



PAPER

Prevalence and trends of obesity among school children in Taiwan — the Taipei Children Heart Study

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BACKGROUND: In Taiwan, the availability of a high-fat and high-energy diet has steadily risen over the past 30 y, while people have become increasingly sedentary. This lifestyle of poor diet and little physical activity has caused the prevalence of obesity to increase among adults and children. Obesity and associated chronic disease risk factors are becoming important public health issues. The purpose of this study is to evaluate the prevalence and secular trends of being overweight and obese among school children in Taiwan.

METHODS: We conducted a cross-sectional survey among junior high school students in Taipei in 1994 to ascertain a representative distribution of demographic, lifestyle and biochemical characteristics, including several cardiovascular disease risk factors. After multistage sampling of 85 junior high schools in Taipei, we randomly selected 1500 children for this survey. We defined being overweight and obese based on ideal body weight (IBW) criteria. Children are considered to be overweight if their body weight is 110–120% of IBW, and obese if their body weight is greater than 120% of IBW within age- and gender-specific strata.

RESULTS: In general, obese children have higher blood pressure, plasma glucose and triglyceride levels and lower high-density-lipoprotein cholesterol levels than normal-weight children. From 1980 to 1994, the mean value of body weight increased significantly over increases in body height (especially among boys). Although the percentage of overweight children remained steady from 1980 to 1994 in both genders, the prevalence and trends of obesity increased significantly, especially among boys and older girls.

CONCLUSION: From this survey we find that in Taiwan from 1980 to 1994 body weight increased dramatically over body height among school children. The prevalence of obesity also increased significantly, especially among boys, while the percentage of overweight children did not vary. Overall, this study indicates that obesity and the adverse effects of being over the ideal body weight is no longer just a problem of Western countries.

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Introduction

Obesity is a widespread and growing problem in the world with significant medical, psychosocial and economic consequences.^{1–3} The prevalence of obesity has increased substantially over the last few decades and indications are that this trend will continue.^{4–6} In the US, one-third of overweight Americans are at an increased risk of developing

chronic diseases such as type 2 diabetes, cardiovascular disease, gallbladder disease, hypertension and certain forms of cancer.^{3,7,8}

In children, the development of obesity is associated with the simultaneous deterioration in chronic diseases risk profiles.^{9–14} Excess weight in childhood is the leading cause of pediatric hypertension, and overweight children are at a high risk for developing long-term chronic conditions, including adult-onset diabetes mellitus, coronary heart disease, orthopedic disorders and respiratory disease.^{10–16} In fact, there is substantial evidence suggesting that obesity in childhood lays the metabolic groundwork for adult cardiovascular disease.^{10,13} Also, many studies demonstrate that overweight children tend to become overweight adults.^{17–20}

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Overall, obesity in childhood appears to increase the risk of subsequent morbidity, whether or not obesity persists into adulthood.^{16,21}

For the general population in Taiwan, the availability of a high-fat and high-energy diet has steadily increased over the past few decades, while the lifestyle has also become more and more sedentary and physically inactive.^{22,23} Since the prevalence of obesity is continuously increasing among adults and children,^{23,24} obesity and associated chronic disease risk factors are becoming an important public health issue.^{23,25}

The purpose of this study is to evaluate the prevalence and secular trends of overweight and obese school children in Taipei from 1980 to 1994.

Materials and methods

Study design and sampling method

The Taipei Children Heart Study is an epidemiological survey of cardiovascular disease risk factors among school children in Taipei in 1994. The details of the sampling methods and results are described elsewhere.^{25,26} Briefly, we conducted a cross-sectional survey among junior high school students in Taipei to ascertain a representative distribution of demographic, lifestyle and biochemical characteristics and cardiovascular disease risk factors. After multistage sampling of 85 junior high schools in Taipei, we randomly selected 1500 school children for this survey.

Data collection

General information. All participants completed a questionnaire on their disease history and lifestyle characteristics, including cigarette smoking, alcohol consumption, puberty development, usual physical activity and dietary intake.

