Original Article

Prevalence of obesity and its comorbidities among schoolchildren in Taiwan

Nain-Feng Chu MD[1] and Wen-Han Pan PhD[2,3,4]

[1]*Department of Community Medicine, Tri-Service General Hospital and School of Public Health, National Defense Medical Center, Taipei, Taiwan, ROC*
[2]*Institute of Biomedical Science, Academia Sinica, Taipei, Taiwan, ROC*
[3]*Institute of Microbiology and Biochemistry, National Taiwan University, Taipei, Taiwan, ROC*
[4]*College of Public Health, National Taiwan University, Taipei, Taiwan, ROC*

To evaluate the prevalence of obesity and its comorbidities among a representative sample of elementary schoolchildren in Taiwan, the Nutrition and Health Survey in Taiwan Elementary School Children used a stratified, multi-staged complex sampling scheme. In total 2,405 children (1,290 boys and 1,115 girls) were included. The prevalence of overweight and obesity was 15.5 and 14.7% in boys and 14.4 and 9.1% in girls. With respect to geographic differences, the prevalence of obesity for boys was highest in the southern area (23.3% for the 3rd stratum) and lowest in the mountain area (4.3%). For girls, the prevalence of overweight and obesity was highest in the central area (13.0% for the 3rd stratum) and lowest in the southern area (2.6% for the 3rd stratum). The obese children had higher mean levels of blood pressure, triglyceride, low density lipoprotein-cholesterol, uric acid and serum glutamic pyruvic transaminase, but lower level of high density lipoprotein-cholesterol when compared with the normal weight children. For obese and normal weight boys, the prevalence was 12.9 % vs. 0.3 % for high blood pressure, 31.4 % vs. 19.6 % for dyslipidemia, and 6.4 % vs. 0.8 % for abnormal serum glutamic pyruvic transaminase level. In conclusion, we found that about one third of the boys and one quarter of the girls were overweight and/or obesity in Taiwan. Furthermore, the prevalence of obesity-related comorbidities was significantly increased for obese and/or overweight elementary schoolchildren in the Taiwan area.

Key Words: schoolchildren, obesity, prevalence, comorbidities, Taiwanese

INTRODUCTION

Obesity is a widespread and growing problem in the world with significant medical, psychosocial and economic consequences. The prevalence of obesity has increased substantially over the last several decades and indications are such that this trend will continue not only in developed but also in developing countries.[1-6]

Childhood obesity is a potential health problem because it is an important predictor of adult obesity.[7-11] About one third of obese preschool children and one-half of obese school children become obese adults. However, whether or not obesity persists into adulthood, obesity in childhood appears to increase the risk of subsequent morbidity.[12,13] The development of obesity is associated with the simultaneous deterioration in chronic disease risk profiles.[4, 12-14] Excess weight in childhood is the leading cause of pediatric hypertension. In addition, overweight children are at a high risk for developing long-term chronic conditions, including dyslipidemia, impaired glucose tolerance, adult-onset diabetes mellitus, hepatic gastrointestinal disturbance, coronary heart disease, orthopedic disorders and respiratory disease.[11, 13-15]

Although, there is substantial evidence suggesting that obesity in childhood lays the metabolic groundwork for adult cardiovascular disease,[14-16] the obesity related consequences may be preventable if we can control the body weight starting from childhood. Therefore the purpose of this study is to evaluate the prevalence of obesity and its comorbidities among schoolchildren in Taiwan in order to provoke public health actions against this high impact health risk.

MATERIALS AND METHODS

This study is based on the Nutrition and Health Survey in Taiwan Elementary School Children (NAHSIT Children, 2001-2002). Children aged 6 to 13 who lived in the Taiwan area were the target population of the survey. After applying a stratified, multistaged, and clustered sampling method, 2,405 school children (1,290 boys and 1,115 girls) were included in this survey. Base on specific ethnic and geographical characteristics in Taiwan, we designated the Hakka areas; the Mountain areas; the Eastern stratum; the Penghu Islands, and the Northern, the Central, the Southern areas, which in turn were divided into three strata in each area based on population density (the 3rd stratum is with relative low population density area).

