European Journal of Clinical Nutrition (1998) 52, 908–916

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The nutritional status and dietary pattern of Chinese adolescents, 1991 and 1993

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Objective: To increase understanding about current dietary patterns and short-term relationships between economic change and adolescent nutrition in a lower-income country, using the 1991 and 1993 China Health and Nutrition Survey data.
Design: Cross-sectional study.
Setting: Eight provinces in China that vary substantially in geography, economic development, public resources, and health indicators.
Subjects: 2236 and 2018 adolescents aged 10–18 years who completed three 24-hour recalls in the 1991 and 1993 survey, respectively.
Results: Chinese adolescents experienced an improvement of diet and nutritional status. The prevalence of stunting declined from 23% in 1991 to 19% in 1993. Under-nutrition was a problem of concern although the prevalence (12–13%) was relatively low. Overweight was emerging as a problem associated with young, high-income and urban adolescents, but the prevalence (4%) was quite low compared with developed countries. Chinese adolescents' energy and protein intakes were adequate compared with the American RDA. About 27% of the participants derived more than 30% of their dietary energy from fat and 16% of them derived over 10% of energy from saturated fat by 1993.
Conclusion: Chinese adolescents have experienced an improvement in diet and nutritional status, but under-nutrition is still an important nutrition problem, especially among young and poor groups. More attention should focus on the increase of dietary fat intake and obesity.
Source of support: Funding comes from the National Institutes of Health (R01 HD30880), the Chinese Academy of Preventive Medicine, and the National Science Foundation (grant #37486).
Descriptors: adolescent nutrition; BMI; China; dietary intake; overweight; stunting; under-nutrition

Introduction

Adolescents are defined by the World Health Organization (WHO, 1986) as persons aged 10–19 years. They comprise 20% of the global population, and about 80% of them live in developing countries (United Nations, 1997). During this important period of growth and maturation, children gain 20% and 50% of their adult height and weight, respectively (Mahan and Escott-Stump, 1996). Sexual maturation and the shift toward independence in decision making make this an important period. Body composition and dietary patterns acquired during this period are likely to be continued as adults (Rolland-Cachera *et al*, 1987, 1989; Serdula *et al*, 1993). It is important for adolescents to lay out the foundation for chronic disease prevention by the promotion and maintenance of healthful lifestyles (US Public Health Service, 1990). Therefore, for a wide variety of reasons related to the rapid physical and emotional development during this period, adolescence represents a period of peak concern.

Little attention has been paid to adolescent nutrition in developing countries. A series of studies conducted with small unrepresentative samples in Latin America and the Caribbean, sub-Saharan Africa, and Asia represent the most complete examination of this topic (International Center for Research on Women, 1994; Kurz, 1996). Girls and boys were included in seven of the eleven studies. Stunting was highly prevalent (around 50%) in nine of these studies and in all three Asian countries studied (Philippines, Nepal, and India). Current or acute under-nutrition was relatively low in most of these samples (3–13%), except in three countries. Adolescent girls were reported at a higher risk of dietary inadequacy and poorer nutritional status than boys in several countries of Asia (Waslien and Stewart, 1994). However, there is minimal understanding about adolescent dietary patterns in developing countries.

Studies from industrialized countries show that adolescents have unique dietary patterns. Adolescents may place themselves at particular nutritional risk by choosing to follow extreme eating patterns (Bull, 1988; American School Health Association *et al*, 1989; Kann *et al*, 1995; Krebs-Smith *et al*, 1996; Siega-Riz *et al*, 1998). Dieting and skipping meals are common practice among adolescents in the United States and other Western countries (McGuffin, 1983; Skinner *et al*, 1985; Bull, 1988). The prevalence of obesity among US adolescents is over 20% and still increasing (Troiano *et al*, 1995; US Department of Health and Human Services, 1997; Popkin & Udry, 1998).

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Received 30 March 1998; revised 6 July 1998; accepted 21 July 1998

Research on child nutrition in several lower and middle income countries shows that obesity is emerging as an important problem (Mo-Suwan *et al*, 1993; Mo-Suwan & Geater, 1996; Popkin *et al*, 1996). Of greatest concern are the biological and behavioral risk factors linking adolescent obesity and adult health.