Anthropometrics measurement. Research technicians recorded body weight to the nearest 0.1 kg using a standard beam balance scale with subjects barefoot and wearing light indoor clothing. Body height was recorded to the nearest 0.5 cm. We calculated ideal body weight (IBW) as the average body weight among age- and gender-specific strata of this group. Body mass index (BMI) was defined as the ratio of body weight to body height squared, expressed as kg/m².

Blood pressure and lipids measurement. After 10 min rest, we measured blood pressure (BP) on the right arm in a sitting position, using an appropriate cuff size; the first and fifth Korotkoff sounds were recorded as systolic and diastolic BP. We measured blood pressure again after a 5 min rest and the average was used in the analysis.

To reduce extraneous between-person variation, we collected a 12 h fasting blood sample only from students who had consumed their usual dietary pattern during the previous 3 days. Children who had recently attended a holiday or family celebration were recontacted several weeks later. We

measured serum total cholesterol using an esterase oxidase method, triglycerides (TG) using an enzymatic procedure, and high-density-lipoprotein-cholesterol (HDL-C) by an enzymatic method with magnesium precipitation using the Synchron CX5 analyzer (Beckman Instrument, Palo Alto, CA). Because no triglyceride concentration exceeded 400 mg/dl and all samples were collected after a 12 h fast, we used Friedewald's formula to calculate LDL cholesterol: $LDL\ cholesterol = ((total\ cholesterol - HDL-C) - (triglyceride/5))$.

Previous national surveys

Two previous national surveys conducted before this study were used to compare the trends of change in body height and body weight among school children in Taiwan. The first survey was conducted in 1980–1982²⁷ and the second was conducted in 1986–1988.²⁸ The national prevalence and secular trends of being overweight and obese among 12–15-y-old school children are based on the data of these three surveys.

Definition of overweight and obese children

With no universal definition of obesity for school children and limitations on the availability of anthropometric information from previous national surveys in Taiwan, we defined overweight and obese based on weight–IBW criteria (ratio of body weight to ideal body weight). We considered children to be overweight if their body weight was 110–120% of weight–IBW ratio and to be obese if their body weight was greater than 120% of weight–IBW ratio within age- and gender-specific strata. For the 1994 survey, we also compared the corresponding mean value of BMI among different obese groups using weight–IBW ratio criteria with age- and gender-specification.

Statistical analysis

To reduce differences due to maturation, gender-specific distribution of anthropometric and biochemical measures is directly standardized to the age distribution of the whole study population in the 1994 survey. We compared the differences in general characteristics among children with different categories of obesity using analysis of variance (ANOVA) after adjusting for age and with gender specification (only 1994 data). A two-tailed *P*-value < 0.05 was considered statistically significant. All statistical analyses were conducted using the statistical package SAS (SAS Institute Inc, Cary, NC).

Results

General characteristics among study subjects

In the 1994 survey, we excluded 134 subjects who refused to enter the survey protocol or had missing or incomplete data. The final sample for analysis included 1366 children (681

boys and 685 girls). From this cross-sectional survey, the mean (\pm s.d.) body height is 161.9 ± 8.2 and 156.3 ± 5.5 cm and body weight is 55.6 ± 12.5 and 50.7 ± 9.5 kg for boys and girls, respectively. The anthropometric and biochemical characteristics among different categories of obesity in 1994 are presented in Table 1. In general, obese children have higher blood pressure, plasma glucose and triglyceride levels and lower high-density-lipoprotein-cholesterol levels than normal-weight children ($P < 0.05$). Furthermore, over-

weight boys had higher plasma triglyceride levels and lower HDL-C levels, while both genders had higher systolic BP than normal weight children.