Corresponding Author: Dr. Nain-Feng Chu, Department of Community Medicine, Tri-Service General Hospital and School of Pubilc Health, National Defense Medical Center, No. 325, Sec. 2, Cheng-Gong Rd., Nei-Hu, Taipei, Taiwan, ROC.
Tel: +886 2 8791 0506; Fax: + 886 2 8791 0590
Email: chuepi@ndmctsgh.edu.tw
Accepted 28 March 2007

Details of the sampling method and health examination including anthropometry and blood pressure measurement are described and referenced elsewhere.[17] Height and weight were measured using the German SECA 707 continuous display electronic scales (and the SECA 220 height rod). Participants were asked to first remove their shoes and the weight of their clothes was estimated by categorizing them into appropriate cloth types. Body weight was measured to the nearest 0.1 kg, and body height was measured to the nearest 1mm. BMI was measured from calculated weight and height as weight (kg)/height^2 (m^2). Blood pressures were measured after the subject had rested for at least 5 minutes, using the Omega 1400 Non-Invasive Blood Pressure Monitor (Invivo Reach Inc., Orlando, Florida, USA) with cuffs of appropriate sizes. The subject's arm was placed at the same height as the heart. Two measurements were recorded. If the first and second measurements differ by more than 10mmHg, a third measurement was performed. Mean values of the two or the two closest pressures were used for data analyses.

Definition of overweight and obesity in children

Obesity is in general defined as the presence of excess adipose tissue accumulated in the body to such a degree that it may lead to health hazards.[1,2] The operational definition of overweight and obesity often relates to applying sex- and age-specific percentile cut-points of a reference population (most use the 85th percentile for overweight and 95th percentile for obesity).[4,5] The Department of Health (DOH) childhood obesity expert panel has defined overweight (≥ the 85th percentile value of body mass index) and obesity (≥ the 95th percentile value of body mass index) using gender- and age-specific criteria. Each age group from 2 to 18 years has its own cut-off point for overweight and obesity.[21]

Definition of comorbidities among children

Abnormal blood pressure: the cut-off point for abnormal blood pressure (BP) for systolic BP is≥ 120 mmHg and for diastolic BP is≥ 80 mmHg. Abnormal blood pressure was defined as either SBP or DBP meet the criteria.[22]

Abnormal biochemical parameters: abnormal blood glucose us defined as≥ 100 mg/dl, abnormal total cholesterol (TC) is defined as≥ 200 mg/dl; abnormal high density lipoprotein-cholesterol (HDL-C) is defined as≤ 35 mg/dl; abnormal low-density lipoprotein cholesterol (LDL-C) is defined as≥ 150 mg/dl; abnormal triglyceride is defined as≥ 120 mg/dl; abnormal uric acid is defined as≥ 7.0 mg/dl; abnormal liver function is defined as either SGOT or SGPT≥ 35 IU/L.[22]

Statistics

For continuous data, mean and standard error (s.e.) were described; for categorical data, frequency and percentage were calculated. All data were weighted using the SUDDAN version 8.0 (Research Triangle Institute; 2001) to account for the effect of complex sampling design. Abnormal blood pressure and biochemical data were compared among different weight status with gender-specification using one-way analysis of variance (ANOVA) after adjusting for age and post-comparison with Scheffe test. All statistical analyses were performed using SUDAAN. *p*-value less than 0.05 were considered as statistically significant.

RESULTS

The prevalence of overweight and obesity among school children with gender- and age-stratification are shown in Table 1. The overall prevalence of overweight and obesity was 15.5 and 14.7% in boys and 14.4 and 9.1% in girls. For boys, the prevalence was the highest at age 11 (20.2%) and lowest at age 7 (10.8%); for girls, the prevalence was the highest at the age 12 (14.8%) and lowest at age 10 (6.7%).

