

Original Article

Dietary nutrient intake and major food sources: the Nutrition and Health Survey of Taiwan Elementary School Children 2001-2002

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The aim of the study was to investigate nutrient intake and their dietary sources in Taiwanese children ages 6-12 years by analyzing the 24-hour recall data of 2386 participants from a nationally representative sample. Results showed that children in Taiwan were slightly lower in mean proportion of energy intake from carbohydrates (53.5% of energy intake) and higher in those from fats (30.8%) and protein (15.8%) as based on the recommendations of Department of Health in Taiwan. The mean intake of vitamins and of minerals by children was equivalent to or exceeded Daily Reference Intake of Taiwan (DRI) or other recommended standards with the exception of a seriously insufficient calcium intake and extremely high sodium intake. A substantial proportion of children in different age/gender/location strata had lower mean vitamin and mineral intake by DRI and other recommended standards. These nutrient profiles were mainly related to dietary patterns with relatively low intake of fruits, vegetables, cereals/grains, and dairy products, but high intake of the protein-rich foods, salt/sauces, and fats/oils. According to the suboptimal dietary nutrient profiles of Taiwanese children, particularly in the underprivileged areas, recommendations are made in this article for policy makers and health practitioners to consider in order to improve dietary quality of elementary school children.

Key Words: 24-hour recall, elementary school children, food sources, Nutrition and Health Survey, Daily Reference Intakes

INTRODUCTION

Research from a large number of countries has blamed the unhealthy shift in children's dietary patterns for the recent rapid increase in childhood obesity.¹⁻³ The development of many chronic diseases has also been linked to poor dietary patterns in children.⁴⁻⁶ As a result, it has become important to understand children's dietary patterns and develop appropriate methods to nurture healthy eating habits among them. In 2001-2002, the Department of Health (DOH) in Taiwan sponsored an island-wide nutritional survey of elementary school children ages 6 to 12 years to obtain in-depth knowledge about children's diet, total wellbeing, and related factors. The aim of the present study was to analyze the 24-hour recall data of children in this survey to provide information on nutritional intake levels and differences by gender, age and geographical location. Furthermore, for each of the six major food groups in the DOH's *Daily Dietary Guidelines for Children Aged 7-12 Years*⁷ (DDG), children's diets were evaluated to determine whether their diets were balanced. The Taiwanese Daily Reference

Intakes (DRI)⁸ (like the US⁹ was used as a reference for insufficient or excess nutrient intake. The data were analyzed to reveal children's dietary nutrient levels and food choices to provide a basis for nutritional interventions aimed at reducing the prevalence of unhealthy dietary habits.

MATERIALS AND METHODS

Data were obtained from the *Nutrition and Health Survey in Taiwan Elementary School Children 2001-2002*. The household recipe records and 24-hour recalls collected in the survey were analyzed. A multi-staged, stratified, and

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clustered probability sampling scheme was used to recruit participants.

First, townships or districts with particular ethnic and/or geographical characteristics were grouped into four strata, namely Hakka, Mountainous areas, Eastern Taiwan and PengHu Islands. The remainder were divided into three areas, namely northern, central and southern Taiwan, each of which was further divided into three strata based on population density,¹⁰ resulting in 13 strata total (4+3×3=13). Probability proportional to size sampling (PPS) was used to choose eight schools from each stratum, resulting in 104 schools total. A random sample of 24 students was selected from each school. Finally, 2386 children (1277 boys and 1109 girls) participated in the survey, which took into consideration seasonal effects.¹⁰

The same methods as those used in the previous *Nutrition and Health Survey in Taiwan*¹¹⁻¹³ were used to obtain household recipe records and 24-hour recalls. The same grouping method for food sources (12 major items, 47 minor items) and database were used. Daily nutrient intake for each participant, mean daily intake of all participants, standard error of the mean and contribution percentage to nutrient intake from various food sources were calculated using the software in Survey Data Analysis

(SUDAAN)¹⁴ to adjust for the design effect of the complex sampling scheme. Main outcomes of interest included: (1) Weights of foods consumed; (2) Major food sources; (3) Mean nutrient intake level, standard error and comparison with DRI; (4) Food sources of nutrients; (5) Amounts consumed for each of the six food groups in the DDG; (6) Projected nutrient intake levels for a diet in accordance with the Taiwanese DDG, assuming the food choice of the surveyed children.¹³ Data analyses compared results by location, gender and age group (age 6-12, by year).

To assess the prevalence of imbalanced intake of various nutrients, we derived the true distribution of nutrient intake levels by removing intra-individual variation of 24-hour recall data. With triplicate, three-season balanced 24-hour recall data collected in 167 randomly selected children, mean Pearson's correlation coefficients (r) were calculated from all possible pairs of nutrient measurements and the ratio of within to between individual variance (intra-variability / inter-variability) was estimated as: ratio = [(1-r)/r]. The variance of the true distribution was obtained by dividing the original variance by (1+ratio). Then, the true distribution was used to estimate the percentage of people under or above the cut-off point according to Chang's method.¹⁵

Table 1. Nutrient intake of elementary school children by gender

	Boys (n=1277)			Girls (n=1109)		
	Mean (SE)	DRI %		Mean (SE)	DRI %	
Energy						
(kcal)	2114 (35.8)	116% [†]		1904 (41.9)	114% [†]	
(kJ)	8845			7966		
Macronutrient	Mean (SE)	DRI %	Energy %	Mean (SE)	DRI %	Energy %
Protein(g)	83 (1.8)	196%	15.8%	73 (1.8)	172%	15.7%
Fat(g)	75 (1.8)		30.7%	68 (2.1)		30.8%
Carbohydrate(g)	279 (5.0)		53.5%	249 (5.6)		53.5%
Vitamins	Mean (SE)	DRI %		Mean (SE)	DRI %	
B ₁ (mg)	1.54 (0.09)	166%		1.30 (0.06)	150%	
B ₂ (mg)	1.5 (0.05)	149%		1.34 (0.04)	141%	
B ₆ (mg)	1.36 (0.04)	142%		1.21 (0.04)	127%	
C(mg)	143 (5.57)	215%		142 (7.58)	214%	
Niacin(mg)	19.3 (0.94)	157%		16.8 (0.65)	152%	
A(IU)	5463 (306)	150%		5153 (278)	141%	
E(mg α-TE)	10.0 (0.44)	118%		8.76 (0.46)	104%	
Minerals	Mean (SE)	DRI %		Mean (SE)	DRI %	
Calcium(mg)	544 (14.3)	64%		498 (14.4)	59%	
Phosphorus(mg)	1132 (21.5)	171%		1010 (23.5)	153%	
Iron(mg)	15.6 (0.7)	130%		13.8 (0.6)	117%	
Magnesium(mg)	247 (5.75)	135%		228 (6.23)	123%	
Sodium(mg)	4850 (168) ≅ 12.3g salt			4480 (228) ≅ 11.4g salt		
Potassium(mg)	2431 (59.5) ≅ 62.3 mmol			2263 (6.2) ≅ 58.4 mmol		
Fatty acids	Mean (SE)	Ratio	DGA ⁽¹⁵⁾	Mean (SE)	Ratio	DGA ⁽¹⁵⁾
PUFA(g)	21598 (580)	0.84		20118 (929)	0.88	
MUFA(g)	25985 (667)	1.02		23487 (758)	1.02	
SFA(g)	25499 (609)	1.00	10.9%	22924 (603)	1.00	10.9%
Fiber	Mean (SE)		DGA ⁽¹⁵⁾	Mean (SE)		DGA ⁽¹⁵⁾
Dietary fiber(g)	16.4 (0.45)		55.8% [‡]	15.6 (0.51)		58.4% [‡]
Crude fiber(g)	4.2 (0.15)			4.0 (0.17)		
Cholesterol	Mean (SE)	upper limit		Mean (SE)	upper limit	
(mg)	361 (9.5)	300 [§] , 400 [¶]		313 (10.6)	300, 400 [¶]	

[†] Comparison with the recommended intake for children getting moderate physical activity as reported in the 'Dietary Reference Intakes'.

