

Weight-for-Height Reference and the Prevalence of Obesity for School Children and Adolescents in Taiwan and Fuchien Areas

Yi-Ching Huang¹
Jen-Yee Wu²
Mei-Jung Ou Yang²

¹ Department of Exercise and Health Science, National Taipei College of Nursing

² Department of Physical Education, Ministry of Education, R.O.C.

Key Words

adolescents;
children;
obesity;
weight-for-height

Overweight and obesity in childhood and adolescence are recognized as public health problems worldwide, even though the criteria used to define overweight and obesity may vary among countries. The prevalence rate of overweight and obesity in childhood has increased in North America.¹⁻⁴ Childhood obesity has also been reported in some Asian countries.⁵ Singapore described a rising prevalence of obesity among the first-, sixth- and seventh-grade children from 5% in 1980 to 15% in 1992, with obesity defined as weight greater than 120% median weight-for-height.^{6,7} A study in Hong Kong⁸ showed that 5% of the 7-year-old children had weight above 120% median NCHS⁹ (National Center for Health Statistics) weight-for-height standard. Taiwan also reported around 20% for the prevalence rate of childhood obesity using the criteria of weight greater

Background. Overweight and obesity in childhood and adolescence are recognized as public health problems worldwide. Updated growth reference values of weight-for-height are needed for monitoring physical growth of children and adolescents.

Methods. Weight-for-height and the prevalence of obesity for school children and adolescents in Taiwan and Fuchien Areas were analyzed based on the data obtained in a 2002 nationwide survey of 86,967 subjects, including 44,133 boys and 42,834 girls, ages 6.5 to 18.5 years. Weight-for-height percentile curves were smoothed separately by regression model with polynomials.

Results. The growth reference values of weight-for-height were updated for monitoring physical growth. The prevalence of childhood and adolescent obesity was 18.5% (range: 10.6% - 22.8%) in boys and 15.0% (range: 10.0% - 18.4%) in girls. Boys had a higher prevalence of obesity than girls did at all ages. The peak of prevalence of obesity in boys was around 10.0-12.0 years old.

Conclusion. At all ages, the prevalence of childhood and adolescent obesity for both sexes is higher in the 2002 than in 1997. This evidence strongly suggests an increasing prevalence of obesity during childhood and adolescence in recent years, irrespective of sex.

than 120% weight-for-age.¹⁰

One study in 1997 using the definition of 120% median weight-for-height showed that the prevalence of childhood and adolescent obesity in Taiwan was between 9.9% and 18.3% in boys and between 7.6% and 14.8% in girls.¹¹ Meanwhile, boys have a higher prevalence of obesity than that of girls at all ages. In the past 3 decades, significant secular increases in body height and weight have been reported in Taiwanese children and adolescents.^{12,13} Therefore, updated growth reference values of weight-for-height are needed for monitoring physical growth due to the secular trend toward and increasing prevalence of childhood obesity. With this aim, the current study also used the definition of Huang and Wu¹¹ to estimate the prevalence rate of obesity for comparison of both studies.

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Correspondence to: Yi-Ching Huang, Department of Exercise and Health Science, National Taipei College of Nursing, 365, Min Te Road, Taipei, Taiwan.
Tel: +886-2-2822-7101 ext. 2902; E-mail: ych1999@ms39.hinet.net