Table 2 presents the prevalence of overweight and obesity in different sampling strata defined by gender- and age-specific cut-off points. For example, the prevalence of obesity for boys was the highest in the southern area (23.3% in the 3rd stratum) and lowest in the mountain area (4.3%). For girls, the prevalence of obesity was the highest in the central area (about 13.0% in the 3rd stratum) and the lowest in the southern area (about 2.6% in the 3rd stratum).

The gender-specific characteristics of blood pressures and biochemical parameters among different weight status are presented in Table 3. Aggravating trends were observed from normal body mass index group, overweight group, to obese group for all parameters except for heart rate and serum cholesterol. For example, the triglyceride levels among normal, overweight and obese boys were 64.6±1.6, 79.3±3.5, 92.2±4.0 mg/dl ($p < 0.05$ when compared with normal). For girls, the triglyceride

Table 1. Prevalence of overweight and obesity by age among elementary schoolchildren in Taiwan

Age	Total			Boys			Girls		
	Normal (%)	Overweight (%)	Obesity (%)	Normal (%)	Overweight (%)	Obesity (%)	Normal (%)	Overweight (%)	Obesity (%)
6 (n=203)	70.2	17.8	12.0	69.5	15.3	15.2	70.9	20.2	8.9
7 (n=413)	78.6*	12.2	9.2	77.6	11.6**	10.8	79.9***	12.9	7.2
8 (n=405)	75.8	14.1	10.1	74.6**	14.4	11.0	77.0	13.8	9.2
9 (n=391)	67.5	19.5	13.0	65.1	18.6	16.3	70.0	21.0	9.0
10 (n=408)	73.2	15.5	11.3	63.4	20.7	15.9	82.9	10.3	6.7
11 (n=403)	70.5	13.8	15.7	66.6	13.2**	20.2	75.2	14.7	10.1
12 (n=182)	73.4	12.6	14.0	70.2	16.7	13.1	76.6	8.6***	14.8
Total (n=2405)	73.0	15.0	12.0	68.9	15.5	14.7	76.5	14.4***	9.1

* The reference group for total children is the 9 years old. ** The reference group for boys is the 10 years old. *** The reference group for girls is the 10 years old.

Table 2. Prevalence of overweight and obesity by stratum among elementary school children in Taiwan

	Total		Boys		Girls	
	Overweight (%)	Obesity (%)	Overweight (%)	Obesity (%)	Overweight (%)	Obesity (%)
Hakka areas (n=189)	13.7	8.5	14.6	8.9	12.8	8.1
Mountain areas (n=185)	10.5	6.3	11.2	4.3	9.7	8.5
Eastern areas (n=190)	11.5	11.1	16.2	10.5	6.4	11.7
PengHu islands(n=189)	10.2	6.5	9.7	8.7	10.8	4.2
Northern areas:1st stratum (n=167)	16.5	12.2	17.3	14.2†	15.7	9.9
Northern areas:2nd stratum (n=178)	16.4	10.4	15.8	17.4†	17.0	2.7
Northern areas:3rd stratum (n=187)	11.3	10.6	10.0	12.3	12.8	8.8
Central areas:1st stratum (n=190)	17.9	9.9	15.8	12.7	20.2	6.7
Central areas:2nd stratum (n=199)	15.2	13.5†	18.8	14.1†	11.3	12.9
Central areas:3rd stratum (n=163)	12.9	13.5†	18.6	14.0†	6.6	13.0
Southern areas:1st stratum (n=188)	13.7	13.3†	15.1	23.3†	12.2	2.6
Southern areas:2nd stratum (n=189)	14.3	15.8†	16.4	19.0†	11.9	12.3
Southern areas:3nd stratum (n=191)	15.6	15.5†	13.7	15.6†	17.7	15.5

† Base on Mountain areas, $p<0.05$

Table 3. Characteristics of blood pressure and biochemical variables by obesity status among elementary schoolchildren in Taiwan