[‡] The 2005 Dietary Guidelines for Americans (DGA) recommend that adequate intake for dietary fiber is 14 g/1000 kcal.¹⁶ [§] The 2005 Dietary Guidelines for Americans (DGA) recommend an upper limit for cholesterol of 300 mg.¹⁶ [¶] The 2005 Dietary Guidelines for Taiwan (DGT) recommend an upper limit for dietary fiber of 400 mg.¹⁶

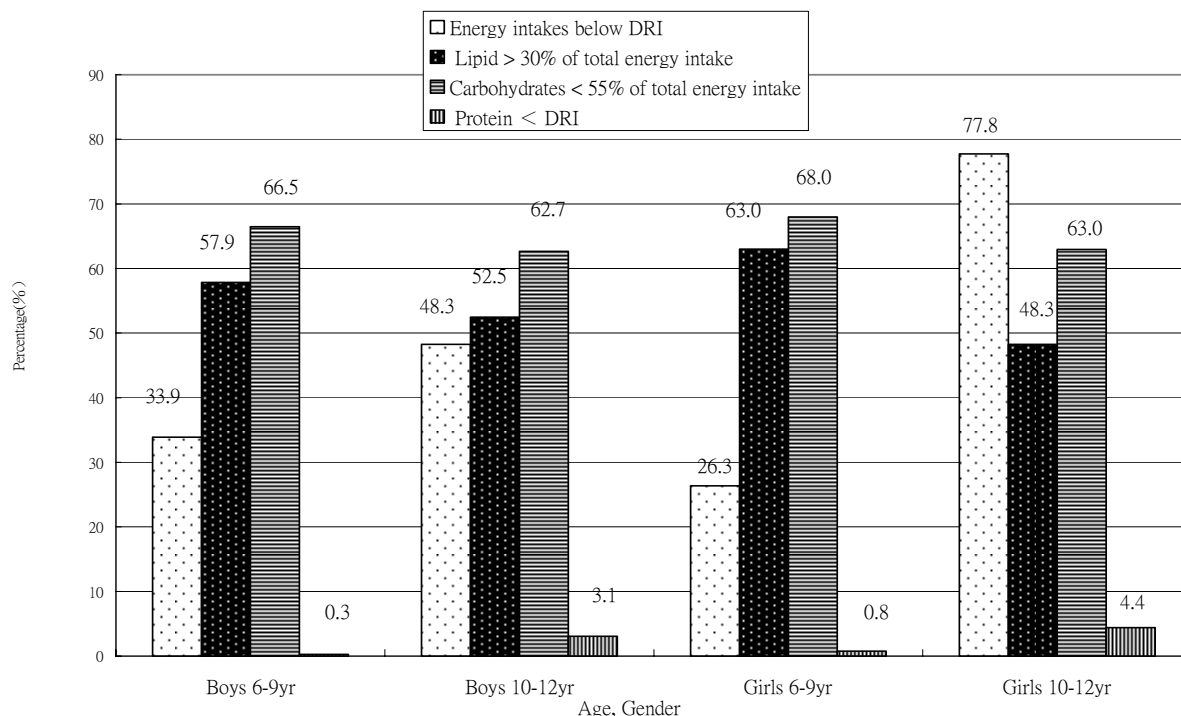


Figure 1. Comparison of non-ideal intake of energy and macronutrients[†] by elementary school children by age and gender
[†]The referential standard in estimating insufficient or excessive nutrient intake of protein is the Recommended Dietary Allowance (DRA), which is the average daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all (97 to 98 percent) of healthy individuals in a particular life-stage and gender group.

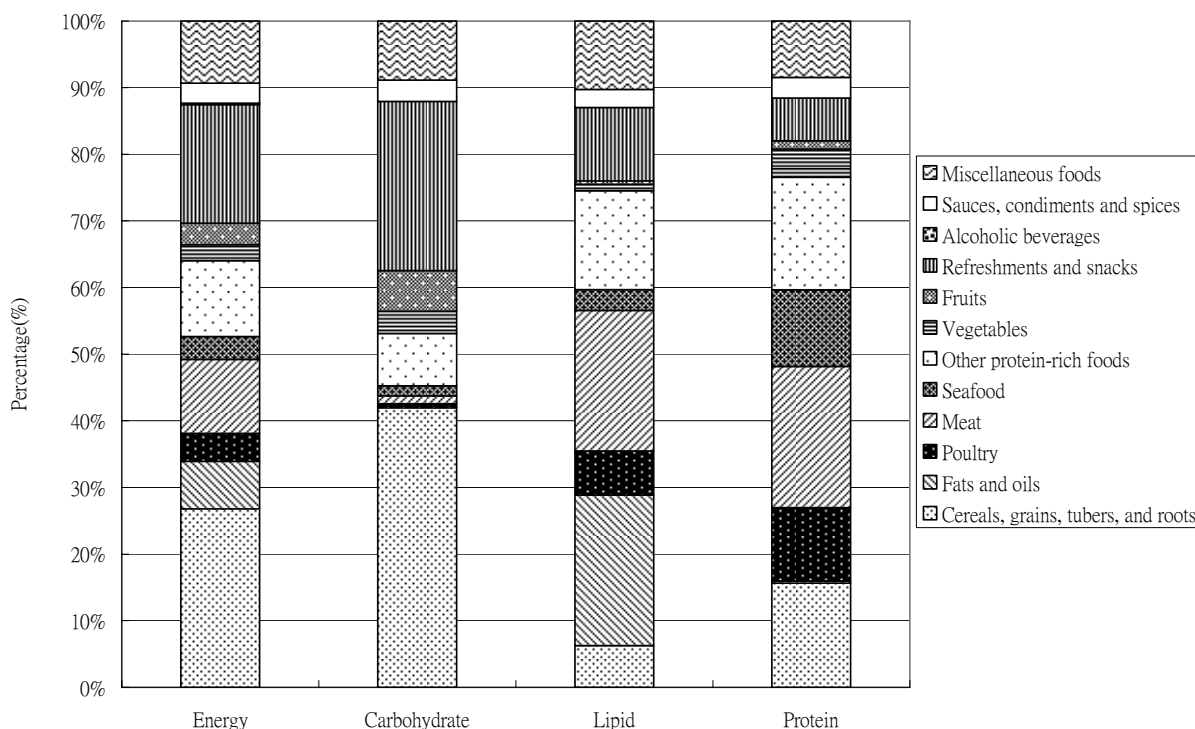


Figure 2. Major food sources of energy and macronutrients for elementary school children.

RESULTS

Energy and macronutrients

The mean daily intake of energy, protein, fats/lipids, carbohydrates and other nutrients is presented by gender and age in Table 1.

Intake levels and nutritional imbalances. The mean energy intake for boys and in girls met the DRI (Table 1). However, many boys and girls had energy intake below

the DRI, particularly girls 10-12 years (Figure 1). The contribution of the three macronutrients to energy intake was 53.5% from carbohydrates, 30.8% from lipids, and 15.8% from protein (Table 1). Over 60% of boys and girls had carbohydrate intake less than 55% of total energy intake (Fig 1). The carbohydrate intake of children increased with age. Boys had higher carbohydrate intake than girls (Table 1). Around 60% of the children 6-9

years and 50% of those 10-12 years had fats/lipids intake accounting more than 30% of total energy. The mean protein intake of both girls and boys apparently exceeded DRI. Only a small proportion of children had protein intake below the DRI. Children's protein intake also increased with age.

Major food sources. The major food sources of energy for elementary school children are shown in Figure 2. The most important energy source was cereals/roots (mean 540.3 kcal, 26.9% of energy intake) and refreshments/snacks (356.0 kcal, 17.7% of energy intake). The main sources of carbohydrates were also cereals/roots (111.1 g, 42.0% of carbohydrate) and refreshments/snacks (67.2 g, 25.4%). The main sources of lipids were fats/oils (16.1 g, 22.6%) and meat (15 g, 21.1%). Nuts/nut products provided only 0.53 g of lipid intake. The most important source of protein was meat (16.3 g, 20.9% of protein intake) and other protein-rich foods including eggs, soybeans and dairy products (13.4 g, 16.6%).

Cholesterol and fatty acids. The mean daily cholesterol intake of boys and girls is shown in Table 1. As many as 75% of boys consumed more than 300 mg of cholesterol and 31% consumed more than 400 mg. For girls, 51% consumed more than 300 mg and 20% consumed more than 400 mg. The cholesterol intake of 10-12 year olds was higher than that of 6-9 year olds. Children's major food sources of cholesterol were eggs/egg products (39.4% of cholesterol intake), meat (18.8% of cholesterol intake) and seafood (12.8% of cholesterol intake), which probably reflects the popularity of soy-eggs, tea-eggs, and fish egg sushi (a kind of Japanese food). There was a large geographical difference in cholesterol intake. A greater proportion of boys in PengHu and the first and second southern strata had cholesterol intake of over 400 mg. Regarding fatty acid consumption (Table 1), the ratio of P/M/S (polyunsaturated/monounsaturated saturated fatty acids) was 0.86/1.02/1, with 10.8% energy intake provided by saturated fatty acids, 9.37% by polyunsaturated fatty acids, and 11.0% by monounsaturated fatty acids.

Consumption of food in the six major groups, dietary fiber, and sugary drinks

Tables 2-4 compare the actual food intake from the six groups with that recommended by the DDG for children 6-9 and 10-12 years.

Cereals and grains group. The cereals and grains group was divided into three parts: cereals/roots, carbohydrate-rich convenience foods, and pastries/cookies.

Children had a mean daily intake of cereals/roots consisting of about two bowls of rice. The total mean intake of cereals and grains after the inclusion of carbohydrate-rich convenience foods and pastries/cookies was 2.5 bowls of rice for children 6-9 years and 2.8 bowls of rice for children 10-12 years. Children from different strata had different intake levels of cereals and grains (Table 2). Boys from mountainous areas had the highest intake of cereals/roots for all locations, whereas their intake of carbohydrate-rich convenience foods and pastries/cookies was lower. On the other hand, Children from the first northern stratum had lower intake of cereals/roots, but their intake of carbohydrate-rich convenience foods and

pastries/cookies was higher.