METHODS

The study population consisted of students from Taiwan and Fuchien Areas. Taiwan Area is divided into 23 district regions, including 16 counties (Taipei, Ilan, Taoyuan, Hsinchu, Miaoli, Taichung, Changhua, Nantou, Yunlin, Chiayi, Tainan, Kaohsiung, Pingtung, Taitung, Hualien, and Penghu) and 7 cities (Keelung, Hsinchu, Taichung, Chiayi, Tainan, Taipei, Kaohsiung). Fuchien Area includes 2 counties, Kingmen County and Lienchiang County. According to the list of all schools from the Department of Statistics of the Ministry of Education, there are 2,600 elementary schools, 709 secondary high schools, 277 senior high schools, and 188 vocational schools in Taiwan and Fuchien Areas. There are 3,639,470 students in totality, including 1,925,981 students in elementary schools, 929,534 students in secondary high schools, 356,589 students in senior high schools, and 427,366 students in vocational schools. The list of all schools was arranged in random manner by county and city. A multistage cluster sampling method with stratification was used to select the sample schools. The sampling process involved 2 stages. In the first stage, all schools were divided into 3 parts: elementary schools, secondary high schools, and senior high and vocational schools. A random starting school was selected, and then every tenth school of the elementary schools, every sixth school of the secondary high schools, and every fourth school of the senior high and vocational schools was selected for the sample. Some schools which are a combination of secondary and senior high schools were also included. Once stratified, 251 elementary schools, 119 secondary high schools, and 112 senior high and vocational schools were selected with systematic random sampling. The school sample size of the elementary schools was more than twice that of the secondary high schools, senior high and vocational schools. Thus, in order to obtain analogous sample size at each age level, in the second stage, the sampling unit was one classroom randomly selected for each grade from the first to sixth grade of the chosen elementary schools. Meanwhile, 2 classrooms were randomly selected for each grade from the first to third grade of the chosen secondary high schools, senior high and vocational schools.

All of the children in the selected classrooms were re-research subjects.

Data from these chosen 482 school samples included 86,967 subjects, 44,133 boys and 42,834 girls, ages 6.5 to 18.5 years. The total subjects represented approximately 2.4% of the study population living in Taiwan and Fuchien Areas. The measurements of body height and weight were made by school nurses between the beginning of April and the end of May in 2002. Approval to take the measurements was obtained from the school administrators in each selected school before children were measured. The school nurse of each chosen school provided data according to a common protocol and uniform format. In brief, body height and weight of all the children were measured in a standardized way using a portable metal stadiometer and digital or balance beam scale. In comparison with the results of Huang and Wu,¹¹ age was listed at the half-year point; for example, 6.5 years represented 6.25-6.74 years or 6.25 years up to but not including 6.75 years of age. Meanwhile, the percentile (3rd, 10th, 25th, 50th, 75th, 90th and 97th) curves of weight-for-height were calculated by 2-cm intervals. The weight-for-height of different height groups was also smoothed separately by regression model with polynomials up to the 3rd degree. The final smoothing equations had R-square larger than 0.995.

RESULTS

Sample size, median, mean and standard deviation (SD) of weight-for-height by sex are presented in Table 1. The respective percentile (3rd, 10th, 25th, 50th, 75th, 90th and 97th) curves of weight-for-height are shown in Fig. 1 for boys between 110 and 184 cm and in Fig. 2 for girls between 110 and 172 cm. Table 2 shows the percentage of obesity, defined as weight greater than 120% median weight-for-height from Huang and Wu,¹¹ of both sexes from 6.5 to 18.5 years in Taiwan and Fuchien Areas. The results show that the prevalence of childhood and adolescent obesity was between 10.6% and 22.8% in boys and between 10.0% and 18.4% in girls. Boys had a higher prevalence of obesity than girls did at all ages.

Table 1. Weight-for-height (kg) of boys and girls, 6.5 to 18.5 years, presented as median, mean and standard deviation (SD) in Taiwan and Fuchien Areas