	Boys (n=1290)			Girls (n=1115)		
	Normal (n=900) Mean±s.e.	Overweight (n=200) Mean±s.e.	Obesity (n=190) Mean±s.e.	Normal (n=853) Mean±s.e.	Overweight (n=161) Mean±s.e.	Obesity (n=101) Mean±s.e.
SBP (mmHg)	95.2±0.4	102±0.6 *	107±1.0 *,**	94.2±0.4	97.8±0.8 *	104±1.1 *,**
DBP (mmHg)	55.9±0.3	58.7±0.6 *	61.6±0.8 *,**	56.6±0.3	57.4±0.7	60.1±0.9 *,**
Heart rate (beat/min)	93.1±0.6	92.8±0.8	92.4±1.1	96.2±0.6	94.5±1.1	93.7±1.6
Glucose (mg/dl)	96.4±0.5	98.1±0.8 *	98.8±0.6 *	95.2±0.5	96.4±0.9	95.6±0.7
Cholesterol (mg/dl)	177±2.4	177±2.3	181±3.4	176±1.5	172±3.0	182±3.6
Triglyceride (mg/dl)	64.6±1.6	79.3±3.5 *	92.2±4.0 *,**	69.4±1.3	76.5±3.5	105±5.3 *,**
HDL-C (mg/dl)	62.0±0.5	55.2±0.9 *	52.0±0.9 *,**	60.5±0.6	54.6±0.9 *	50.0±1.2 *,**
LDL-C (mg/dl)	106±2.1	110±2.1	115±2.5	106±1.5	108±3.0	115±2.9 *
Creatinine (mg/dl)	0.6±0.0	0.6±0.0	0.6±0.0	0.6±0.0	0.6±0.0	0.6±0.0
Uric acid (mg/dl)	5.7±0.1	6.4±0.2	7.3±0.2 *,**	5.5±0.1	6.2±0.2 *	6.7±0.2 *
SGOT (IU/L)	22.3±0.4	20.3±0.6	20.7±0.8	20.7±0.3	20.2±0.7	22.3±1.4
SGPT (IU/L)	11.7±0.3	13.8±0.7	19.7±1.7	10.1±0.2	12.8±1.2 *	18.4±2.3 *,**

* $p<0.05$ when compared with normal; ** $p<0.05$ when compared with overweight. Abbreviations: SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HDL-C: High Density Lipoprotein – Cholesterol; LDL-C: Low Density Lipoprotein – Cholesterol; SGOT: Serum Glutamic Oxaloacetic Transaminase; SGPT: Serum Glutamic Pyruvic Transaminase

levels were 69.4±1.3, 76.5±3.5, 105±5.3 mg/dl ($p < 0.05$ when compared with normal).

Table 4 shows the gender-specific prevalence of obesity-related comorbidities among different weight status. For example, the prevalence of abnormal liver function (either SGOT or SGPT ≥ 35 IU/L) was 2.5, 3.6 and 6.4% for normal weight, overweight and obese boys and was 3.1, 4.1 and 7.5% for normal weight, overweight and obese girls.

DISCUSSION

In this study, we found that the prevalence of obesity was 14.7% in boys and 9.1% in girls. The prevalence of obesity was the highest in the southern area (the 3rd stratum) in boys and in the central area (the 3rd stratum) in girls. In general, there were more overweight and obese children in southern Taiwan, central Taiwan in that order than in the northern and other specific areas. Furthermore, the obese children generally had higher levels of BP, triglyderide, uric acid levels, liver enzymes, but lower level of HDL-C when compared with the normal weight children.

Childhood obesity is an important predictor of adult obesity. In addition, obesity in childhood appears to increase the risk of subsequent morbidity, whether or not obesity persists into adulthood. Preventing excess weight gain and obesity among children and adolescents is important in obesity control and will lead to a decreased risk of chronic diseases among adults.[20]