Trends of body height and body weight in Taiwan

Tables 2 and 3 show the secular trends of mean values and percentile distributions of body height and weight among 12 to 15-y-old school children in Taiwan. In both genders, the

Table 1 General characteristics of study children among different categories of obesity with gender specification on 1994–1996 survey

	Boys						Girls					
	Normal (n = 490)		Overweight ^a (n = 79)		Obese ^a (n = 112)		Normal (n = 539)		Overweight (n = 70)		Obese (n = 76)	
	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
Body height	160.4	8.2	164.9*	8.0	166.2*	5.9	155.5	5.5	158.4*	5.6	159.5*	4.5
Body weight	49.7	7.6	63.9*	4.7	75.2*	9.8	47.0	5.6	57.7*	3.3	70.1*	8.8
SBP ^b	111.9	12.4	117.1*	11.6	121.3*	12.1	102.5	11.7	106.8*	11.9	115.5*	11.8
DBP	66.4	8.8	68.1	9.3	72.3*	10.3	66.8	8.8	66.6	9.3	74.4*	10.0
GLUC	92.9	7.7	93.9	8.1	95.3*	8.3	91.4	7.8	91.4	6.3	93.7*	10.0
CHOL	151.3	27.1	149.2	27.0	154.0	27.6	161.6	29.6	159.6	23.0	161.7	26.8
TG	64.6	26.4	81.4*	42.2	86.6*	45.9	75.9	31.5	74.1	29.0	88.7*	47.5
HDL-C	55.6	13.4	50.9*	12.0	46.9*	13.2	56.3	12.9	55.0	10.9	49.4*	10.8
LDL-C	82.8	25.1	82.0	25.4	89.7*	24.1	90.2	27.1	89.8	20.4	94.6	23.4

^aOverweight is defined as body weight at 110–120% of mean body weight and obese is defined as > 120% mean body weight at same age and gender stratum.

^bSBP, systolic blood pressure (mmHg); DBP, diastolic blood pressure (mmHg); GLUC (mg/dl); CHOL, cholesterol (mg/dl); TG, triglyceride (mg/dl); HDL-C, high density lipoprotein-cholesterol (mg/dl); LDL-C low density lipoprotein-cholesterol (mg/dl).

* $P < 0.05$ when compared with the same gender normal-weight group using ANOVA after adjusting for age.

Table 2 Mean values of body height and body weight among 12 to 15 y old school children in Taiwan with gender specification

Age (y)	1980–1982		1986–1988 ^a		1994–1996	
	n	Mean \pm s.d.	n	Mean \pm s.d.	n	Mean \pm s.d.
Body height (cm)						
Boys						
12	544	144.9 \pm 7.8	609	146.6	131	155.4 \pm 7.7
13	173	152.8 \pm 8.6	591	153.6	240	160.4 \pm 7.5
14	1053	159.9 \pm 9.6	617	159.8	238	165.8 \pm 6.9
15	538	163.3 \pm 9.6	439	164.1	64	166.8 \pm 5.6
Girls						
12	531	146.7 \pm 7.0	556	148.0	151	153.9 \pm 5.3
13	142	151.3 \pm 6.0	558	152.5	225	156.3 \pm 5.6
14	971	154.6 \pm 7.0	537	154.7	237	157.3 \pm 5.4
15	544	155.4 \pm 5.2	430	156.4	71	157.4 \pm 5.0
Body weight (kg)						
Boys						
12	541	35.7 \pm 7.6	609	37.9	131	50.8 \pm 11.0
13	172	41.3 \pm 8.3	591	43.1	240	53.5 \pm 12.7
14	1057	47.3 \pm 8.8	617	48.6	238	58.8 \pm 11.7
15	536	51.4 \pm 8.7	439	52.2	64	61.3 \pm 2.2
Girls						
12	531	36.7 \pm 7.3	556	38.2	151	47.0 \pm 7.9
13	143	41.5 \pm 6.6	558	42.7	225	49.8 \pm 8.9
14	971	45.1 \pm 6.5	537	44.9	237	52.8 \pm 10.1
15	542	46.8 \pm 6.9	430	52.2	71	54.4 \pm 9.9

^aNo Information on s.d. was available in this survey.