Height (cm)	N	Boys			N	Girls		
		Median	Mean	SD		Median	Mean	SD
110.0	52	19.0	19.1	2.1	75	18.5	19.2	3.0
112.0	114	19.7	20.0	3.0	135	19.0	19.3	1.7
114.0	206	20.2	21.0	2.8	258	20.0	20.2	2.1
116.0	369	21.0	21.4	2.3	426	21.0	21.1	2.3
118.0	466	22.0	22.3	2.7	539	21.8	21.9	2.3
120.0	671	23.0	23.4	2.8	711	22.6	23.2	3.0
122.0	907	24.0	24.7	3.5	827	23.8	24.2	3.0
124.0	960	25.0	25.7	3.7	932	24.4	25.1	3.4
126.0	1117	26.0	27.1	4.1	929	25.6	26.4	3.7
128.0	1063	27.2	28.4	4.6	971	26.8	27.6	4.2
130.0	1111	28.2	29.6	5.2	944	27.8	28.8	4.7
132.0	1166	30.0	31.3	5.5	900	29.0	30.0	4.7
134.0	1127	30.6	32.3	5.8	869	30.4	31.6	5.3
136.0	1176	32.2	34.0	6.5	894	31.7	32.6	5.3
138.0	1081	33.4	35.1	6.2	850	33.1	34.4	6.0
140.0	1097	35.1	37.0	7.0	802	34.7	36.0	6.3
142.0	1093	37.0	38.6	7.2	904	36.0	37.5	6.6
144.0	1002	38.7	40.8	8.1	927	38.1	39.4	7.3
146.0	994	40.0	42.1	8.2	1103	40.2	41.6	7.4
148.0	992	41.5	43.9	9.1	1513	42.2	43.5	7.7
150.0	932	43.5	45.5	8.7	2095	44.5	45.6	7.5
152.0	994	44.6	46.8	9.1	2820	46.0	47.6	7.9
154.0	1079	46.1	48.9	9.7	3455	47.6	49.1	8.0
156.0	1186	47.9	50.1	9.3	3798	49.0	50.7	8.5
158.0	1364	51.0	52.9	10.4	3834	50.0	51.8	8.6
160.0	1623	51.5	54.1	10.5	3762	51.5	53.3	8.9
162.0	1909	54.1	56.4	10.7	2920	53.0	54.6	9.2
164.0	2227	55.3	57.6	10.3	2022	54.0	56.0	9.8
166.0	2525	57.4	59.9	11.3	1223	55.1	57.2	9.9
168.0	2656	59.0	61.6	11.2	711	56.6	58.9	10.4
170.0	2788	61.0	63.5	11.3	343	58.2	60.4	10.5
172.0	2438	62.5	65.1	12.2	165	60.0	62.7	12.1
174.0	1973	64.0	67.4	12.7	----	----	----	----
176.0	1426	65.4	68.2	12.5	----	----	----	----
178.0	961	67.0	69.4	12.1	----	----	----	----
180.0	599	70.0	72.3	13.5	----	----	----	----
182.0	352	69.9	73.0	13.5	----	----	----	----
184.0	156	73.5	76.3	14.5	----	----	----	----

The peak of prevalence of obesity in boys is around 10.0-12.0 years old.

In boys, the 3rd and 50th percentiles of the 1997¹¹ and the 2002 (the current study) references displayed similar values for all height groups, the differences being almost negligible. Nonetheless, the 97th percentile of

boys in the 2002 becomes progressively higher than that of boys in the 1997. The differences become more obvious with increasing height (Fig. 3). As for girls, the 3rd and 50th percentiles of the 1997 and 2002 growth references also displayed similar values for all height groups, the differences being very tiny. However, the 97th per-