China's population accounts for about one-quarter of the world population; and the 217.4 million adolescents aged 10–19 years comprise 19.2% of the nation's population (United Nations, 1997). Rapid economic development has significantly reduced physical activity among Chinese adults as well as being associated with a marked change in the structure of the adult diet and body composition (Smith, 1993; Popkin *et al*, 1993, 1995a, b; Ge *et al*, 1994; Popkin, 1994; Chen, 1996; Chen & Xu, 1996). Some national nutrition surveys show that, during the past several decades, younger Chinese children have experienced a steady increase in weight and height and also a marked shift from problems of under-nutrition to those of overweight during the past several decades (Zhang & Huang, 1988; Lin *et al*, 1992b; Popkin *et al*, 1996; Shen *et al*, 1996), but little further study about adolescent nutrition in China has been conducted.

To understand current patterns as well as short-term relationships between economic change and adolescent nutrition, we investigated the effects of gender, age, household income and residence on the nutritional status and macronutrient intakes of Chinese adolescents in a cross-sectional analysis.

Materials and methods

Survey design

The China Health and Nutrition Surveys (CHNS) are longitudinal. They cover eight provinces (Guangxi, Guizhou, Henan, Hubei, Hunan, Jiangsu, Liaoning and Shandong provinces) that vary substantially in geography, economic development, public resources and health indicators. A multistage, random-cluster process was used to draw the sample surveyed in each of the provinces. Counties in the eight provinces were initially stratified by income (low, middle and high), and a weighted sampling scheme was used to select randomly four counties in each province. Within each county, the township capital was selected, and three villages were chosen randomly. Each provincial capital and a lower income city from each province were selected. This analysis was confined to 2236 and 2018 adolescents aged 10–18 years who were surveyed in 1991 and 1993, respectively. (See either the World Wide Web site for the China Health and Nutrition Survey (http://www.cpc.unc.edu/projects/china/china_home.htmlt) or Popkin *et al* (1993) for details on the sampling.)

Anthropometric data

Measurements of weight and height were obtained from all subjects. Anthropometric measurements were carried out by trained health workers who followed standard protocol similar to the NHANES protocol developed by the National Center for Health Statistics. In addition, all interviewers had to take inter-observer reliability tests as part of the training. Weight was measured in light indoor clothing to the nearest 0.1 kg with a beam balance scale. Height was measured without shoes to the nearest 0.1 cm using a portable stadiometer. Each of these measurements was carried out by at least two health workers—one took the measurements while a second recorded the readings.

Sociodemographic data

The data concerning income and age are relevant to this analysis and special attention has been paid to them. During the household interview, questions about income were asked for all income-producing activities that each family member had engaged in. Full income from market and non-market activities, such as non-monetary government subsidies (such as food ration coupons) was recorded. According to the practice in China, both the Western and Chinese calendars were used when collecting age data, with the traditional Chinese dates later converted into Western dates.

Dietary data

Detailed household food consumption data and individual dietary intake data were collected for 3 consecutive days. The sample was randomly allocated from Monday to Sunday and almost equally balanced across the 7 days of the week from each sampling unit. Household food consumption was determined from inventory change from the beginning to the end of each day. Individual dietary intake data for the same 3 consecutive days were obtained from all family members based on a 24-h recall basis by asking each individual—except for young children, whose mothers were asked. From the household dietary data, information on the added fat (cooking oil represents a significant component of fat intake for this sample of Chinese) and other condiments was used to supplement the individual dietary intake data (Zhai *et al*, 1996). The collection of household and individual dietary intake allowed us to check the quality of each against the other. At the time of data collection, the individual and household dietary data were compared and used to identify major discrepancies. Where significant discrepancies were found, the household and the individual in question were revisited and asked about their food consumption to resolve these discrepancies.

The survey team comprised 20–23 trained nutritionists for each of the eight provinces in 1991 and 1993. They worked full time in the respective provinces and had experience in other national nutrition surveys. All interviewers were trained for 10 days (in 1991) or 8 days (1993) over a 2-week period in methods of data collection. Interviewers were required to follow a carefully developed protocol. The 1991 China Food Consumption Table (Institute of Nutrition and Food Hygiene, 1991) was used to calculate adolescent nutrient intakes from dietary data. The Chinese RDA and the American RDA for protein and energy (National Research Council, 1989) were used when evaluating macro-nutrient intakes.