Over the past 30 years, there were escalating prevalence rates of overweight and obese children and adolescents in both genders in the western countries [3, 4, 11, 21]. For example, in US, from 1963 to 1991, the prevalent overweight children (based on 85th percentile BMI) increased from 15.1 to 21.7% for boys and 15.2 to 21.2% for girls at 12 to 17 years old [19, 22]. The prevalence of obesity (≥ 95th percentile of BMI) increased from 5.1% in the 1960's to 11.7% in 1988-1994 in the 6-11 years age group and from 4.8% to 10% in the 12-17 years age group [3]. The NHANES III survey showed that the prevalence of overweight among children ages 6-11 was around 9.2 to 17.4% and was 8.5 to 15.7% among ages 12-17, in 1988-94. The prevalence rates of overweight and obese in-

Table 4. Prevalence of abnormal blood pressure and biochemical variables by obesity status among elementary schoolchildren in Taiwan

	Total (n=2405)			Boys (n=1290)			Girls (n=1115)		
	Normal % (n=1756)	Overweight % (n=361)	Obesity % (n=289)	Normal % (n=900)	Overweight % (n=200)	Obesity % (n=190)	Normal % (n=853)	Overweight % (n=161)	Obesity % (n=101)
Abnormal blood pressure[†]	0.3	2.2	9.4	0.4	3.1	12.9	0.1	1.1	3.3
SBP ≥120mmHg	0.3	2.2	8.8	0.4	3.1	12.0	0.1	1.1	3.3
DBP≥80mmHg	0.1	0.1	1.0	0.0	1.1	0.9	0.1	0.0	1.2
Abnormal blood glucose (≥100mg/dl)	25.9	35.4	29.0	27.5	38.0	32.3	24.3	32.3	23.3
Abnormal blood lipid [‡]	21.9	22.5	35.1	19.6	21.9	31.4	24.1	23.2	41.7
Blood cholesterol ≥200mg/dl	18.2	16.8	24.4	16.7	16.3	19.7	19.8	17.4	32.7
Blood TG ≥120mg/dl	5.3	9.0	21.9	4.2	9.1	19.6	6.3	8.1	26.1
HDL-C ≤35mg/dl	1.1	2.0	3.5	1.2	2.8	3.0	1.0	1.1	4.3
LDL-C ≥150mg/dl	6.2	5.8	8.7	6.5	5.9	9.1	5.9	5.6	8.1
Abnormal liver function [§]	2.8	3.8	6.8	2.5	3.6	6.4	3.1	4.1	7.5
SGOT ≥35IU/L	2.8	2.9	3.1	2.4	1.8	1.9	3.1	4.1	5.2
SGPT ≥35IU/L	0.5	2.4	6.1	0.8	2.4	6.4	0.2	2.5	5.7
Abnormal blood uric acid (≥7.0mg/dl)	14.5	29.7	43.3	16.8	31.1	47.7	12.1	28.0	35.7

[†]:Definition of abnormal blood pressure is systolic blood pressure ≥120mmHg or Diastolic blood pressure ≥80mmHg; [‡]:Definition of abnormal blood lipid level is cholesterol ≥200mg/dl or Triglyceride ≥120mg/dl; [§]:Definition of abnormal liver function is Glutamic Oxaloacetic Transaminase(SGOT) ≥35 IU/L or Glutamic Pyruvic Transaminase(SGPT) ≥35 IU/L. Abbreviations: SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HDL-C: High Density Lipoprotein – Cholesterol; LDL-C: Low Density Lipoprotein – Cholesterol; SGOT: Serum Glutamic Oxaloacetic Transaminase; SGPT: Serum Glutamic Pyruvic Transaminase

creased about 2 folds among the Hispanic children from 1986 to 1998.[18]

According to NAHSIT 1993-1996, the prevalence rates of overweight and obesity among 7 to 12 year-old children were 12.8% and 4.9% for boys and 10.8% and 6.9% for girls, respectively (unpublished data). However, in the NAHSIT Children 2001-2002, the obesity prevalence tripled for boys and doubled for girls. About one-third of boys and one-fourth of girls were associated with either overweight or obesity. Furthermore, the boys had higher prevalence of overweight and obesity than girls. In this survey, the girls had lower prevalence of overweight and obesity which may be associated with the greater emphasis placed on body image at this age period.

