of obesity more than doubled, from 4.2% in the 1976 to 1980 period to 9.7% in 1996 to 2000. In terms of residential areas, the increasing trends of obesity were most apparent in small towns, specifically for 9- to 11-year-old children of both sexes. A trend of slightly decreasing prevalence of obesity in girls 12 to 14 years of age in the metropolitan areas was observed, but was not significant.

Table 2. Body height, weight, and BMI of Japanese boys by age from 1976 to 2000 (National Nutrition Survey, Japan)

	Year of surveys, mean (SD)				
	1976 to 1980	**1981 to 1985**	**1986 to 1990**	**1991 to 1995**	**1996 to 2000**
Body height (meters)					
Age (years)					
6	114.6 (5.5)	115.5 (5.1)	116.0 (5.3)	116.3 (5.3)	115.9 (5.1)
7	120.8 (5.1)	120.8 (5.6)	121.8 (5.3)	122.0 (5.5)	122.1 (5.0)
8	126.2 (5.5)	126.5 (5.5)	127.4 (5.2)	127.4 (5.9)	127.8 (5.6)
9	131.3 (5.3)	131.7 (5.5)	132.0 (5.8)	132.9 (5.6)	132.7 (5.7)
10	136.8 (6.0)	137.0 (6.0)	138.0 (6.4)	138.1 (6.1)	138.1 (6.3)
11	142.0 (6.4)	142.5 (6.7)	143.7 (6.9)	144.3 (7.0)	144.1 (7.5)
12	149.1 (8.0)	149.2 (7.7)	150.6 (7.7)	151.2 (8.3)	151.3 (7.9)
13	156.3 (8.1)	156.6 (7.8)	157.7 (7.9)	158.5 (8.1)	158.7 (7.6)
14	162.4 (7.2)	163.4 (6.7)	163.4 (6.6)	164.3 (6.8)	164.4 (6.5)
Body weight (kg)					
Age (years)					
6	20.4 (2.9)	20.9 (3.0)	21.2 (3.2)	21.5 (3.3)	21.4 (3.8)
7	23.0 (3.5)	23.1 (3.5)	23.9 (4.0)	24.3 (4.4)	24.0 (4.2)
8	25.7 (4.3)	26.2 (4.8)	26.8 (4.8)	27.0 (5.0)	27.6 (5.9)
9	28.5 (4.7)	29.1 (5.1)	29.4 (5.6)	30.4 (6.0)	30.5 (6.6)
10	32.2 (6.3)	32.5 (6.3)	33.6 (6.8)	34.0 (7.2)	34.5 (7.9)
11	35.7 (6.8)	36.3 (7.4)	38.1 (8.2)	38.9 (8.4)	37.9 (8.0)
12	40.4 (7.8)	41.2 (8.6)	42.4 (9.1)	43.1 (9.2)	43.1 (9.3)
13	45.8 (8.7)	46.8 (9.0)	47.6 (9.2)	48.4 (10.1)	48.3 (9.5)
14	51.6 (8.8)	52.9 (9.8)	53.0 (9.0)	54.0 (10.2)	53.4 (9.8)
BMI (kg/m^2)					
Age (years)					
6	15.5 (2.1)	15.6 (1.5)	15.7 (2.1)	15.8 (1.6)	15.8 (2.0)
7	15.7 (1.7)	15.8 (2.0)	16.0 (2.0)	16.2 (2.1)	16.0 (2.1)
8	16.1 (1.9)	16.3 (2.1)	16.4 (2.3)	16.6 (2.5)	16.8 (2.7)
9	16.4 (2.0)	16.7 (2.1)	16.8 (2.4)	17.1 (2.6)	17.2 (2.7)
10	17.1 (2.4)	17.3 (2.5)	17.5 (2.6)	17.7 (2.9)	17.9 (3.2)
11	17.6 (2.5)	17.8 (2.6)	18.3 (2.9)	18.5 (3.0)	18.1 (2.9)
12	18.1 (2.5)	18.4 (2.7)	18.6 (2.9)	18.7 (2.8)	18.7 (3.1)
13	18.6 (2.5)	19.0 (2.6)	19.0 (2.6)	19.1 (2.9)	19.1 (2.8)
14	19.5 (2.5)	19.7 (2.9)	19.8 (2.7)	19.9 (3.0)	19.7 (2.9)

Table 6 shows the changes in the prevalence of overweight and obesity over the 25-year period using the IOTF definition. The prevalence of overweight and obesity increased. A slightly decreasing tendency of overweight in 12- to 14-year-old girls living in metropolitan areas after the period of 1986 to 1990 was also observed from an analysis using the IOTF definition, which was similar to the trends according to the Hibi's monogram.