Table 3 Percentiles distribution of body height and weight among 12 to 15-y-old school children in Taiwan with gender specification

Age (y)	1980–1982 Percentiles					1986–1988 Percentiles					1994–1996 Percentiles				
	10	25	50	75	90	10	25	50	75	90	10	25	50	75	90
Body height (cm)															
Boys															
12	135	139	145	150	155	136	141	146	152	158	148	150	155	161	169
13	142	148	153	159	163	143	147	154	160	166	149	156	161	166	170
14	150	156	161	165	170	149	155	161	165	170	157	162	166	171	174
15	154	160	164	169	172	156	160	165	169	173	161	163	167	170	175
Girls															
12	137	142	147	152	155	139	144	149	153	157	148	151	154	158	161
13	145	147	151	155	159	145	149	153	157	160	149	153	156	160	163
14	148	152	155	159	162	148	151	155	159	162	151	154	158	161	165
15	149	152	156	159	163	150	153	157	160	163	151	154	158	161	164
Body weight (kg)															
Boys															
12	27.6	30.5	33.9	39.5	45.6	28.4	31.4	36.3	42.3	50.0	37.5	41.5	49.5	60.0	67.5
13	31.6	36.0	40.5	46.9	53.9	32.0	35.4	41.5	48.8	56.3	40.5	44.5	51.5	59.5	71.5
14	36.6	41.9	47.4	52.0	57.5	36.9	41.6	47.3	53.8	60.8	45.0	50.5	57.8	65.0	74.5
15	41.8	46.3	51.0	56.3	62.3	41.8	45.8	50.9	56.5	63.5	47.0	52.0	60.5	68.0	76.0
Girls															
12	28.4	31.6	35.7	40.5	47.1	28.8	33.0	37.1	43.1	48.0	37.0	40.5	47.0	51.5	55.5
13	34.0	37.2	41.6	45.2	49.8	34.1	38.2	42.4	46.9	51.5	40.5	44.0	48.0	54.0	62.0
14	38.0	41.0	44.6	48.4	53.6	36.3	39.8	44.4	49.2	53.8	42.5	46.5	50.5	56.0	64.0
15	39.4	42.8	46.0	50.3	55.1	39.1	42.7	46.6	51.6	57.2	44.0	47.0	53.0	60.0	67.0

mean body height has increased in all age groups from 1980 to 1994; however, this increase in average height could not explain the increase in body weight (especially among boys) when compared within the same age and gender group. For example, the mean body height of a 15-y-old boy was 163.3, 164.1 and 166.8 cm, in 1980, 1986 and 1994, respectively, while the mean value of body weight was 51.4, 52.2 and 61.3 kg. Over this period, the gain in mean body weight was disproportionate to the gain in height.

Prevalence and secular trends of being overweight and obese in Taiwan

The prevalence and secular trends of being overweight and obese among children with age- and gender-specification are shown in Table 4. Although the trends of being overweight remained steady from 1980 to 1994 in both genders, the prevalence and trends of obesity increased significantly (Figure 1), especially among boys of all age and older age girls.

Table 4 Prevalence and secular trends of overweight and obesity among 12 to 15-y-old school children in Taiwan with gender specification

Age (y)	1980–1982			1986–1988			1994–1996		
	n	Overweight ^a	Obese ^a	n	Overweight	Obese	n	Overweight	Obese
Boys									
12	541	9.8	15.7	609	10.2	16.4	131	12.2	21.4
13	172	15.1	15.1	591	10.3	17.4	248	10.1	16.5
14	1057	13.9	11.1	617	11.5	13.9	238	12.6	14.7
15	536	13.6	10.6	439	11.9	10.5	64	12.5	12.5
Total ^b	2306	13.0	12.4	2256	10.9	14.8	681	11.6	16.4
Girls									
12	531	9.8	15.4	556	12.4	14.8	151	14.6	8.8
13	143	12.6	9.1	538	14.2	10.2	226	9.3	11.9
14	971	10.6	9.0	537	14.3	9.3	237	8.9	11.0
15	542	13.8	7.2	430	10.9	9.8	71	8.5	16.9
Total ^b	2187	11.3	10.1	2061	13.1	11.1	685	10.2	11.1

^aOverweight is defined as body weight at 110–120% of mean body weight and obese is defined as > 120% of mean body weight at same age and gender stratum.