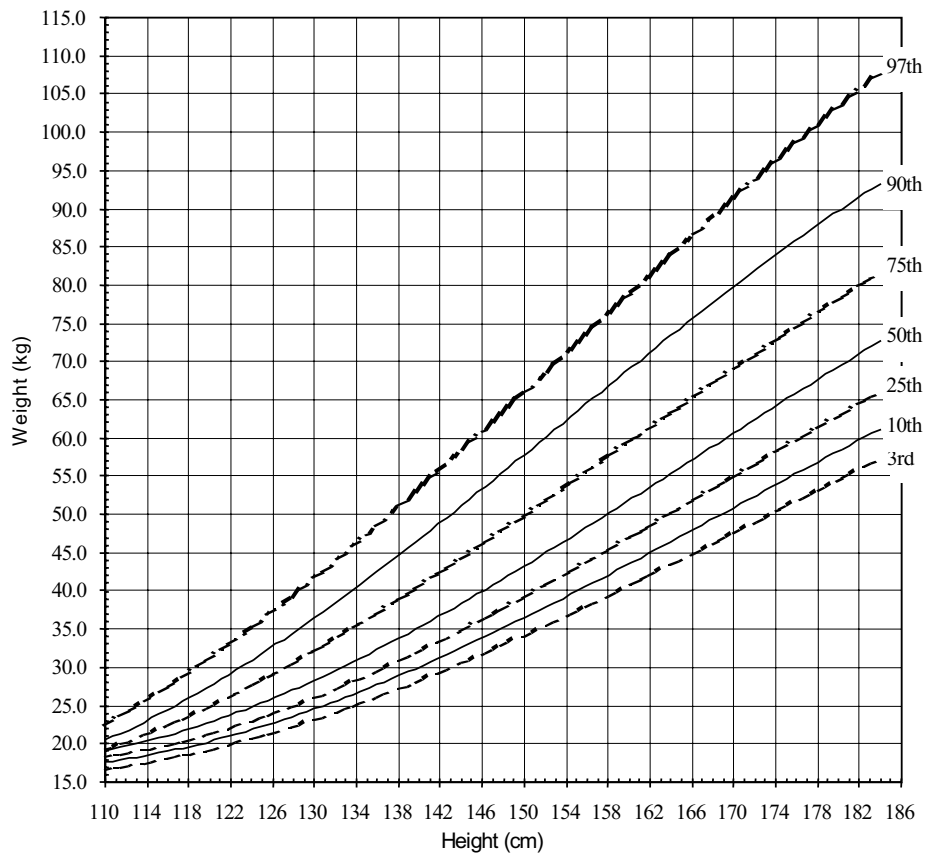


Fig. 1. The percentile curves of weight-for-height of boys from 6.5 to 18.5 years in Taiwan and Fuchien Areas.

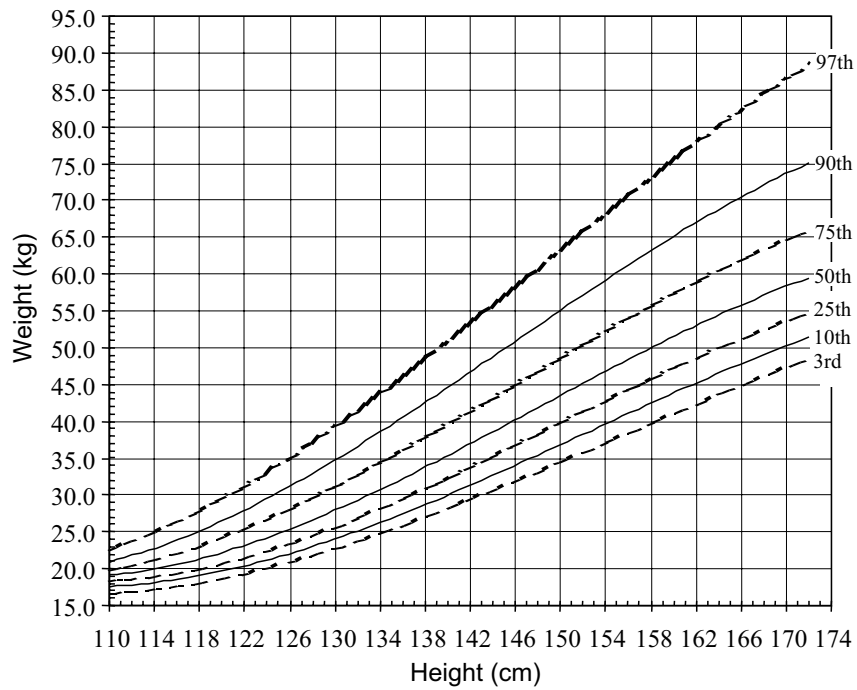


Fig. 2. The percentile curves of weight-for-height of girls from 6.5 to 18.5 years in Taiwan and Fuchien Areas.

Table 2. Frequency and percentage of obesity[§] of boys and girls from 6.5 to 18.5 years in Taiwan and Fuchien Areas