Discussion

Public Health Implication of Our Findings

To our knowledge, this is the first report using nationally representative samples, with considerations for a geographic factor in the development of obesity early in life, that clearly shows an increasing trend of obesity in Japanese school children. Obesity is now considered a global epidemic (16), and the increasing trends in adults

Table 3. Body height, weight, and BMI of Japanese girls by age from 1976 to 2000 (National Nutrition Survey, Japan)

	Year of surveys, mean (SD)				
	1976 to 1980	1981 to 1985	1986 to 1990	1991 to 1995	1996 to 2000
Body height					
Age (years)					
6	114.4 (4.8)	114.7 (5.2)	115.4 (5.0)	115.6 (5.0)	114.8 (4.8)
7	119.9 (5.6)	120.7 (5.5)	120.8 (5.8)	121.7 (5.0)	121.2 (6.0)
8	125.3 (5.3)	126.3 (5.7)	126.6 (5.5)	127.0 (5.7)	126.7 (5.7)
9	131.1 (6.1)	131.8 (5.9)	132.1 (6.0)	133.3 (6.0)	132.9 (6.7)
10	137.7 (7.0)	137.8 (6.5)	138.8 (6.7)	139.3 (6.5)	139.3 (7.1)
11	144.2 (7.1)	144.7 (6.9)	145.7 (6.7)	146.6 (6.8)	145.7 (7.5)
12	149.8 (6.2)	150.3 (6.3)	151.1 (6.5)	151.4 (5.9)	151.2 (6.2)
13	153.5 (5.4)	154.0 (5.7)	154.4 (5.3)	154.7 (5.6)	154.3 (5.8)
14	155.1 (5.1)	155.5 (5.4)	156.1 (5.0)	156.3 (5.3)	155.8 (5.5)
Body weight					
Age (years)					
6	20.1 (3.0)	20.3 (2.9)	20.8 (3.2)	21.0 (3.3)	20.9 (3.7)
7	22.6 (3.8)	23.0 (3.8)	23.2 (4.0)	23.7 (4.0)	23.5 (4.9)
8	24.9 (3.9)	25.8 (4.6)	26.4 (5.0)	26.7 (5.0)	26.5 (5.2)
9	28.3 (5.3)	28.7 (4.9)	29.0 (5.4)	30.4 (6.1)	30.1 (6.5)
10	32.2 (6.2)	32.5 (6.1)	33.4 (6.7)	33.9 (6.9)	34.1 (7.5)
11	36.5 (7.0)	37.5 (7.2)	38.6 (7.3)	39.1 (7.7)	38.5 (8.1)
12	41.3 (7.3)	42.0 (7.1)	43.2 (7.5)	42.7 (7.0)	43.4 (8.2)
13	45.3 (6.6)	46.1 (7.4)	46.6 (7.0)	46.7 (7.9)	46.7 (7.7)
14	48.0 (7.2)	48.4 (6.8)	48.9 (6.8)	49.2 (7.8)	48.2 (6.7)
BMI					
Age (years)					
6	15.3 (1.6)	15.4 (1.5)	15.6 (1.7)	15.7 (2.0)	15.8 (2.1)
7	15.6 (2.0)	15.7 (1.8)	15.8 (2.0)	15.9 (1.9)	15.9 (2.4)
8	15.8 (1.8)	16.1 (2.1)	16.4 (2.4)	16.5 (2.2)	16.4 (2.3)
9	16.4 (2.2)	16.5 (2.0)	16.6 (2.3)	17.0 (2.5)	16.9 (2.6)
10	16.9 (2.4)	17.0 (2.2)	17.2 (2.4)	17.4 (2.5)	17.5 (2.9)
11	17.4 (2.3)	17.8 (2.5)	18.1 (2.6)	18.1 (2.6)	18.0 (3.0)
12	18.3 (2.4)	18.5 (2.3)	18.8 (2.6)	18.6 (2.4)	18.9 (3.0)
13	19.2 (2.4)	19.4 (2.6)	19.5 (2.6)	19.5 (2.7)	19.5 (2.6)
14	19.9 (2.5)	20.0 (2.4)	20.0 (2.5)	20.1 (3.1)	19.8 (2.5)