^bAge-adjusted prevalence.

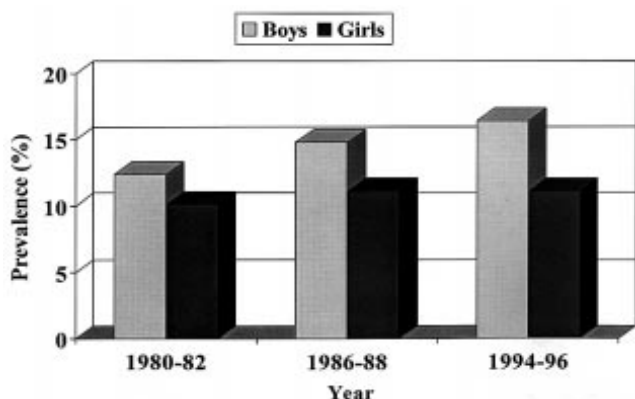


Figure 1 Age-adjusted prevalence of obesity among school children in Taiwan.

Table 5 Corresponding mean and median values of body mass index for overweight and obese school children on the 1994–1996 survey

Age (y)	Mean		Median	
	Overweight ^a	Obese	Overweight	Obese
Boys				
12	23.7	25.2	23.5	25.6
13	23.1	27.7	22.6	27.1
14	23.3	27.9	23.2	27.6
15	26.2	28.9	26.3	28.4
Girls				
12	22.1	25.9	22.2	26.2
13	22.7	26.6	22.6	26.2
14	23.8	28.8	24.2	27.5
15	24.9	28.5	25.5	28.6

^aOverweight is defined as body weight at 110–120% of mean body weight and obese is defined as > 120% of mean body weight at same age and gender stratum.

Table 5 describes the corresponding mean and median values of BMI for overweight and obese school children based on the weight–IBW ratio criteria from our 1994–1996 survey.

Discussion

In this survey of 1366 school-aged Taiwanese children, we found that the prevalence of obesity has steadily increased from 1980 to 1994, from 12.4 to 16.4% for boys and 10.1 to 11.1% for girls. Furthermore, our results show that obese and even overweight children had higher systolic blood pressures and more adverse lipid profiles, with higher glucose levels (only obese) compared to normal-weight children.

Longitudinal data is best to evaluate the sensitivity, specificity and predictive value of comparative measures of childhood and adolescent adiposity used to identify current and future morbidity.^{29,30} One potential problem of our study is the sampling variability between the 1994 data

and the previous surveys. In our study, the children are from the Taipei area which is likely to represent a more urban population compared to the previous national surveys which enrolled children from all of Taiwan. Therefore, the increased trends of obesity demonstrated in our results may be associated with the increased urbanization and industrialization over time,^{31–33} but one must consider that these data could be a result of sampling variability.

The relationship between obesity and chronic diseases has been documented in numerous studies.^{1–3,16} In the US, excess weight is responsible for approximately 300 000 deaths each year, making it second only to smoking as a cause of death.⁶ The economic cost of obesity and its complications are estimated to exceed \$45 billion per year.^{14,34} Furthermore, weight gain and obesity during childhood and adolescence are associated with many risk factors for poor health, including higher levels of blood pressure and adverse lipid profiles.^{14,35,36} The prevention of excess weight gain and obesity among children and adolescents is an important factor in the prevention of obesity and decreasing the risk of chronic disease among adults.^{4,37,38}

The causes of obesity are multifactorial and complicated, but it is clear that decreased physical activity is strongly associated with the development of obesity.^{4,15,39} In general, weight gain is a result of a positive energy balance where energy intake from food exceeds energy expenditure in physical activity.^{5,40} Over the past 30 y in Western countries, there is an increasing prevalence of overweight and obese children and adolescents in both genders.^{4,6,41,42} For example, in the US, from 1963 to 1991, the prevalence of overweight children (based on 85th percentile BMI) increased from 15.1 to 21.7% for boys and 15.2 to 21.2% for girls 12 to 17-y-old.⁴ Societal changes over the past 30 or more years could be responsible for decreases in physical activity, including altered transportation patterns and household work, as well as greatly increased time spent being physically inactive, such as watching television, using computers and playing electronic games.^{4,5,39,43}