Carbohydrate-rich convenience foods contributed a mean of 216 kcal of energy intake per day, of which 54% was from carbohydrate, 34% from fat and 13% from protein. Pastries/cookies provided a daily mean intake of 120 kcal, of which 59% was from carbohydrate, 36% from fat and 6% from protein. Girls and adult women had similar contributions to energy intake from these products⁹. Children's daily mean intake of sugary drinks was about 7.1% of total energy intake. In these drinks, 89% energy was from carbohydrate, 7.6% from fat, and 3.1% from protein. There was little difference in energy intake from these drinks between boys and girls 6-9 years. However, by age 10-12 years, boys had higher intake of sugary drinks. Sugary drink intake was highest in the mountainous areas and the eastern stratum, where sugary drinks accounted for more than 10% of energy intake in girls (Table 2).

Vegetable group, fruit group, and fiber intake. Intake of vegetables was low in elementary school boys and girls of all ages (Table 3). The daily mean intake of vegetables in children 6-9 years and 10-12 years was 1.6 and 2.0 servings, respectively. The types of vegetables consumed were dark-green and yellow vegetables (31.1%), light-green vegetables (26.2%), seaweed (14.3%), and squash (11.9%). Vegetable intake by children in mountainous areas (1.3 servings per day) was significantly lower compared with other areas.

Daily mean intake of fruit was around one serving for boys and girls irrespective of age. Intake of fruit was lowest in children in mountainous areas and boys in the third northern stratum and third central stratum. Fruit intake in these low-population density areas was less than one serving per day.

The major sources of dietary fiber for children were vegetables, cereals/roots, and fruit. In Taiwan, no recommendation has been made for dietary fiber for children. The amount was compared to the recommendations of the American Dietetic Association (ADA)¹⁶ and the 2005 *Dietary Guidelines for Americans* (DGA)¹⁷. The daily mean intake of dietary fiber of Taiwanese children was higher than that of American children in the same age range (13.1 g/day)¹⁸, and the intake reached ADA recommendations, but it was only half of the DGA recommendations (Table 3). Mean dietary fiber intake also varied by strata. In the mountainous areas stratum, where fruit and vegetable intake was the lowest, dietary fiber intake was also the lowest and children had fiber intake less than 50% of that recommended in the DGA.

Meat/fish/eggs/soybean (or protein-rich) group. Boys and girls 6-9 years consumed a mean number of 5.9 and 5.2 servings of meat/fish/eggs/soybean, respectively (Table 4). For children 10-12 years, boys consumed a mean of 6.9 servings per day and girls a mean of 6.3 servings. Children on average consumed more than 2 servings of meat, in which the per-serving of meat contained 6.4 g lipid. There were large differences in intake between different strata (Table 4). Boys in the first and boys and girls in the second southern stratum had the highest intake levels (>7 servings).

Dairy group. The mean daily intake of dairy foods by children 6-9 years was about 0.9 servings, whereas it was

Table2. Mean servings of cereals/roots and carbohydrate-rich foods by age/gender/ stratum

Stratum Food type (servings)	DDG for 7-12 yrs	6-9 yrs	10-12 yrs	Hakka	Mountainous areas	Eastern	PengHu	First Northern	Second Northern	Third Northern	First Central	Second Central	Third Central	First Southern	Second Southern	Third Southern		
								Boys										
Cereals/roots [†]		7.5	8.6	8.0	9.1	7.6	7.2	7.0	8.0	8.1	8.9	7.7	8.8	8.5	8.0	8.3		
Carbohydrate rich convenience foods [‡]		1.9	2.3	2.6	2.0	1.9	1.8	2.5	1.5	1.8	2.5	1.8	2.3	2.0	1.9	1.8		
Pastries/cookies [§]		1.1	1.2	0.9	0.8	1.3	1.2	1.4	0.6	0.9	1.2	1.5	0.9	1.1	1.1	1.4		
Cereals and grains group Total	10-18	10.5	12.1	11.6	11.9	10.8	10.2	10.9	10.2	10.8	12.6	10.9	12.0	11.7	11.1	11.5		
Sugary drinks [¶] (% of total energy intake)		6.8	7.4	7.5	9.9	9.3	6.6	7.9	6.1	7.0	5.4	6.3	8.5	6.9	7.0	7.2		
								Girls										
Cereals/roots [†]		6.5	7.3	7.1	6.3	6.7	6.3	6.4	5.9	6.8	6.9	7.5	7.0	5.9	7.4	6.9		
Carbohydrate rich convenience foods [‡]		1.6	1.9	1.7	2.1	1.6	1.4	2.5	1.5	1.3	2.5	1.8	1.3	1.5	1.7	1.7		
Pastries/cookies [§]		1.2	1.2	1.0	0.8	1.2	0.9	1.4	1.2	1.5	1.0	0.8	1.1	1.4	1.2	1.0		
Cereals and grains group Total	10-18	9.3	10.4	9.8	9.2	9.5	8.6	10.2	8.7	9.6	10.4	10.0	9.4	8.7	10.3	9.7		
Sugary drinks [¶] (% of total energy intake)		7.2	7.3	7.7	10.5	10.5	6.9	7.5	6.4	6.8	8.7	6.0	4.9	7.0	7.1	8.5		

[†] Cereals/roots: rice and rice products, wheat and wheat products, starchy roots, stems and products, and starch-rich beans and products. One serving contains 15 g of carbohydrate. [‡] Carbohydrate rich convenience foods: bread, steamed buns and dumplings, instant noodles, sandwiches, and hamburgers. One serving contains 15 g of carbohydrate. [§] Pastries/cookies: one serving contains 15 g of carbohydrate. [¶] Sugary drinks: drinks with added sugar, sugary crushed ice and sugary drink, processed fruit juice and sugar.

Table 3. Daily servings of vegetables, fruit and dietary fiber by age/gender/stratum

Food type (servings)	Stratum	DDG for 7-12 yrs	6-9 y	10-12 y	Hakka	Mountainous areas	Eastern	PengHu	First Northern	Second Northern	Third Northern	First Central	Second Central	Third Central	First Southern	Second Southern	Third Southern
	Boys																
Vegetables group [†]		3	1.6	2.1	1.9	1.2	1.7	1.9	1.7	1.7	1.9	2.1	1.6	1.6	2.0	2.2	1.6
Fruit group [‡]		2	1.1	1.2	1.1	0.8	1.0	1.4	1.0	1.2	0.6	1.4	1.1	0.8	1.6	1.1	1.2
Dietary fiber (g)			15.3	18.3	17.9	13.7	15.2	16.6	14.8	15.4	14.7	18.4	15.3	15.6	18.7	18.3	
ADA Recommendation (s%) [§]			123	115	128	98	109	118	106	110	105	131	110	111	133	130	124
Dietary Guidelines for Americans Recommendations (%) [¶]			54	58	59	47	55	59	50	58	52	56	51	50	60	61	59
Girls																	
Vegetables group [†]		3	1.5	2.0	1.4	1.4	1.8	1.9	1.9	1.7	1.5	2.1	1.5	1.7	1.9	2.1	1.6
Fruit group [‡]		2	1.0	1.1	1.3	0.9	1.0	1.1	0.9	1.0	1.0	1.1	1.0	1.0	1.2	0.8	1.2
Dietary fiber (g)			14.3	17.4	14.1	12.6	15.8	15.9	16.2	16.1	14.5	17.5	14.0	13.9	16.8	14.7	16.5
ADA Recommendations (%) [§]			115	109	100	90	113	113	115	115	103	125	100	99	120	105	118
Dietary Guidelines for Americans Recommendations (%) [¶]			56	62	56	49	61	67	59	68	59	61	50	52	65	52	59

[†] Vegetables group: dark-green/yellow vegetables and other vegetables (light-green vegetables, bamboo shoots, squash, beans, mushrooms, pickles and seaweed). One serving contains 5 g of carbohydrate. [‡] Fruit group: fresh fruit, processed fruit and fresh fruit juices. One serving contains 15 g of carbohydrate. [§] American Dietetic Association (ADA) Recommendations: Dietary fiber recommendations for children above 2 years are for an extra 5 g per year of age.¹⁵ [¶] Dietary Guidelines for Americans Recommendations: 14 g/1000 kcal of dietary fiber.¹⁶

Table 4. Mean servings of the meat/fish/eggs/soybean group, fat and oil group, and mean cholesterol intake by age/gender/ stratum