have been well recognized for several years as an important issue of public health in Japan (17). The "tracking" of obesity from childhood into adulthood has been well established (6,18,19), and findings suggest that childhood obesity could have a great impact on health conditions in adulthood, such as being a risk factor for the development of type 2 diabetes (20) and other metabolic disorders (9,21). Therefore, it is quite important to have reliable data for understanding the current situations and the changing patterns of obesity in children.

In Japan, a 10-year national plan for health promotion and disease prevention, "Health Japan 21," was recently established by the Ministry of Health, Labour and Welfare (22). The plan covers nine focus areas, including nutrition and physical activity, which indicate the objectives for decreasing obesity in adults (mainly targeting middle-aged men)

Table 4. Changes in average BMI of Japanese children by age, sex, and residential area, from 1976 to 2000 (National Nutrition Survey, Japan)

	Changes in BMI (kg/m^2/10 years)*	
	Boys	**Girls**
Overall†	+0.32 (+0.28 to +0.36)	+0.24 (+0.20 to +0.28)
Age (years)		
6 to 8	+0.27 (+0.21 to +0.33)	+0.24 (+0.18 to +0.30)
9 to 11	+0.42 (+0.34 to +0.50)	+0.31 (+0.23 to +0.39)
12 to 14	+0.27 (+0.19 to +0.35)	+0.17 (+0.09 to +0.25)
Residential area‡		
Overall†		
Metropolitan	+0.26 (+0.16 to +0.36)	+0.05 (−0.05 to +0.15)
Cities	+0.27 (+0.21 to +0.33)	+0.26 (+0.20 to +0.32)
Small towns	+0.47 (+0.39 to +0.55)	+0.31 (+0.23 to +0.39)
6 to 8 years of age†		
Metropolitan	+0.36 (+0.20 to +0.52)	+0.07 (−0.09 to +0.23)
Cities	+0.20 (+0.12 to +0.28)	+0.25 (+0.17 to +0.33)
Small towns	+0.35 (+0.23 to +0.47)	+0.33 (+0.21 to +0.45)
9 to 11 years of age†		
Metropolitan	+0.37 (+0.17 to +0.57)	+0.01 (−0.19 to +0.21)
Cities	+0.36 (+0.26 to +0.46)	+0.33 (+0.23 to +0.43)
Small towns	+0.60 (+0.44 to +0.76)	+0.46 (+0.30 to +0.62)
12 to 14 years of age†		
Metropolitan	+0.05 (−0.17 to +0.27)	+0.06 (−0.14 to +0.26)
Cities	+0.24 (+0.12 to +0.36)	+0.21 (+0.11 to +0.31)
Small towns	+0.46 (+0.30 to +0.62)	+0.16 (+0.00 to +0.32)

* Calculated by general linear and logistic models using the raw data from 25 points of observation. Data are expressed as: value (95% confidence interval).
† Adjusted for age by multivariate models.
‡ Defined by the size of municipality of residence (see the text).

and school children (17). The baseline figure (10.7% in 1998) on the prevalence of obesity in children 6 to 15 years of age, which was calculated by the same method as in this report, is expected to be <7% within a period of 10 years and is expected to be at the level found 20 years before (i.e., in 1978) (23).

In this new plan for action on health promotion, population strategies are emphasized for chronic disease prevention, including health education in the early stages of life (22). In most primary and secondary schools in Japan, regular anthropometric measurements are commonly carried out in school health programs. Therefore, early detection of overweight and health education on healthy body weight actually take place in many schools (24). In addition to such individual approaches, more wide-ranging health education programs for all children, such as enhancing physical activities or promoting healthier eating, should be created with careful consideration of the epidemiological aspects of childhood obesity.