From Table 2, among different geographic areas, the prevalence of obesity and overweight among boys was highest in the first stratum of southern area (with the rate of 38.4%), and lowest in the mountain area (around 15.5%). For girls, the highest was in the third stratum of southern area (with the rate of 33.2%), and lowest in the first stratum of southern area (around 14.8%). In general, the Penghu area (with the rate of 16.7%) and the mountain area (16.8%) had the lowest prevalence of overweight and obesity. However, the third stratum of the southern area had highest prevalence of overweight and obesity (31.1%). The prevalence of obesity in different geographic areas was significantly different. Taking aside those remote strata in this study, in western Taiwan, the areas with less urbanization had higher prevalence of overweight and obesity, which was different from the results of the NAHSIT (1993-1996) in that the urbanized areas had higher prevalence of overweight and obesity. These changes may be due to more health information flow and related activities in the urban area so that more attention is paid on the health and weight issues of the children.

The increasing prevalence of obesity has been observed in Taiwanese adults and children, which may be in part explained by an imbalance between energy intake and expenditure. In Taiwan, the availability of a high-fat and high-energy diet has steadily increased over the past few decades among general population, while the lifestyle has also become more sedentary and physically inactive. Although, total energy available increased from 2661.7 to 2992.9 calories/day and fat availabilty rose from 63.5 to 128.4 g/day from 1970 to 1989 in the Taiwan, the energy intake level did not increase.[24,25] Rather the quality of diet has been gradually modified. This information suggests that increasingly sedentary lifestyles including excessive TV watching and physical inactivity are partly to blame for this trend, indicating lifestyle as well as dietary factors are associated with the development of obesity among children in the Taiwan area. However, further nutritional studies on youths are needed to evaluate the association between diet patterns and food intakes on the development of obesity among this specific population.

Obesity is associated with the occurrence of diabetes, cardiovascular disease, hypertension, gallbladder disease and certain cancers.[5,11-13,26-28] There are many studies linking obesity in youth with adult morbidity and mortality. Adults who had been overweight as children had 20% higher prevalence of chronic disease such as cardiovascular disease, hypertension and diabetes when compared with those normal weight children.[7] The Bogalusa Heart Study has provided detailed information on cardiovascular disease risk factors in overweight and obese childhood and their persistence into adulthood. Adults overweight since their adolescence were 3.0 to 5.8 times as likely to have at least two or more cardiovascular disease risk factors as lean adults who had been lean adolescents.[8] Adults who had been overweight during childhood had higher levels of fasting blood glucose, systolic and diastolic blood pressure in adulthood 40 years later.[9]

In this study, the prevalence of obesity-related comorbidities was significantly increased among overweight or obese children. The prevalence increased significantly as the BMI increased. However, there are some interesting points such as that the prevalence of abnormal blood pressure, abnormal blood glucose and abnormal uric acid are more common in obese boys than in obese girls. Abnormal blood lipids and abnormal liver function are more common in obese girls than in obese boys.

Many studies have shown that in addition to genetic factors, environmental factors such as dietary patterns and lifestyles are associated with the occurrence of obesity and its-related comorbidities.[8,29] Most importantly, adverse dietary patterns such as high-energy, high-fat, and low-fiber diets are also associated with development of high blood pressure, dyslipidemia, hyperglycemia and other comorbidities.[25,29] These may be associated with increased risk of developing cardiovascular disease later in life. Systematic approach to provide adequate nutrition education, dietary intervention and to encouragement of regular physical activities are needed to prevent the occurrence of obesity and to halt the increase of obesity-related disorders among children.

From this survey, we found that overweight and obese children had higher prevalence of obesity-associated comorbidities. The efforts and programs combating obesity problems should be incorporated into existing health promotion programs organized by local community, region, country and international parties in order to alleviate the problem of obesity efficiently. Further studies are also needed to collect more data and develop the guidelines for preventing and managing obesity in Taiwan.