Age	Boys			Girls		
	N	Frequency	%	N	Frequency	%
6.5	357	38	10.6	372	37	10.0
7.0	1465	175	12.0	1368	137	10.0
7.5	1652	255	15.4	1553	173	11.1
8.0	1481	236	15.9	1388	177	12.8
8.5	1688	305	18.1	1507	225	14.9
9.0	1423	247	17.4	1315	192	14.6
9.5	1590	313	19.7	1437	218	15.2
10.0	1373	306	22.3	1303	220	16.9
10.5	1648	357	21.7	1475	221	15.0
11.0	1465	308	21.0	1346	182	13.5
11.5	1717	341	19.9	1602	223	13.9
12.0	1533	349	22.8	1365	186	13.6
12.5	1861	359	19.3	1671	224	13.4
13.0	1994	398	20.0	2055	296	14.4
13.5	2551	458	18.0	2515	429	17.1
14.0	2188	423	19.3	2126	352	16.6
14.5	2083	355	17.0	2171	321	14.8
15.0	2149	399	18.6	2086	372	17.8
15.5	2080	339	16.3	2074	318	15.3
16.0	1856	343	18.5	1976	363	18.4
16.5	2188	400	18.3	2308	366	15.9
17.0	1928	362	18.8	2186	348	15.9
17.5	2316	430	18.6	2368	354	15.0
18.0	1917	364	19.0	1822	285	15.6
18.5	1630	315	19.3	1445	218	15.1
Total	44133	8175	18.5	42834	6437	15.0

[§] Obesity is defined as weight greater than 120% median weight-for-height from Huang and Wu.¹¹

centile of girls in the 2002 study became higher than that of girls in the 1997 study, the differences also becoming obvious with increasing height (Fig. 4). The differences between the 97th percentile values in both sexes reflect a secular change in body size and a higher prevalence of obesity during childhood and adolescence. Figs. 5 and 6 show that at all ages the percentages of obesity for both sexes were higher in 2002 than in 1997. For boys, the smallest difference was 0.1% at age 6.5 and the largest difference was 7.1% at age 18.5. As for girls, the smallest difference was 0.2% at age 14.5 and the largest difference was 5.4% at age 10.0.

DISCUSSION

The data used in our study came from a 2002 nationwide cross-sectional population-based growth study of children followed from 6.5 to 18.5 years of age in Taiwan and Fuchien Areas. Thus, the updated growth reference for weight-for-height would be a more reliable indicator in further studies and can be an important tool for the assessment of nutritional status and for monitoring the prevalence of obesity.

In recent years, there has been growing interest in the use of the body mass index (BMI) in pediatric years because of its simplicity and high correlation with total body fatness when measured using the underwater

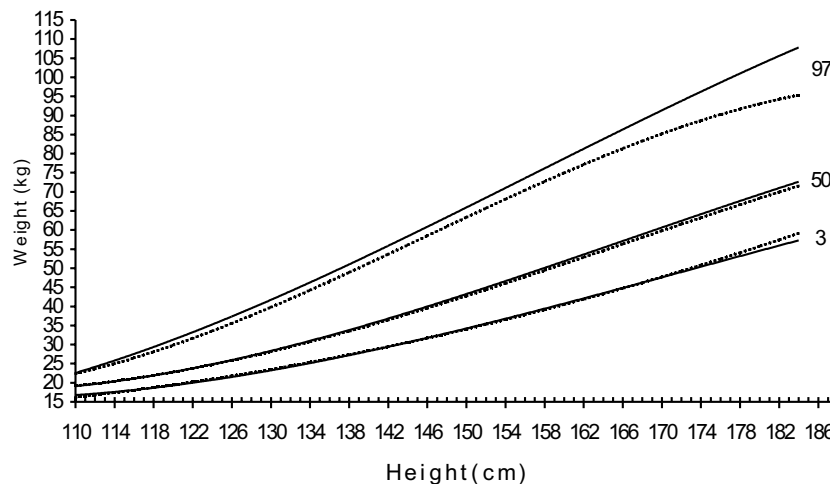


Fig. 3. Comparison of weight-for-height values (3rd, 50th and 97th percentiles) for boys between the 1997 (dashed lines) and the 2002 (solid lines) cross-sectional studies.