This increasing prevalence of obesity is also seen in Taiwanese adults and children, which may partly be explained by an imbalance between energy intake and expenditure. For example, total energy available increased from 2661.7 to 2992.9 calories/day and fat intake rose from 63.5 to 128.4 g/day during 1970 to 1989 in Taiwan.²² Of course, increasingly sedentary lifestyles, including excessive TV watching and physical inactivity, are partly to blame for this trend. In this study, the rising prevalence of obesity and stable proportion of being overweight may partly be explained by the heavier children having increased their body weight more than normal and the shift towards greater obesity in the whole population. In Table 3, the percentile distribution of body height among children from 1980 to 1994 was increased similarly in each percentile group. However, the increase in body weight was more significant in the higher percentile children than that in the lower percentiles which may be associated with the prevalence of obesity

increasing but that of overweight remaining stable among Taiwanese school children. The possible mechanisms of the discrepant rising obesity among genders are more complicated. In Taiwan, the girls had an earlier puberty development than boys (girls at 11–13 y when compared with boys at 12–14 y), which may be associated with the gain in body weight being disproportionate to the gain in height among different gender and age groups. Dietary and activity patterns may also play a certain role in the development of obesity at these ages. According to results of previous body image and eating behavior surveys among young females study in Taipei, more than half of the young girls were not satisfied with their body shape and image and tried to use laxatives, diet pills and restricting diets to control their body weight and shape.⁴⁴ This may be associated with the trend of obesity rising more significantly in boys than in girls of this age range.

For children and adolescents, classifying obesity is complicated, since body weight and body composition are continually changing.^{29,30} Taking this into consideration, BMI is the most appropriate measure for clinical assessment of adiposity in children and adolescents.^{30,45} However, in our previous national surveys the definition of obesity is based on the weight–IBW ratio. For comparison with information from these surveys, we also used the weight–IBW ratio to define overweight and obese children in this study. Additionally, we presented the BMI values that correspond to the weight–IBW ratio for the 1994–1996 survey. For example, based on BMI criteria, we considered children to be obese if their BMI was greater than or equal to the 85th percentile of age- and gender-specific strata.²⁵ For boys, the cut-off point for obesity was 25.0, 24.6 and 25.5 kg/m² for 12, 13 and 14 or greater year olds; for girls it was 22.4, 23.3 and 24.8 kg/m². When 120% weight–IBW ratios are used as cut-offs for obesity, the corresponding BMI were 25.2, 27.7 and 27.9 for boys and 25.9, 26.6 and 28.8 for girls among 12, 13 and 14 y, respectively. Therefore, the weight–IBW ratio is a higher cut-off for defining obesity compared to BMI. Our data may be an underestimation of the prevalence of obesity compared to data generated using BMI.

In conclusion, this study demonstrates that the prevalence of overweight children remained steady over the period from 1980 to 1994, whereas obesity increased significantly, especially among boys in Taiwan. Since obesity in adults is associated with the development of chronic diseases, prevention of excess weight gain and obesity early in life may decrease the risk of chronic disease in later life.^{4,15,39} Further studies are needed to evaluate these data to better understand and potentially prevent the causes of obesity among children.

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Appendix

Table A1 Percentiles distribution of body mass index among 12 to 15-year-old school children in Taipei with gender specification on the 1994–1996 survey

Age (y)	Percentiles				
	5	15	50	85	95
<i>Boys</i>					
12	15.9	17.2	20.3	25.0	27.1
13	16.3	17.3	19.6	24.5	28.7
14	16.7	17.7	20.4	25.3	28.9
15	17.3	18.0	21.2	26.5	29.9
<i>Girls</i>					
12	15.9	16.8	19.4	22.4	25.0
13	16.2	17.4	19.7	23.3	27.2
14	16.9	18.2	20.4	24.5	28.2
15	17.4	18.6	21.2	27.3	28.9