In conclusion, obesity in adults is associated with the development of many chronic disorders. We believe that the most appropriate way to manage obesity in Taiwan is to support the notion and strategy to prevent excess weight gain and obesity early in life which may in turn decrease the risk of chronic diseases later in life.

ACKNOWLEDGMENTS

This study was supported by a grant (DOH-1999-3) from the Department of Health (DOH). Data analyzed in this paper were collected by the research project "Nutrition and Health Survey in Taiwan (NAHSIT)" sponsored by the Department of Health in Taiwan (DOH-88-FS, DOH89-88shu717, DOH90-FS-5-4, DOH91-FS-5-4). This research project was carried out by the Institute of Biomedical Sciences of Academia Sinica and the Research Center for Humanities and Social Sciences, Center for Survey Research, Academia Sinica, directed by Dr. Wen-Harn Pan and Dr. Su-Hao Tu. The Center for Survey Research of Academia Sinica was responsible for data management. The assistance provided by the Institutes and aforementioned indi-

viduals is greatly appreciated. The views expressed herein are solely those of the authors.

AUTHOR DISCLOSURES

Nain-Feng Chu and Wen-Harn Pan, no conflicts of interest.

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Appendix 1. Definition of overweight and obesity among children in Taiwan

Age	Boys			Girls		
	Underweight (BMI≤)	Overweight (BMI≥)	Obesity (BMI≥)	Underweight (BMI≤)	Overweight (BMI≥)	Obesity (BMI≥)
6	13.9	17.9	19.7	13.6	17.2	19.1
7	14.7	18.6	21.2	14.4	18.0	20.3
8	15.0	19.3	22.0	14.6	18.8	21.0
9	15.2	19.7	22.5	14.9	19.3	21.6
10	15.4	20.3	22.9	15.2	20.1	22.3
11	15.8	21.0	23.5	15.8	20.9	23.1
12	16.4	21.5	24.2	16.4	21.6	23.9

From: Department of Health, Executive Yuan, Taiwan, ROC http://www.doh.gov.tw, 2003.[21]

Original Article

Prevalence of obesity and its comorbidities among schoolchildren in Taiwan

Nain-Feng Chu MD[1] and Wen-Han Pan PhD[2,3,4]

[1]*Department of Community Medicine, Tri-Service General Hospital and School of Public Health, National Defense Medical Center, Taipei, Taiwan, ROC*
[2]*Institute of Biomedical Science, Academia Sinica, Taipei, Taiwan, ROC*
[3]*Institute of Microbiology and Biochemistry, National Taiwan University, Taipei, Taiwan, ROC*
[4]*College of Public Health, National Taiwan University, Taipei, Taiwan, ROC*

臺灣地區學童肥胖及其相關合併症盛行率

本研究是以一代表性樣本，臺灣學童營養及健康調查來評估學童肥胖及其合併症盛行率，本調查是一分層多步驟抽樣調查。總計有 2405 名學童（男童 1290 名，女童 1115 名）參加本研究。男童過重及肥胖盛行率分別約為 15.5%及 14.7%；女童過重及肥胖盛行率分別為 14.4%及 9.1%。不同區域，男童肥胖盛行率最高地區為南部第三層（約 23.3%），最低為山部地區（約 4.3%）。女童肥胖盛行率最高為中部第三層區（約 13.0%），最低為南部第三層抽樣地區（約 2.6%）。肥胖學童的血壓、血三酸甘油酯、低密度脂蛋白膽固醇、尿酸及丙胺酸轉胺酶值等皆較正常體重學童為高，而高密度脂蛋白膽固醇值則較正常體重學童為低。肥胖及正常體重男童，其高血壓盛行率分別為 12.9%比 0.3%；血脂異常盛行率為 31.4%比 19.6%；肝功能指數異常盛行率為 6.4%比 0.8%。本研究發現，在臺灣約有三分之一男童及四分之一女童為體重過重或肥胖。更值得注意的是，肥胖或過重學童其肥胖相關合併症的盛行率也顯著的升高。

關鍵字：學童、肥胖、盛行率、合併症、臺灣。