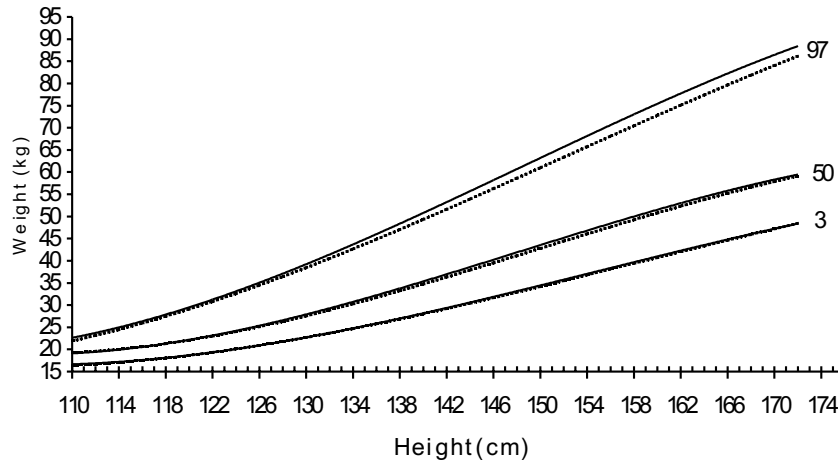


Fig. 4. Comparison of weight-for-height values (3rd, 50th and 97th percentiles) for girls between the 1997 (dashed lines) and the 2002 (solid lines) cross-sectional studies.

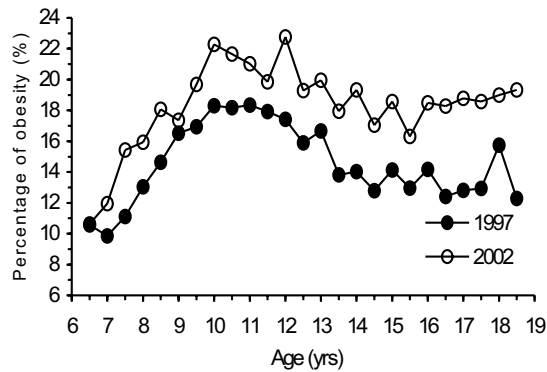


Fig. 5. Comparison of the percentages of obesity for boys between the 1997 and the 2002 cross-sectional studies.

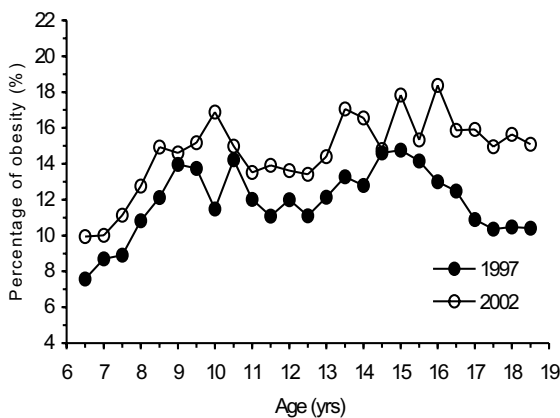


Fig. 6. Comparison of the percentages of obesity for girls between the 1997 and the 2002 cross-sectional studies.

weighing method ($r = 0.90$ for boys and 0.84 for girls) in children between 6 and 13 years old.¹⁴ There is no doubt that the above information supports the use of the BMI as an index of body fatness and obesity in childhood and adolescence. Previous studies have published several BMI reference values for children in the US,¹⁵ Britain,¹⁶ France,¹⁷ Sweden,¹⁸ Italy,¹⁹ Germany,²⁰ Hong Kong²¹ and Taiwan.²² Although Cole *et al.*²³ retrofitted the international data so that percentiles passed through 25 and 30 kg/m² at age 18 to establish standard definitions for child overweight and obesity, the criteria may not be useful for Asian children and adolescents. Several studies²⁴⁻²⁶ supported that the cut-off values using the BMI to define obesity should be lower in Asian than in Western countries. According to an expert consultation²⁴ of the World Health Organization on appropriate BMI for Asian adults, the range for optimal BMI values should be narrowed to 18.5-23 kg/m². Lin *et al.*²⁵ suggested that the cut-off values for overweight and obesity of Taiwanese adults were 23.6 kg/m² in men and 22.1 kg/m² in women. Furthermore, Zhou²⁶ recommended 24 and 28 kg/m² as the cut-off points for overweight and obesity in Chinese adults. Obviously, BMI varies with different ethnic groups and the 2 sexes.²⁷ Beyond BMI, the current study provides another criteria (weight-for-height reference) of assessing childhood obesity.