Food type (servings)	Stratum	DDG for 7-12 yrs	6-9 y	10-12 y	Hakka	Mountainous areas	Eastern	PengHu	First Northern	Second Northern	Third Northern	First Central	Second Central	Third Central	First Southern	Second Southern	Third Southern
Boys																	
Dairy products [†]		1-2	0.8	0.6	0.5	0.2	0.6	0.8	0.6	0.7	0.6	0.9	0.7	0.6	0.9	0.7	0.8
Poultry [‡]			1.1	1.6	1.3	1.0	1.3	1.0	1.8	0.9	1.3	2.0	1.2	1.5	1.3	1.6	1.0
meat [‡]			2.3	2.6	2.7	3.1	2.3	2.3	2.4	2.6	2.8	2.3	2.4	2.3	3.0	2.7	2.1
seafood [‡]			1.2	1.2	1.2	1.1	1.1	1.6	1.2	1.0	1.5	1.2	1.1	1.2	1.6	2.1	1.5
eggs /egg products [‡]			0.6	0.6	0.6	0.6	0.7	0.8	0.4	0.5	0.5	0.5	0.6	0.7	0.7	0.6	0.8
soybean/soybean products [‡]			0.6	0.6	0.5	0.3	0.8	0.6	0.7	0.5	0.3	0.9	0.7	1.0	0.4	0.7	0.5
Meat/fish/eggs/soybean group Total		2-3.5	5.9	6.9	6.4	6.0	6.1	6.4	6.5	5.5	6.3	6.9	6.0	6.7	7.0	7.7	6.0
Fats and oils group [§]		6-7.5	3.1	3.3													
Cholesterol	Mean (mg)		346	370	382	334	368	405	317	331	329	361	379	361	400	419	389
	Standard error		-	-	33	19	28	23	29	19	28	18	39	39	26	41	33
Girls																	
Dairy products		1-2	0.9	0.6	0.6	0.2	0.4	0.6	0.5	0.7	0.6	0.6	0.7	0.7	0.9	0.6	0.5
Poultry			1.0	1.0	0.8	1.3	0.9	0.8	1.3	1.0	0.8	1.0	1.2	1.7	0.9	1.7	1.3
meat			2.1	2.1	2.2	2.3	2.4	1.6	2.0	2.0	2.2	2.5	2.1	1.6	2.4	2.7	2.3
seafood			1.0	1.0	1.1	0.7	1.0	1.7	1.0	0.8	1.2	1.1	0.8	2.0	1.2	1.5	1.3
eggs /egg products			0.5	0.6	0.3	0.3	0.5	0.5	0.5	0.4	0.6	0.5	0.5	0.7	0.6	0.6	0.5
soybean/soybean products			0.6	0.5	0.5	0.6	0.5	0.6	0.8	0.7	0.5	0.8	0.6	0.7	0.5	0.6	0.4
Meat/fish/eggs/soybean group Total		2-3.5	5.2	6.3	5.0	5.3	5.3	5.2	5.6	4.9	5.2	5.9	5.2	6.7	5.6	7.1	5.9
Fats and oils group [§]		6-7.5	3.3	3.2													
Cholesterol	Mean (mg)		303	335	273	243	312	301	314	253	336	312	287	395	364	374	326
	Standard error		-	-	22	16	26	26	46	22	27	19	19	43	14	35	40

[†] Dairy group: fresh milk, yogurt, cheese and other dairy products. One serving contains 8 g of protein. [‡] Meat/fish/eggs/soybean group: poultry, meat, seafood, eggs, soybean and products. One serving contains 7 g of protein. [§] Fats and oils group: cooking oil, peanuts, cashews, and other nuts. One serving contains 5 g of lipid.

Table 5. Daily intake of vitamins and minerals by gender/stratum

Stratum	Hakka		Mountainous areas		Eastern		PengHu		First Northern		Second Northern		Third Northern		First Central		Second Central		Third Central		First Southern		Second Southern		Third Southern	
	Mean SE	DRI (%)	Mean SE	DRI (%)	Mean SE	DRI (%)	Mean SE	DRI (%)	Mean SE	DRI (%)	Mean SE	DRI (%)	Mean SE	DRI (%)	Mean SE	DRI (%)	Mean SE	DRI (%)	Mean SE	DRI (%)	Mean SE	DRI (%)	Mean SE	DRI (%)	Mean SE	DRI (%)
Boys																										
Vit B ₂ [†] (mg)	1.4 (0.1)	128	1.1 (0.1)	99	1.4 (0.1)	125	1.4 (0.1)	125	1.3 (0.1)	116	1.4 (0.1)	121	1.3 (0.1)	116	1.6 (0.1)	141	1.7 (0.1)	151	1.5 (0.1)	129	1.8 (0.2)	161	1.5 (0.1)	135	1.5 (0.2)	137
VitA [†] (I.U.)	6131 (481)	169	4346 (591)	118	5819 (1708)	155	4711 (596)	131	4641 (728)	130	4634 (568)	127	5131 (636)	140	5320 (816)	147	6726 (2159)	184	5630 (680)	150	5026 (558)	138	6147 (813)	167	6109 (956)	170
VitE [‡] (mg)	10886 (1747)	124	7881 (665)	91	8024 (1081)	95	9240 (1717)	108	11550 (1018)	134	9386 (1417)	114	9994 (1675)	115	9162(779)	108	9126(1075)	107	11853 (2585)	139	8498 (586)	101	9741 (1450)	114	10513 (1634)	124
Ca [‡] (mg)	542 (21)	63	346 (28)	41	490 (67)	59	551 (44)	67	524 (30)	61	525(20)	62	500(54)	58	685 (43)	81	500 (53)	59	493 (38)	57	608 (34)	72	598 (71)	70	520 (70)	62
Fe [‡] (mg)	15.9 (1.6)	130	12.5 (1.3)	104	13.5 (0.7)	117	13.9 (0.9)	121	14.1 (1.3)	119	12.0 (0.8)	101	15.0 (1.7)	124	18.6 (1.5)	159	14.0 (1.6)	121	16.0 (1.6)	134	16.5 (1.5)	141	15.5 (1.5)	131	12.9 (1.4)	113
Mg [†] (mg)	240 (17)	131	194 (10)	107	230 (26)	125	252 (8)	141	247 (16)	134	219 (12)	118	236 (17)	128	287 (12)	159	247 (27)	136	229 (11)	124	265 (13)	146	273 (23)	150	247 (23)	140
Na [†] (mg)	4738 (440)		4815 (388)		4867 (474)		5265 (300)		4123 (373)		4224 (441)		4601 (586)		5820 (537)		5807 (755)		5460 (501)		4331 (228)		4940 (471)		5249 (669)	
K [†] (mg)	2521 (237)		1878 (109)		2175 (305)		2457 (129)		2332 (144)		2188 (159)		2285 (206)		2774 (136)		2468 (176)		2152 (80)		2767 (98)		2812 (338)		2346 (211)	
Girls																										
Vit B ₂ [†] (mg)	1.2 (0.1)	108	0.9 (0.0)	87	1.3 (0.1)	121	1.3 (0.2)	122	1.4 (0.1)	129	1.2 (0.1)	111	1.4 (0.1)	134	1.5 (0.1)	145	1.3 (0.1)	124	1.4 (0.2)	129	1.5 (0.1)	138	1.4 (0.1)	129	1.2 (0.1)	118
VitA [†] (I.U.)	4635 (656)	124	3207 (472)	88	5751 (615)	157	3947 (614)	106	4490 (664)	127	3548 (447)	99	7357 (1737)	207	6756 (1443)	181	4570 (436)	125	6115 (893)	164	5473 (576)	150	6038 (1277)	166	5030 (711)	133
VitE [‡] (mg)	7941 (1100)	92	7787 (992)	91	9510 (999)	114	8978 (1367)	101	7222 (872)	88	8406 (1400)	99	9994 (2436)	116	8973 (1123)	108	12042 (2277)	145	10909 (1358)	128	7951 (927)	94	7894 (911)	93	8147 (1344)	96
Ca [‡] (mg)	440 (36)	52	354 (37)	42	540 (78)	66	458 (64)	52	539 (55)	64	483 (34)	56	448 (56)	53	547 (46)	64	478 (29)	56	523 (89)	60	593 (34)	70	479 (45)	57	464 (43)	55
Fe [‡] (mg)	11.6 (0.5)	98	11.0 (0.7)	93	13.1 (1.0)	112	13.2 (2.2)	107	13.3 (1.5)	114	13.1 (2.4)	106	12.6 (0.9)	105	16.3 (1.6)	139	12.6 (1.0)	105	12.7 (1.2)	107	13.7 (0.8)	117	15.5 (1.6)	129	12.6 (1.3)	108
Mg [†] (mg)	204 (8)	110	183 (7)	98	222 (19)	123	225 (23)	119	247 (28)	135	224 (17)	118	220 (18)	120	246 (12)	132	210 (15)	112	220 (16)	116	234 (16)	126	229 (24)	125	234 (20)	132
Na [†] (mg)	3947 (270)		4710 (360)		4703 (355)		4891 (584)		4171 (405)		4228 (441)		3944 (544)		5131 (419)		5569 (1810)		5081 (641)		3797 (473)		4576 (399)		4607 (524)	
K [†] (mg)	2048 (91)		1675 (52)		2137 (177)		2207 (214)		2367 (278)		2131 (149)		2161 (176)		2486 (151)		2184 (248)		2082 (121)		2436 (184)		2565 (418)		2282 (244)	

[†]The referential standards for estimating the insufficient or excess intake of VitA, C, B1, B2, B6, niacin, Mg, and Fe are from the Recommended Dietary Allowance (DRA), which is the average daily dietary intake level that is sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a particular life-stage and gender group.

[‡]The referential standards for estimating the insufficient or excess intake of VitE, Ca, and P are from Adequate Intake (AI), which is a recommended average daily nutrient intake level based on experimental data or determined by estimating the amount of a nutrient eaten by a group of healthy people. An AI is set when there is not sufficient scientific evidence available to determine an Estimated Average Requirement and calculate a Recommended Dietary Allowance.

0.6 servings for children 10-12 years. Intake of dairy foods decreased with age. Children from mountainous areas consumed only 0.2 servings of dairy foods per day (Table 4).