Statistical analysis

Body mass index (BMI = weight/height^2) and height-for-age *Z*-scores were calculated for each individual. Stunting was defined as height-for-age below −2 s.d. (*Z*-score) from the NCHS/WHO reference median value (WHO, 1986). Under-nutrition was defined as age- and gender-specific BMI less than the 5th centile of the NCHS/WHO reference; overweight was defined as BMI 85th centile (WHO Expert Committee, 1995). The WHO-recommended BMI cut-offs are based on the National Health and Nutrition Examination Survey (NHANESI) of the United States National Center for Health Statistics, and the data were

collected between 1971 and 1974 (Must *et al*, 1991a, b; WHO Expert committee, 1995).

Tertiles of household income based on distribution were used when conducting data analysis to assess the effect of income. Adjusted prevalences of stunting, under-nutrition, and overweight were calculated controlling for covariates. When comparing differences of energy and nutrient intakes, least-squares means were calculated to control for covariates. Age was adjusted as a continuous variable, and income as two dummy variables (low income and high income). Multivariate logistic regression analysis was conducted when risk factors of stunting, under-nutrition, and overweight were estimated. All odd ratios (OR) presented were adjusted for potential confounders. Analysis was performed using SAS (version 6.12, Cary, NC, USA) and Stat (version 5.0, College Station, TX, USA).

Results

Complete anthropometric and sociodemographic data were available for 2079 and 1858 adolescents aged 10–18 years in the 1991 and 1993 surveys, respectively. Table 1 summarizes the average of height, weight and BMI of the study population surveyed in 1991 and 1993. Most results are stratified by two age groups (10–13 years and 14–18 years) based on the following considerations. The sample is inadequate to present more detailed age breakdowns. The selection of the age breakdown is based on biological and social behavior characteristics of Chinese adolescents. This sample and a number of previous studies of Chinese adolescents indicate that the average age of menarche for Chinese girls is between 13 and 14 years (Yie, 1991; Lin *et al*, 1992a; Liu, 1997). In addition, in China the transition to middle schools usually occurs at the age of 14 years.

Nutritional status

Stunting (height-for-age): Low height-for-age might be an indicator of long-term nutritional experience or growth impairment caused by malnutrition in the past, although it is argued that the major cause of short stature during adolescence is genetically late initiation of puberty (Mahan & Escott-Stump, 1996). Table 2 shows that the adjusted prevalence of stunting declined from 23% in 1991 to 19% by 1993. Logistic regression analysis found that stunting was associated with gender, age, residence and family income. In 1993, for urban residence, the adjusted OR was 0.46 (0.32, 0.64); compared with middle income, the OR was 0.70 (0.51, 0.97) for high income and 1.30 (0.98, 1.71) for low income. The interaction between gender and age was significant. The adjusted OR for young age (10–13 years) was 0.56 (0.40, 0.79) among boys, and 1.11 (0.79, 1.57) among girls. Being female was associated with increased risk ((OR = 1.45 (1.02, 2.07)) among young adolescents, but not among older adolescents (OR = 0.73 (0.52, 1.01)). The 1991 results were similar to the 1993 findings.

Table 2 Prevalence of stunting among Chinese adolescents, China Health and Nutrition Surveys, 1991 and 1993

	1991		*1993*	
	Sample	*(%)*	*Sample*	*(%)*
All	2079	23.0	1858	18.6
Gender				
Male	1063	24.5	964	18.5
Female	1016	21.5	894	18.7
Age group				
10–13 y	961	18.7[a]	913	15.9[a]
14–18 y	1118	26.0[a]	945	20.6[a]
Residence				
Rural	1592	26.7[b]	1416	21.3[b]
Urban	487	10.9[b]	442	10.0[b]
Income				
Low	692	29.2[c]	627	23.6[c]
Middle	691	23.4[d]	624	19.1[d]
High	696	16.4[cd]	607	13.1[cd]

[a,b,c,d]In each year, prevalences with the same superscripts were significantly different after controlling for other covariates (gender, age, residence, or income), $P < 0.05$.