Our finding that increasing trends in childhood obesity are rather prominent in rural areas may suggest a key issue for effective strategies on obesity control in school children. Unfortunately, no data are available that show the changes in physical activity levels from a nationally representative sample (25). The increasing trends in obesity, especially among children living in rural areas, could be the result of environmental and cultural changes that lead to low levels of physical activity in rural settings. Approximately 80% of students in junior high school (12 to 15 years of age) in Japan have been reported to live a sedentary lifestyle outside of school (26,27). Murata (26) has indicated that sedentary behavior could be caused by stressful academic stud-

Table 5. Changes in prevalence (%) of obesity among Japanese children using Hibi's monogram by age, sex, and residential area, from 1976 to 2000 (National Nutrition Survey, Japan)

Sex	Year of surveys (%)					Changes in the prevalence of obesity (Odds ratio for +10 years)*
	1976 to 1980	1981 to 1985	1986 to 1990	1991 to 1995	1996 to 2000	
Boys						
Overall†	6.1	7.8	9.2	10.2	11.1	1.38 (1.30 to 1.46)
Age (years)						
6 to 8	4.2	5.0	7.5	7.7	9.7	1.58 (1.40 to 1.79)
9 to 11	8.4	10.4	12.5	14.9	15.0	1.41 (1.29 to 1.55)
12 to 14	5.9	7.9	7.7	7.9	8.5	1.17 (1.05 to 1.31)
Residential area‡						
Overall†						
Metropolitan	7.4	9.8	10.1	12.5	10.8	1.30 (1.13 to 1.49)
Cities	6.0	7.4	8.6	8.6	10.6	1.31 (1.21 to 1.43)
Small towns	5.5	7.7	10.1	11.8	12.2	1.57 (1.40 to 1.76)
6 to 8 years of age†						
Metropolitan	4.3	6.4	6.1	11.7	8.3	1.64 (1.24 to 2.17)
Cities	4.1	4.8	7.3	6.0	9.9	1.53 (1.30 to 1.80)
Small towns	4.3	4.5	8.5	8.5	10.0	1.66 (1.32 to 2.09)
9 to 11 years of age†						
Metropolitan	11.1	12.1	16.0	15.8	14.2	1.24 (1.01 to 1.53)
Cities	8.1	10.3	10.8	13.0	14.4	1.35 (1.19 to 1.53)
Small towns	7.1	9.8	13.9	18.3	16.7	1.69 (1.42 to 2.01)
12 to 14 years of age†						
Metropolitan	7.2	10.9	7.6	9.7	10.1	1.12 (0.87 to 1.46)
Cities	6.0	6.8	7.5	6.8	7.5	1.10 (0.94 to 1.29)
Small towns	5.0	8.6	8.1	9.0	9.8	1.34 (1.09 to 1.65)
Girls						
Overall†	7.1	7.7	8.9	9.4	10.2	1.21 (1.14 to 1.29)
Age (years)						
6 to 8	6.1	7.4	8.9	9.8	10.3	1.35 (1.21 to 1.50)
9 to 11	7.5	7.7	9.0	10.4	12.2	1.30 (1.17 to 1.45)
12 to 14	8.1	8.2	8.8	8.0	8.4	1.00 (0.90 to 1.12)
Residential area‡						
Overall†						
Metropolitan	9.3	8.9	8.6	9.3	8.4	0.94 (0.81 to 1.10)
Cities	6.5	7.0	8.4	8.7	9.9	1.24 (1.14 to 1.35)
Small towns	7.0	8.6	10.3	10.9	12.2	1.35 (1.21 to 1.52)
6 to 8 years of age†						
Metropolitan	8.9	7.7	9.1	9.2	8.8	0.99 (0.76 to 1.29)
Cities	5.9	6.5	8.8	10.3	9.9	1.38 (1.19 to 1.59)
Small towns	4.6	9.0	9.1	9.0	12.1	1.56 (1.27 to 1.92)
9 to 11 years of age†						
Metropolitan	10.0	11.3	8.0	9.9	11.0	0.93 (0.72 to 1.20)
Cities	7.1	6.6	8.1	9.5	11.7	1.33 (1.15 to 1.54)
Small towns	6.7	8.0	11.7	12.6	14.0	1.56 (1.28 to 1.90)
12 to 14 years of age†						
Metropolitan	9.1	7.4	8.9	8.9	5.4	0.91 (0.69 to 1.19)
Cities	6.8	8.1	8.2	6.3	8.2	1.02 (0.88 to 1.20)
Small towns	9.9	8.7	10.0	11.0	10.7	1.05 (0.86 to 1.27)