(e) *Fats and oils group.* The mean intake of fats and oils by children 6-12 was 3 servings per day. The fats and oils group includes only fats and oils used in cooking or contained in nuts. It does not include hidden fats and oils from the other five food groups or those that have been artificially added during processing. As a result, the actual intake of fats and oils by children is likely to be higher.

Vitamins

The mean daily intake of every vitamin reached the DRI in boys and girls (Table 1). However, there were large differences between strata (Table 5). Girls from mountainous areas had mean intake of VitB₂, VitA and VitE below DRI, whereas VitE intake was below DRI in other strata (Table 5). Further comparisons of vitamin intake below DRI by age and gender revealed quite large differences between groups (Table 6). Insufficient vitamin intake increased with age, and this phenomenon was particularly marked for girls. Girls 10-12 years had the highest proportion of insufficient intake in most vitamins.

Food sources of vitamins are listed in Table 7. Important sources of VitB₁ included pork/pork products, rice/rice products, and soybean/soybean products, whereas sources of VitB₂ were dairy products, pork/pork products, and eggs/egg products. Children from mountainous areas had low overall intake of VitB₂ due to their low intake of dairy products. Food sources for VitB₆ ranged widely, comprising pork/pork products and other sources for which the proportion was evenly divided. Niacin intake was mainly from pork/pork products, rice/rice products and chicken/chicken products.

The most important source of VitA was dark-green/yellow vegetables. Other sources included fresh fruit, starchy roots, stems/products, pork/pork products, dairy products and eggs/egg products, which together provided more than 80% of VitA intake. Girls in mountainous areas had intake less than DRI (88%) because of low intake of fruit and vegetables. The most important source of VitC was fresh fruit, followed by light-green vegetables, sugary crushed ice, and sugary drinks, whereas sources for VitE intake were vegetable oils, sugary crushed ice, and sugary drinks.

Minerals

The mean daily mineral intake of boys and girls of each age is presented in Table 1. Apart from calcium intake, which was clearly lower than DRI, mean intake of phosphorus, iron and magnesium reached DRI. The ratio of calcium to phosphorus was 1:2. Mean intake of these minerals was above DRI in all strata except that calcium intake was apparently lower than DRI in all strata and intake of magnesium and iron in mountainous areas and iron in the Hakka stratum was slightly lower than DRI (Table 5). The proportion of children with calcium intake below DRI in boys and girls was over 84%, whereas about 40% of children 10-12 years had magnesium intake below DRI. In addition, for boys and girls entering pu-

erty, the recommended daily iron intake increases from 10 mg to 15 mg.⁹ Therefore, 36% of boys and over half of girls 10-12 years had iron intake below the DRI, which was higher than that for boys of all ages (Table 6).

Mean daily intake of sodium was high for both boys and girls (Table 1). Particularly, the highest sodium intake levels (equivalent to 13-14 g of salt) were for boys from PengHu and the third southern stratum and for boys and girls from the first central and second central strata. Mean daily intake of potassium was lowest for children in mountainous areas and highest for boys from the second southern stratum (Table 5). In Taiwan, no recommendation for potassium intake has been established, but the US¹⁹ recommends a daily intake of 3800 mg for children 4-8 years and 4500 mg for those 9-13 years; these levels are based on the assumptions of an average height of 115 cm and weight of 20 kg for children 4-8 years, 144 cm and 36 kg for boys 9-13 years, and 144 cm and 37 kg for girls 9-13. In Taiwan, the calculated average height/weight were 144 cm/41 kg for boys 9-12.5 years and 145 cm/40 kg for girls 9-12.5 years; these values are close to the above assumptions.²⁰ Thus, based on these recommendations, the potassium intake of Taiwanese children was far below recommended levels although still slightly higher than those consumed by American children ages 6-11 years.²¹

Based on the nutritional density of iron in the current Taiwanese diet,¹³ we estimated the daily intake of iron

Table 6. Proportion of children with vitamin or mineral intake below DRI by age and gender

Nutrient	Gender. Age	Boys		Girls	
		6~9	10~12	6~9	10~12
Vit B ₁ [†]		1.4%	2.2%	9.7%	21.0%
Vit B ₂ [†]		7.1%	20.1%	8.8%	25.8%
Vit B ₆ [†]		2.3%	11.1%	14.2%	25.5%
Niacin [†]		2.5%	3.1%	12.1%	23.9%
Vit A [†]		5.8%	18.1%	29.1%	32.5%
Vit C [†]		0.8%	4.0%	0.0%	0.0%
Vit E [‡]		25.5%	56.0%	31.6%	68.8%
Ca [‡]		84.6%	98.2%	98.4%	100%
P [‡]		0.6%	8.8%	2.1%	12.8%
Fe [†]		2.2%	36.1%	27.4%	53.0%
Mg [†]		3.6%	37.0%	2.5%	45.6%

[†]The referential standards for estimating the insufficient intake of VitA, C, B₁, B₂, B₆, niacin, Mg, and Fe are from the Recommended Dietary Allowance (DRA), which is the average daily dietary intake level that is sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a particular life-stage and gender group. [‡]The referential standards for estimating the insufficient intake of VitE, Ca, and P are from Adequate Intake (AI), which is a recommended average daily nutrient intake level based on experimental data or determined by estimating the amount of a nutrient eaten by a group of healthy people. An AI is set when there is not sufficient scientific evidence available to determine an Estimated Average Requirement and calculate a Recommended Dietary Allowance.

Table 7. Food sources of vitamins for children

Rank	Vitamin B ₁		Vitamin B ₂		Vitamin B ₆		Niacin		Vitamin C		Vitamin E	
	Subcategory food	Daily mean (mg)	Subcategory food	Daily mean (mg)	Subcategory food	Daily mean (mg)	Subcategory food	Daily mean (mg)	Subcategory food	Daily mean (mg)	Subcategory food	Daily mean (mg)
	(Cumulative %)		(Cumulative %)		(Cumulative %)		(Cumulative %)		(Cumulative %)		(Cumulative %)	
1	pork/pork products	0.49 (35.0)	dairy products	0.33 (22.6)	pork/pork products	0.24 (19.0)	pork/pork products	2.67 (14.7)	fresh fruit	51.3 (36.0)	vegetable oils	2814 (29.9)
2	rice/rice products	0.17 (47.1)	pork/pork products	0.16 (33.6)	other spices	0.09 (26.2)	rice/rice products	2.61 (29.1)	light-green /vegetables	22.9 (52.2)	sugary crushed ice and sugary drink	2264 (53.9)
3	soybean/soybean products	0.15 (57.9)	eggs/egg products	0.13 (42.5)	fresh fruit	0.07 (31.7)	chicken/chicken products	1.87 (39.4)	sugary crushed ice and sugary drink	19.6 (65.9)	pastries/ cookies	632 (60.6)
4	dairy products	0.06 (62.1)	sugary crushed ice/ sugary drink	0.1 (49.3)	soy sauce	0.07 (37.3)	soybean/ soybean products	1.46 (47.5)	dark-green/yellow vegetables	16.3 (77.4)	soybean /soybean products	420 (65.1)
5	fresh fruit	0.05 (65.7)	rice/rice products	0.08 (54.8)	rice/rice products	0.06 (42.1)	dairy products	1.03 (53.1)	processed juices	7.5 (82.7)	pork/pork products	322 (68.5)
6	wheat/wheat products	0.04 (68.6)	chicken/ chicken products	0.08 (60.3)	eggs/egg products	0.06 (46.8)	sugary crushed ice /sugary drink	0.88 (58.0)	squash	5.1 (86.3)	other spices	309 (71.8)
7	chicken/ chicken products	0.04 (71.4)	fresh fruit	0.06 (64.4)	pickles	0.06 (51.6)	saltwater fish(fresh)	0.75 (62.1)	pork/pork products	3.2 (88.5)	rice/rice products	246 (74.4)
8	steamed buns/ dumplings	0.04 (74.3)	dark-green /yellow vegetables	0.05 (67.8)	chicken / chicken products	0.05 (55.6)	steamed buns/dumplings	0.6 (65.4)	starchy roots, stems/ products	3.2 (90.8)	dairy products	232 (76.9)
9	starchy roots, stems/products	0.03 (76.4)	wheat/ wheat products	0.04 (70.5)	wheat/wheat products	0.04 (58.7)	wheat/wheat products	0.55 (68.5)	fresh fruit	2.7 (92.7)	eggs/egg products	230 (79.3)
10	other meat products	0.03 (78.6)	soybean/ soybean products	0.03 (72.6)	starchy roots, stems/ products	0.04 (61.9)	fresh fruit	0.52 (71.3)	other spices	1.7 (93.9)	instant noodles	227 (81.7)
11	bread	0.03 (80.7)	light-green vegetables	0.03 (74.7)	dairy products	0.04 (65.1)	eggs/egg products	0.41 (73.6)	dairy products	1.7 (95.1)	fresh fruit	188 (83.7)
12	soups	0.03 (82.9)	bread	0.03 (76.7)	light-green vegetables	0.04 (68.3)	starchy roots, stems/products	0.39 (75.7)	soybean/soybean products	0.7 (95.6)	starchy roots, stems/ products	151 (85.3)
13	eggs/egg products	0.02 (84.3)	sandwiches, hamburgers	0.03 (78.8)	sugary crushed ice/sugary drink	0.04 (71.4)	other sea-food/seafood products	0.38 (77.8)	bread	0.6 (96.0)	wheat/wheat products	149 (86.9)