A study²⁸ has demonstrated global increases in prev-

alence of childhood obesity during the past 2 decades. Some^{29,30} have examined change in prevalence of childhood obesity using the definition of weight-for-height > 2 SD from median. These studies reported that the prevalence rates of childhood obesity were 2.2-8.6% (0-5 years old, 1978 to 1996) in Egypt; 0.5-1.9% (0-3 years old, 1988 to 1994) in Ghana; 2.7-6.8% (0-5 years old, 1987 to 1992) in Morocco; 4.6-7.2% (0-6 years old, 1985 to 1995) in Chile; 2.3-6.2% (0-7 years old, 1982 to 1996) in Costa Rica; and 0.8-2.8% (0-5 years old, 1978 to 1995) in Haiti. The current study using the same definition showed that the prevalence rates of obesity were 6.42% (ranging from 5.45 to 8.11%) in boys and 5.52% (ranging from 3.59 to 8.06%) in girls from 6.5 to 18.5 years old (Table 3). These results were very similar to those of Morocco in 1992, Chile in 1995 and Costa Rica in 1996, although the age distributions among these studies were different.

In past years, weight-for-age has been also commonly used as a nutritional or obesity index in pediatrics. A child who is heavy for age may also be tall for age. Therefore, weight-for-age may not be a satisfactory indicator of body fatness. Instead, weight-for-height is more likely to reflect body fatness. In comparison with the 97th percentiles of weight-for-height from Huang and Wu,¹¹ those of the current study display higher values for both sexes at all height groups (Figs. 3 and 4). Meanwhile, the current study also shows higher percentages of obesity for both sexes (Figs. 5 and 6). This evidence strongly suggests an increasing prevalence of obesity during childhood and adolescence in Taiwan in recent years, irrespective of sex. The results may be applied to better understand overweight and obesity of children and adolescents.

The proportions of students in school levels were different. Elementary school students comprised the highest percentage (52.9%) of the study population. Approximately one-fourth (25.5%) of the study population were secondary high school students, and 21.6% were senior high and vocational school students. The percentage of the elementary school students was more than twice that of the secondary high, senior high and vocational school students. However, the current study selected one classroom for each grade in elementary schools and two class-

Table 3. Frequency and percentage of obesity (weight-for-height > 2 SD from median) of boys and girls from 6.5 to 18.5 years in Taiwan and Fuchien Areas

Age	Boys			Girls		
	N	Frequency	%	N	Frequency	%
6.5	357	23	6.4	372	30	8.1
7.0	1465	108	7.4	1368	83	6.1
7.5	1652	134	8.1	1553	96	6.2
8.0	1481	104	7.0	1388	76	5.5
8.5	1688	132	7.8	1507	92	6.1
9.0	1423	92	6.5	1315	64	4.9
9.5	1590	92	5.8	1437	61	4.2
10.0	1373	101	7.4	1303	70	5.4
10.5	1648	112	6.8	1475	64	4.3
11.0	1465	83	5.7	1346	50	3.7
11.5	1717	100	5.8	1602	65	4.1
12.0	1533	86	5.6	1365	49	3.6
12.5	1861	104	5.6	1671	81	4.9
13.0	1994	132	6.6	2055	116	5.6
13.5	2551	139	5.5	2515	157	6.2
14.0	2188	128	5.9	2126	117	5.5
14.5	2083	135	6.5	2171	122	5.6
15.0	2149	159	7.4	2086	137	6.6
15.5	2080	118	5.7	2074	109	5.3
16.0	1856	121	6.5	1976	146	7.4
16.5	2188	137	6.3	2308	144	6.2
17.0	1928	122	6.3	2186	132	6.0
17.5	2316	152	6.6	2368	130	5.5
18.0	1917	118	6.2	1822	95	5.2
18.5	1630	102	6.3	1445	80	5.5
Total	44133	2834	6.4	42834	2366	5.5

rooms for each grade in secondary high, senior high and vocational schools. They obtained similar sample size at each age group. In addition, only 2.4% of the study population was selected for the sample because of insufficient manpower and budget. Therefore, perhaps the results of the current study may not be generalized to all school children and adolescents in Taiwan and Fuchien Areas. Nonetheless, the results do provide an important description of physical growth in childhood and adolescence.

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