* Calculated by general linear and logistic models using the raw data from 25 points of observation. Data are expressed as odds ratios (95% confidence interval).

† Adjusted for age by the multivariate models.

‡ Defined by the size of municipality of residence (see the text).

Table 6. Changes in prevalence (%) of overweight and obesity among Japanese children using the IOTF definition by age, sex, and residential area, from 1976 to 2000 (National Nutrition Survey, Japan)

	Year of surveys (%)									
	Overweight*					Obesity*				
Sex	1976 to 1980	1981 to 1985	1986 to 1990	1991 to 1995	1996 to 2000	1976 to 1980	1981 to 1985	1986 to 1990	1991 to 1995	1996 to 2000
Boys										
6 to 8 years of age										
Metropolitan	7.1	13.3	11.8	19.8	14.1	1.1	2.4	2.5	8.1	3.8
Cities	8.5	8.5	12.0	11.3	15.2	2.1	2.1	3.7	2.2	5.0
Small towns	7.4	7.8	14.0	15.4	16.2	1.7	2.0	4.6	3.9	4.1
All	7.9	9.1	12.5	13.9	15.3	1.8	2.1	3.8	3.7	4.6
9 to 11 years of age										
Metropolitan	14.3	13.2	20.1	20.5	18.7	2.1	2.6	4.3	2.5	3.2
Cities	10.1	12.0	13.1	17.4	17.9	1.4	2.0	2.4	4.6	4.5
Small towns	9.6	11.1	17.7	21.7	19.2	1.5	2.0	4.6	4.2	3.5
All	10.7	11.9	15.4	19.1	18.4	1.6	2.1	3.3	4.1	4.0
12 to 14 years of age										
Metropolitan	12.5	15.0	12.4	15.5	16.0	0.8	3.3	1.2	0.7	3.0
Cities	9.3	11.6	11.4	14.1	14.4	1.0	1.7	2.6	2.1	2.0
Small towns	7.5	13.3	13.8	14.8	15.2	1.1	2.5	1.7	4.4	4.0
All	9.2	12.6	12.2	14.6	14.9	1.0	2.1	2.1	2.5	2.7
Girls										
6 to 8 years of age										
Metropolitan	12.6	11.7	13.6	15.4	14.9	2.4	2.1	3.1	3.1	2.7
Cities	8.1	9.9	12.9	15.1	13.0	2.0	1.4	2.8	2.8	5.1
Small towns	7.6	12.2	13.6	13.4	18.1	1.1	2.7	2.6	3.6	4.4
All	8.7	10.8	13.2	14.7	14.6	1.8	1.9	2.8	3.1	4.6
9 to 11 years of age										
Metropolitan	11.6	15.0	10.5	12.3	15.9	2.7	1.1	0.9	1.0	1.8
Cities	9.0	9.1	12.6	14.1	17.3	0.6	0.9	1.0	2.4	3.9
Small towns	8.5	10.4	14.6	17.6	17.9	1.7	0.9	1.7	1.7	1.9
All	9.3	10.3	12.8	14.8	17.2	1.3	0.9	1.2	2.0	3.0
12 to 14 years of age										
Metropolitan	9.1	8.3	10.5	9.8	8.4	0.5	0.9	1.0	1.3	0.6
Cities	8.2	9.9	9.9	7.6	11.5	0.5	0.4	1.2	1.5	1.0
Small towns	9.3	9.6	10.0	11.8	12.2	0.6	0.6	1.5	1.9	1.1
All	8.6	9.6	10.0	9.0	11.2	0.5	0.5	1.2	1.6	1.0

* Defined by corresponding to BMI ≥25 (overweight) and ≥30 (obesity) kg/m^2 at age 18. The overweight group included obesity.

ies over prolonged periods of time, as well as indoor entertainment (e.g., television shows and video games). Furthermore, he has indicated that increased automobile transportation could also be the cause (26), a tendency that is particularly pronounced in rural areas.