Table 8. Food sources of minerals for children

Rank	Calcium		Phosphorus		Iron		Magnesium		Sodium		Potassium	
	Subcategory food	Daily mean (mg)	Subcategory food	Daily mean (mg)	Subcategory food	Daily mean (mg)	Subcategory food	Daily mean (mg)	Subcategory food	Daily mean (mg)	Subcategory food	Daily mean (mg)
	(Cumulative %)		(Cumulative %)		(Cumulative %)		(Cumulative %)		(Cumulative %)		(Cumulative %)	
1	dairy products	164 (31.5)	dairy products	145 (14.9)	pork and pork products	1.72 (12.3)	rice and rice products	25.0 (10.5)	salt	1386 (29.7)	dairy products	275 (11.7)
2	dark-green/ yellow vegetables	53.8 (41.8)	pork and pork products	117 (26.9)	chicken and chicken products	1.2 (20.9)	dairy products	20.5 (19.2)	soups	451 (39.3)	dark-green and yellow vegetables	219 (21.0)
3	soybean/ soybean products	42.2 (49.9)	rice and rice products	107 (37.9)	dark-green and yellow vegetables	1.04 (28.3)	pork and pork products	15.7 (25.8)	other spices	434 (48.6)	pork and pork products	217 (30.3)
4	light-green vegetables	27.6 (55.2)	chicken and chicken products	92.4 (47.4)	soybean and soybean products	0.9 (34.7)	dark-green and yellow vegetables	15.7 (32.4)	soy sauce	407 (57.3)	fresh fruit	181 (37.9)
5	fish/fish organs/products	22.1 (59.5)	soybean and soybean products	60.6 (53.6)	rice and rice products	0.87 (41.0)	soybean and soybean products	15.6 (38.9)	pork and pork products	270 (63.1)	seaweed	145 (44.1)
6	sugary crushed ice/sugary drink	18.3 (63.0)	eggs and egg products	58.7 (59.6)	other spices	0.81 (46.7)	seaweed	14.0 (44.8)	instant noodles	164 (66.6)	salt	123 (49.3)
7	seaweed	17.9 (66.4)	other sea-food/seafood products	34.5 (63.2)	eggs/egg products	0.59 (51.0)	fresh fruit	12.5 (50.1)	wheat/wheat products	142 (69.6)	rice/rice products	111 (54.0)
8	other seafood/ seafood products	16.6 (69.6)	saltwater fish(fresh)	31.8 (66.4)	other sea-food/seafood products	0.45 (54.2)	pastries/cookies	9.2 (54.0)	bread	123 (72.2)	chicken/chicken products	91.0 (57.9)
9	sandwiches/ hamburgers	15.1 (72.5)	pastries/cookies	31.4 (69.6)	bread	0.44 (57.3)	wheat/wheat products	9.2 (57.8)	steamed buns/dumplings	111 (74.6)	light-green vegetables	75.0 (61.1)
10	fresh fruit	15.0 (75.4)	wheat/wheat products	29.9 (72.7)	pastries/cookies	0.41 (60.3)	bread	7.0 (60.8)	chicken/chicken products	102 (76.8)	soybean/soybean products	71.1 (64.1)
11	pastries/cookies	11.8 (77.6)	sugary crushed ice and sugary drink	28.5 (75.6)	sugary crushed ice and sugary drink	0.41 (63.2)	other sea-food/seafood products	6.6 (63.6)	pickles	92.5 (78.8)	sugary crushed ice and sugary drink	65.7 (66.9)
12	bread	10.1 (79.6)	dark-green/ yellow vegetables	27.7 (78.5)	wheat/wheat products	0.4 (66.0)	other spices	6.4 (66.2)	other	91.3 (80.7)	other spices	64.6 (69.7)
13	pork/pork products	10.1 (81.5)	bread	24.6 (81.0)	fresh fruit	0.37 (68.7)	sugary crushed ice and sugary drink	6.0 (68.8)	dairy products	89.1 (82.7)	pastries/cookies	58.5 (72.1)

provided by a diet based on the dietary recommendations for intake of the six food groups. This demonstrated that if children followed the recommended dietary intake, boys and girls 6-9 years would reach DRI for iron (11.9 mg and 11.5 mg respectively). However, the iron intake of boys and girls 10-12 years would reach only 77.6% and 82.7% of DRI, respectively (11.6 mg, 12.4 mg).

Food sources of minerals are detailed in Table 8. Important sources of calcium were dairy products and dark-green/yellow vegetables, whereas dairy products, pork/pork products and rice/rice products were the main sources of phosphorus. The food sources of iron were dispersed among different food categories, in which pork/pork products were the only source that provided more than 10% of iron intake. Other sources included chicken/chicken products and dark-green/yellow vegetables. These food sources, providing heme iron, represented 30.8% of iron intake for boys and 28.7% for girls. The main food sources for magnesium intake were rice/rice products and dairy products, whereas table salt was the primary source for sodium intake, followed by soups, other spices, and soy sauce. Foods such as instant noodles, bread, steamed buns/dumplings and sandwiches/hamburgers also provided about 10% of daily sodium intake.

DISCUSSION

This survey shows that children's diets in Taiwan are slight lower in carbohydrates and higher in fats with a higher than recommended level of protein intake according to the DOH dietary guidelines with regard to the energy intake from the three macronutrients. The mean intake of vitamins and minerals by children met or exceeded DRI or other recommended standards with the exception of seriously insufficient calcium intake, an extremely high sodium intake, and a substantial proportion of children in different age/gender/strata with lower vitamin and mineral intake levels than DRI and other recommended standards. These problems were mainly related to an imbalance in the amounts of foods distributed in the six food groups. We will discuss the related issues in four aspects: dietary imbalance, two extremities of nutrients intake, body image of pre-pubescent girls, and children in mountainous areas.

Dietary imbalance

Compared to the DDG recommendation, the aforementioned dietary nutrient intake profile of Taiwanese children was associated with lower intake of the cereals and grains group, fruit and vegetable groups, and dairy products, but a higher number of servings in the meat/fish/eggs/soybean group. The amount of fats/oils used in cooking and consumed with meat is high for half of the children according to the estimates of percent fat in total calories. In addition, excess amounts of salt, soups, other spices/soy sauce, and instant noodles contribute to an extreme over-intake of sodium. This dietary pattern is similar to those in many other countries²² in terms of low intake of fruits and vegetables as well as dietary fiber and also to Taiwanese adolescents and adults in terms of the amount of protein consumed¹¹. Therefore, the following

recommendations are provided for children with respect to a balanced diet:

Although the proportions of energy intake from the three macronutrients were low in carbohydrates and high in fats and protein, recent evidence suggests that a low carbohydrate / higher protein diet may be beneficial for weight loss and metabolic disorders.²³ Therefore the promotion of carbohydrate intake above 55% of total energy has become controversial. The advocacy of the consumption of whole-grain carbohydrates and lean meat seems prudent because such a diet not only increases the intake of fiber and minerals but keeps the consumption of carbohydrates and fats at moderate levels.

Because marbled pork is popular in Taiwan, it may be desirable to make children, their guardians and school canteen planners aware that lean red meat should be eaten, that fat should be removed from meat, and that consumption of protein-rich plant foods should be increased. If children increase their intake of whole-grain carbohydrates, fruit and vegetables, and plant protein, then consumption of red meat may be reduced accordingly. This change would increase the proportion of energy intake provided by nutrient-rich foods. Intake of dietary fiber, potassium, and magnesium would increase and the percentage of energy intake provided by animal protein and saturated fats would decrease.

Plasma cholesterol level and dietary saturated fatty acids are important risk factors for cardiovascular disease. Cholesterol intake in Taiwanese children (338 mg/day) is far above that of American children ages 6-11 years (212 mg/day) (comparing years 1999-2000).²⁴ Notably, one-fifth of Taiwanese elementary school boys and one-fourth of girls had abnormal blood cholesterol levels.²⁵ Because the mean intake of cholesterol in children was high and saturated fatty acids were more than 10% of energy intake, it is important for children to decrease their dietary intake of red meat products. This would lead to a decrease in the intake of total fat, saturated fat acids, and dietary cholesterol. In addition, it is prudent for children to consume no-fat or low-fat dairy products.²⁶ As the consumption of nuts was extremely low in Taiwanese children (only 0.1 servings per day), it is recommended that children increase their intake of nuts and nut products²⁷ by consuming more traditional Chinese snacks. These foods are rich in VitE, dietary fiber, potassium, magnesium, and zinc, which are relatively insufficient in Taiwanese diets.

Refreshments and snacks are a major source of energy and carbohydrates for Taiwanese children, as they are for American children.²⁸ Both carbohydrate-rich convenience foods and pastries/cookies that are currently consumed by children have high fat content. When using these foods as staples or desserts, it is important to consume in moderation and to balance them with low-fat dairy products or fresh fruit. Although children's mean intake of sugary crushed ice and sugary drinks was not over 10% of energy intake, the consumption by children 10-12 years already exceeded that of adolescents and was double that of adults.²⁹ Moreover, whereas energy intake from these foods increased with age during childhood, intake of dairy products decreased concurrently. Therefore, it is important to teach young children to maintain their milk-drinking habits by actively promoting the eat-

ing concept encapsulated in 'Drink more dairy products and drink less sugary drinks' and encouraging the food industry to produce low-sugar and low-fat crushed ice desserts and sweets that include dairy and fruit products as ingredients.

Two extremes of nutrient intake

Obesity and metabolic disorders have become important health problems worldwide. While childhood obesity is correlated with adult obesity and future chronic disease, and the incidence of childhood obesity is increasing rapidly in Taiwan,³⁰ the energy intake of children should be of concern. The mean energy intake of boys and girls in this survey was close to DRI, but there were large differences in energy intake between children of different ages and between boys and girls—particularly the older ones. Many children had excessive energy intake, whereas at the other extreme many children had energy intake below the DRI. In addition, although the mean intake of most vitamins and minerals greatly exceeded DRI or other standards (with the exception of calcium intake), a substantial proportion of children had vitamin and mineral intake levels below DRI, and such deficiencies were observed between different groups (i.e., gender, age, and strata). Particularly, the proportion of children ages 10-12 years having primarily lower-than-DRI intake of VitB₁, B₂, B₆, A, E, calcium, iron, and magnesium was higher than that for other age groups, and this situation was particularly severe for girls. Therefore, we propose the following recommendations for children:

When developing nutritional policies and implementing nutritional education for children, it is important not only to suggest that children avoid excessive energy intake but also pay attention to those children with low energy intake who may not consume sufficient amounts of important nutrients.

It is recommended that children increase their consumption of calcium-rich dairy foods to improve their intake of calcium and VitB₂ and to ameliorate the observed poor calcium to phosphorus ratio and related problems. However, considering the high prevalence of lactose intolerance in Chinese people, appropriate policy recommendations should be developed with regard to high-calcium alternatives to dairy products.

Although one-half of children 10-12 years had VitE intake below the DRI, this result does not agree with the VitE levels measured in blood samples.³¹ Therefore, it is important to further investigate the concordance between nutritional biochemical profile, dietary intake, and dietary recommendations for VitE.

Because the intake and blood level of magnesium is significantly lower in obese children³² and a lower intake of magnesium may increase the risk of chronic diseases such as hypertension and insulin resistance,³³ it would be desirable to recommend an increase in magnesium intake.³¹ Although the mean intake of magnesium in Taiwanese children reached the DRI and the proportion with low plasma magnesium was small,³⁴ about 40% of children 10-12 years were below the DRI. These data suggest that the intake of magnesium in older children is of concern.

A high proportion of Taiwanese children 10-12 years

had iron intake below the DRI. As iron deficiency (without anemia) correlates with delayed academic,³⁵ children's iron intake is worthy of attention. Based on the Daily Dietary Guidelines, children 10-12 had only 80% of DRI for iron, and thus it is recommended that older children select foods with higher iron or heme iron content to improve their iron status.

Intake of sodium or salt is related to high blood pressure and is a risk factor for cardiovascular disease and renal disease.³⁶ Taiwanese children had a mean daily intake of sodium equivalent to 11-12 g of salt. Boys in PengHu and the third southern stratum and children in the first and second central strata consumed about 13-14 g of salt per day. In Taiwan, no recommended maximum daily salt intake for children has been established. In the UK, the daily recommendation for salt intake for children 7 to 10 years is not over 5 g (i.e., 2 g sodium), whereas that for children 11 years and over is not over 6 g (2.5 g sodium).³⁷ Therefore, it is recommended that parents reduce the use of salt and other sodium-containing spices during cooking and to select lightly salted foods for children in order to prevent the excess consumption of sodium early on. Moreover, it is also important to choose low-sodium products and to pay attention to the hidden sodium in soups and carbohydrate-rich convenience foods.

Children's intake of potassium was similar to that of American children but far below the recommended American DRI.³⁸ Therefore, it is recommended that parents select for their children potassium-rich and low-sodium foods out of the six food groups; these include fruit and vegetables, whole grains, and dairy products. In contrast, foods low in potassium but high in sodium, such as cookies, breads, and other processed foods should be limited.

Body image of pre-pubescent girls

A high proportion of children 10-12 years, particularly girls, had energy and nutrient intake below DRI, a fact possibly related to very sedentary lifestyles and a desire to be slim—as has been observed in western countries. The desire to be slim may lead to gradual development of a negative body image and unbalanced nutrition in later years of their elementary schooling. However, this requires further research with regard to the health impact, behavioral risk factors and effective intervention measures in Taiwan. The negative body image and dietary problems of adolescents in western countries is already quite a common health problem.³⁹⁻⁴² There also have been studies with Taiwanese children suggesting that, regardless of the actual body size of individuals, many adolescent girls would like to be thinner and that a quite high proportion of them have a negative body image,⁴³⁻⁴⁶ leading to a high risk for developing eating disorders.⁴²⁻⁴³ Therefore, it is important to pay attention to the eating disorders due to poor body image.

Children in mountainous areas

Diets of children in mountainous areas featured the highest intake in sugary drinks (exceeding 10% of energy intake in girls), significantly lower intake of vegetables and fruits than other regions, and extremely low intake of dairy products. As a result, their intake of dietary fiber,

VitA, VitB₂, calcium and potassium was the lowest among all strata. In addition, iron intake did not reach the DRI. Therefore, it is recommended that extra consideration be given to correct the problem of dietary imbalance for children in mountainous areas.

CONCLUSIONS

Following economic development and prosperity, double burdens and challenges have arisen for children's diets and related nutritional issues. Children have developed dietary patterns that include excessive energy intake and a high intake of saturated fatty acids and cholesterol together with insufficient levels of vitamins, minerals, and dietary fiber. Such dietary patterns tend to lead to obesity, metabolic disorders, and poor cardiovascular risk factor profiles. At the same time, micronutrient insufficiency can compromise growth, development, and bone density. These nutritional imbalances may have both biological and psychological impacts, influencing children's ability to learn and increasing their risk of developing chronic diseases as adults. A new battle has begun to ensure the health and nutrition of elementary school children. It is vital that government develop new effective policies and educational strategies to deal with these challenges.

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AUTHOR DISCLOSURES

Shin-Jiuan Wu, Wen-Harn Pan, Nai-Hua Yeh, and Hsing-Yi Chang, no conflicts of interest.

REFERENCES

1. Popkin BM. The shift in stages of the nutrition transition in the developing world differs from past experiences. *Pub Health Nutr.* 2002;5:205-14.
2. Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and trends in overweight among US children and adolescents, 1999-2000. *JAMA.* 2002;288:1728-32.
3. Liu CH, Wu TY, Kuo KL, Chen CC, Lin KY, Huang HC. Overweight and obesity. *Basic Med Sci.* 2005;20(9):219-231. (In Chinese)
4. Berenson G, Wattigney WA, Bao W, Nicklas TA, Jiang X, Rush JA. Epidemiology of early primary hypertension and implications for prevention: The Bogalusa Heart Study. *J Hum Hyper.* 1994;8:303-311.
5. Berenson G, Srinivasan S, Nicklas TA. Atherosclerosis: A nutritional disease of childhood. *Am J Cardi.* 1998;82:22T-29T.
6. Troiano RP, Briefel RR, Carroll MD, Bialostosky K. Energy and fat intakes of children and adolescents in the United States: Data from the national health and nutrition examination surveys. *Am J Clin Nutr.* 2000;72(5):1343S-1353S.
7. Department of Health. Daily Dietary Guidelines for Children Aged 7-12 Years [homepage on the Internet]. Taiwan: Department of Health [cited 2007 May 27]. Available from: <http://food.doh.gov.tw/children/a-01.htm> (In Chinese)
8. Department of Health. Daily Reference Intakes, DRI [homepage on the Internet]. Taiwan: Department of Health; c2002 [cited 2007 May 27]. Available from: http://food.doh.gov.tw/chinese/library/library2_2_1.htm (In Chinese)
9. Office of Dietary Supplements. Nutrient recommendations: Dietary Reference Intakes (DRI) and Recommended Dietary Allowances (RDA) [homepage on the Internet]. Bethesda, MD: National Institutes of Health [cited 2007 May 27]. Available from: http://dietary-supplements.info.nih.gov/Health_Information/Dietary_Reference_Intakes.aspx
10. Tu SH, Hung YT, Chang HY, Hang CM, Hsiao NH, Lin W, Lin YC, Hu SW, Yang YH, Wu TT, Chang YH, Su SC, Hsu HC, Pan WH. Nutrition and Health Survey in Taiwan Elementary School Children 2001-2002: research design, methods and contents. *Asia Pac J Clin Nutr.* 2007;16(S2):507-17.
11. Pan WH, Chang YH, Chen JY, Wu SJ, Tzeng MS and Kao MD. Nutrition and Health Survey in Taiwan (NAHSIT) 1993-1996: Dietary nutrient intakes assessed by 24-hour recall. *Nutr Sci J.* 1999;24:11-39.
12. Wu SJ, Chang YH, Fang CW and Pan WH. Food sources of weight, calories, and three macro-nutrients: NAHSIT 1993-1996. *Nutr Sci J.* 1999;24:41-58.
13. Wu SJ, Chang YH, Wei IL, Kao MD, Lin YC, Pan WH. Intake levels and major food sources of energy and nutrients in the Taiwanese elderly. *Asia Pac J Clin Nutr.* 2005;14(3):211-20.
14. Shah BV, Barnwell BG and Bieler GS. SUDAAN user's manual: Release 7.5. Research Triangle Park, North Carolina: Research Triangle Institute; 1997.
15. Chang, HY, Suchindran CM. and Pan WH. Using the overdispersed exponential family to estimate the distribution of usual daily intakes of people aged between 18 and 28 in Taiwan. *Stat Med.* 2001;20(15):2337-50.
16. Marlett JA, McBurney MI, Slavin JL. Position of American Dietetic Association: Health implications of dietary fiber. *J Am Diet Assoc.* 2002;102(7):993-1000.
17. Dietary Guideline Advisory Committee. Nutrition and your health: Dietary guidelines for Americans [Monograph on the Internet]. Washington: Dietary Guidelines Advisory Committee; c2005-01 [updated 2006 June 15; cited 2005 January 17]. Available from: http://www.health.gov/dietaryguidelines/dga2005/report/HTML/E_translation.htm
18. Position of the American Dietetic Association. Dietary guidance for healthy children aged 2 to 11 years. *J Am Diet Assoc.* 2004;04:660-77.
19. Dietary Food and Nutrition Board (FNB). Dietary reference intakes: Electrolytes and water [part of a monograph on the Internet]. Washington: Institute of Medicine [cited 2006 July 1]. Available from: <http://www.iom.edu/Object.File/Master/20/004/0.pdf>
20. Chang WY. The construction of students' growth model using health management system. Unpublished masters' dissertation, Department and Graduate Institute of Information Management, Chaoyang University Of Technology, Taiwan. (In Chinese)
21. Ervin RB, Wang CY, Wright JD, Kennedy-Stephenson J. Dietary intake of selected minerals for the United States population: 1999-2000. *Adv Data.* 2004;27(341):1-5.