The other important message from our analyses is the particular situation for girls living in metropolitan areas. Previous analyses of Japanese adults have also shown decreasing trends in BMI among women 20 to 40 years of age, especially in metropolitan areas (17,25,28). This finding indicates an alarming tendency toward underweight in young women because of an "unhealthy diet" for reducing body weight (17). Surveys in selected secondary schools have shown high percentages of "dieting" among girls, even though they are not obese (29–31). Therefore, unnecessary pressure to reduce body weight in older girls, especially in urban areas, should be avoided when health education programs for obesity control are provided in schools or communities.

Limitations of the Analyzed Data

A very common problem in the assessment of obesity in growing stages is the lack of appropriate indicators (32,33). Several methods have been used to determine the degree of obesity in Japanese children, including the Rohrer's index, which is a simple indicator (34), and the rather complicated "standard body weight table" for height specified for sex and age groups (35). In this report, we adopted the "classic" indicator of the Hibi's method (10), mainly for comparison with already published data in English (2); the data published in English alone would not allow accurate international comparisons because of local Japanese standards.

In recent years, BMI has been used even for children (32,36,37), because this indicator is likely to be highly correlated to body height in children and adolescents (38). Therefore, if a standard curve of BMI percentiles is available in a selected population, relative ranking of BMI expressed as percentiles is used for the assessment of childhood obesity (32). Unfortunately, because no standard curves of BMI percentiles for Japanese children have been available, we calculated only the mean value of BMI for the purpose of international comparisons. During the 25-year period of our observation, in which both average body height and weight increased in all age and sex groups, magnitudes of increasing body weight were more prominent in a formula for BMI calculation. However, an increasing trend of average BMI observed in a population in which average body height is also increasing should be carefully interpreted because of the limitation of BMI as an indicator for the assessment of childhood obesity.

Comparison with Data from Other Countries

Although we already mentioned the difficulties for international comparisons of our data, some important reports on the trends in childhood obesity in selected countries are summarized below.

In the U.S., 20% of children are estimated to be overweight. An analysis of nationwide data has suggested a clear upward trend in body weight in children of approximately +0.2 kg/year between 1973 and 1994 (21,39). In Canada, since 1981, the BMI of children has increased at the rate of nearly +0.1 kg/m^2 per year in both sexes (in children 7 to 13 years of age) (5); these are thought to be larger than the increases observed in our present study (+0.42 kg/m^2 and +0.31 kg/m^2 per 10 years in boys and girls 9 to 11 years of age, respectively). In another study of Canadian children, significant overall trends of increasing frequency of overweight and obese young inner-city schoolchildren from the early-to-late 1990s have been observed (7). A report on childhood obesity in Aragon, Spain, has shown that children are generally becoming more obese and that previously obese children increased their degree of obesity during the period 1985 to 1995 (40).

According to the IOTF definition, prevalence of overweight (equivalent to a BMI of ≥25 kg/m^2) in Japanese children is thought to be lower than the reported figures in the U.S. and much higher than those found in Brazil and China (4).

These results universally show a striking increase in the prevalence of overweight and obesity in children of developed and developing societies. Our data also suggest the increasing trends in school-aged children at a national level in Japan. Furthermore, our observation of more significant increases of childhood obesity not in urban areas, but rather in rural areas, is unique among the published reports from various other countries or regions, because several reports have shown rapid increases of childhood obesity in urban settings (41).

Acknowledgments

This study is supported, in part, by the Ministry of Health, Labour, and Welfare Research Grant on Children and Families and the research project of the National Institute of Health and Nutrition.

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