22. Yngve A, Wolf A, Poortvliet E, Elmadfa I, Brug J, Ehrenblad B, Franchini B, Haraldsdóttir J, Krølner R, Maes L, Pérez-Rodrigo C, Sjöström M, Thórsdóttir I and Klepp K. Fruit and vegetable intake of mothers of 11-year-old children in nine European countries: The pro children cross-sectional survey. *Ann Nutr Metab.* 2005; 49(4):236-45.
23. Last AR, Wilson SA. Low-Carbohydrate Diets. *Am Fam Physician.* 2006;73(11):1951-8.
24. Ervin RB, Wright JD, Wang CY, Kennedy-Stephenson J. Dietary intake of fats and fatty acids for the United States population: 1999-2000. *Adv Data.* 2004;8(348):1-6.
25. Lee MS. Blood pressure, blood sugar, blood lipid, and uric acid. Paper presented at the Symposium on Child Nutrition and Health Survey in Taiwan (NAHSIT II), Academia Sinica, Taipei, Taiwan, 2004. (In Chinese)
26. National Cholesterol Education Program. Report of the expert panel on blood cholesterol levels in children and adolescents. Washington, DC: US Government Printing Office, 1991. (NIH publication no. 91-2732).
27. Sabaté J. Nut consumption and body weight. *Am J Clin Nutr* 2003; 78(3 Suppl):647S-650S.
28. Ludwig D, Peterson K, Gortmaker S. Relation between consumption of sugar-sweetened drinks and childhood obesity: A prospective, observational analysis. *The Lancet.* 2001;357(9255):505-8.
29. Wu SJ, Pan WH, Yeh NH, Chang YP. Nutrient intake and dietary pattern. Paper presented at the Symposium on Nutrition Monitoring and Health Policy Development, Institute of Biochemistry, Taiwan, 2004. (In Chinese)
30. Chu, NF. Prevalence of obesity and its morbidities among school children in Taiwan. Paper presented at the Symposium on Child Nutrition and Health Survey in Taiwan (NAHSIT II), Academia Sinica, Taipei, Taiwan, 2004. (In Chinese)
31. Huang, CC. Nutrition status of VitA and E in primary school children in Taiwan. Paper presented at the Symposium on Child Nutrition and Health Survey in Taiwan (NAHSIT II), Academia Sinica, Taiwan, 2004. (In Chinese)
32. Huerta MG, Roemmich JN, Kington ML, Bovbjerg VE, Weltman AL, Holmes VF, Patrie JT, Rogol AD, Nadler JL. Magnesium deficiency is associated with insulin resistance in obese children. *Diabetes Care.* 2005;28(5):1175-81.
33. Ma J, Folsom AR, Melnick SL. Associations of serum and dietary magnesium with cardiovascular disease, hypertension, diabetes, insulin, and carotid arterial wall thickness: The ARIC study. *Atherosclerosis Risk in Community Study.* *J Clin Epidemiol.* 1995;48:927-40.
34. Wang JL, Kao MD. The dietary and biochemical status of magnesium and phosphate in the Taiwanese Children. Paper presented at the Symposium on Child Nutrition and Health Survey in Taiwan (NAHSIT II); 2004 Dec 3-4; Academia Sinica, Taipei, Taiwan. 2004. (In Chinese)
35. Bruner, A. B., Joffe, A., Duggan, A. K., Casella, J. F. and Brandt, J. : Randomised study of cognitive effects of iron supplementation in non-anaemic iron-deficient adolescent girls. *Lancet.* 1996;348:992-6.
36. Arbeit ML, Nicklas TA, Berenson GS. Considerations of dietary sodium/potassium/energy ratios of selected foods. *J Am Coll Nutr.* 1992;11(2):210-22.
37. Food Standards Agency. Babies and children [homepage on the Internet]. London: Food Standards Agency [cited 2007 May 25]. Available from: http://www.salt.gov.uk/babies_and_children.html
38. Wright JD, Wang CY, Kennedy-Stephenson J, Ervin RB. Dietary intake of ten key nutrients for public health, United States: 1999-2000. *Adv Data.* 2003;334:1-4.
39. Gowers, SG, Shore, A. Development of weight and shape concerns in the aetiology of eating disorders. *Br J Psychiat.* 2001;179:236-42
40. Markovic J, Votava-Raic A, Nikolic S. Study of eating attitudes and body image perception in the preadolescent age. *Coll Antropol.* 1998;22(1):221-32.
41. Rolland K, Farnill D, Griffiths RA. Body figure perceptions and eating attitudes among Australian schoolchildren aged 8 to 12 years. *Int J Eat Disord.* 1997;21(3):273-8.
42. Rolland K, Farnill D, Griffiths RA. Children's perceptions of their current and ideal body sizes and body mass index. *Percept Mot Skills.* 1996;82(2):651-6.
43. Lin YC. Study of the body image and dietary restraint in adolescence. Unpublished master's dissertation, Department of Home Economics Education, National Taiwan Normal University, Taiwan (R.O.C.), 1998. (in Chinese)
44. Ku CW. The relationship study between body dissatisfaction, social physique anxiety, and disordered eating on high school adolescent girls. Unpublished master's dissertation, Department of Health Education, National Taiwan Normal University, Taiwan (R.O.C.), 2003. (In Chinese)
45. Chaung YZ. The survey on eating disorders related thoughts, behaviors and their relationship with food intakes and nutritional status in high school female students. Unpublished master's dissertation, Institute of Nutritional Science, ChungShan Medical University, Taiwan (R.O.C.), 2003. (In Chinese)
46. Lien PJ. The survey on eating disorders related thoughts, behaviors and their relationship with food intakes in junior high school students. Unpublished master's dissertation, Institute of Nutritional Science, ChungShan Medical University, Taiwan (R.O.C.), 2003. (In Chinese)

Original Article

Dietary nutrient intake and major food sources: the Nutrition and Health Survey of Taiwan Elementary School Children 2001-2002

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臺灣國小學童的營養攝取狀況與食物來源

本研究的主要目的在瞭解臺灣國小學童的營養攝取狀況與食物來源。以 2001~2002 年進行的「臺灣國小學童營養健康狀況調查」中 6~12 歲學童 2386 個全國性樣本為對象，分析其二十四小時飲食回憶記錄中，不同性別、年齡及地區的國小學童，對各種營養素的攝取狀況及其食物來源。結果顯示 6~12 歲學童由三大營養素所提供的總熱量中，醣類佔 53%、脂肪佔 31%、蛋白質佔 16%；學童除了鈣嚴重攝取不足與鈉攝取過量外，各種維生素與礦物質的平均攝取量皆超過或接近「台灣膳食營養素參考攝取量」(DRIs)與其他建議標準；但是不同年齡、性別與地區，仍有一部份學童的維生素與礦物質攝取量低於 DRIs 與其他建議標準。學童的飲食型態，呈現蔬菜、水果、五穀根莖類與乳製品攝取較少；肉魚蛋豆類、鹽/湯與油脂類攝取較多。建議政府與實務工作者，應留意國小學童的營養攝取問題，並提供適當的改善措施。

關鍵字：24-小時回憶法、國小學童、食物來源、營養與健康調查、膳食營養素參考攝取量。