Undernutrition (BMI < 5th centile): Adolescence is an important time for gaining weight as well as height. As shown in Table 3, the prevalence of under-nutrition was relatively low (12–13%) among the participants during 1991–1993. More boys than girls were under-nourished in both years ($P < 0.05$). In 1993, girls were at decreased risk among older adolescents (OR = 0.36 (0.22, 0.59)) but not among young adolescents (OR = 0.93 (0.67, 1.30)). The findings were similar for 1991. Approximately twice as many young adolescents (18%) as older adolescents (9%) were under-nourished. Compared with middle-income adolescents, high-income adolescents were less likely to be under-nourished. The adjusted OR was 0.70 (0.50, 0.98) in 1991 and 0.59 (0.42, 0.83) in 1993.

Overweight (BMI≥85th centile): Table 3 shows that about 4% of these adolescents were overweight or obese. The prevalence among young adolescents was much higher than that among the older group ($P < 0.05$). Results of

Table 1 Characteristics of Chinese adolescents, China Health and Nutrition Surveys, 1991 and 1993[a,b]

Year	*Age group*	*Sex*	*Sample*	*Height (cm)*	*Weight (kg)*	*BMI (kg/m²)*
1991	10–13 y	Male	495	138.8 (11.7)	32.5 (32.5)	16.7 (2.6)
		Female	466	140.6 (10.8)	33.6 (33.6)	16.9 (3.0)
	14–18 y	Male	568	161.1 (9.4)	50.3 (50.3)	19.3 (2.4)
		Female	550	153.8 (6.8)	47.3 (47.3)	20.0 (2.7)
1993	10–13 y	Male	472	141.1 (10.5)	33.9 (8.3)	16.9 (2.6)
		Female	441	141.2 (10.6)	34.4 (8.1)	17.1 (2.8)
	14–18 y	Male	492	162.6 (8.6)	51.2 (9.2)	19.2 (2.4)
		Female	453	155.1 (6.4)	47.2 (6.8)	19.6 (2.4)

[a]Values are mean (s.d.).
[b]Unadjusted values.

Table 3 Chinese adolescents' nutritional status: prevalence of underweight (%), and overweight (%), China Health and Nutrition Surveys, 1991 and 1993

	Underweight		*Overweight*	
Year	*1991*	*1993*	*1991*	*1993*
All	12.4	12.9	4.0	4.1
Gender				
Male	15.4[a]	15.1[b]	3.8	4.1
Female	9.3[a]	10.6[b]	4.2	4.0
Age group				
10–13 y	17.4[c]	18.2[d]	5.6[a]	6.4[b]
14–18 y	9.0[c]	8.9[d]	2.8[a]	2.3[b]
Residence				
Rural	12.6	12.8	3.5	3.8
Urban	11.8	13.4	5.6	4.9
Income				
Low	13.8	13.2	3.2	4.2
Middle	13.2	15.3[e]	3.2	3.2
High	10.3	10.2[e]	5.5	4.8

All the prevalences were adjusted for other covariates (gender, age, residence, or income); underweight was defined as < 5th centile of age- and gender-specific BMI cut-offs and overweight as ≥85th centile.
[a,b,c,d,e]Prevalences with the same superscripts were significantly different after controlling for other covariates (gender, age, residence, or income), $P < 0.05$.

logistic regression analysis suggest that overweight was emerging as a problem associated with being young (10–13 years), coming from high-income families, and living in urban areas. The 1991 data show that young adolescents were at increased risk (OR = 1.84 (1.18, 2.87)), and boys in urban areas or from high-income families were more likely to be overweight—the ORs were 2.12 (1.11, 4.07) relative to rural residence and 2.56 (1.25, 5.25) relative to middle income. In contrast, these associations were not significant among girls. Among rural adolescents or adolescents from low- and middle-income families, girls were at increased risk relative to boys (OR = 2.29 (1.20, 4.39)). Findings were slightly different in 1993. Young age was a stronger predictor for overweight (OR = 3.35 (2.00, 5.62)). Compared to boys, girls in urban areas were less likely to be overweight (OR = 0.22 (0.07, 0.65)), but girls from low-income families were at increased risk (OR = 2.83 (1.19, 6.74)). The greater risk for low-income girls might be part of the emergence of more problems of dietary excess among the poor in China.

Dietary patterns

In the 1991 and 1993 surveys, 2236 and 2018 adolescents had individual dietary data, respectively. The mean dietary intakes of adolescents for specific age, residence and gender groups are shown in Table 4. In general, rural adolescents ate more cereals and carbohydrate but less animal foods, total fat, saturated fat and cholesterol than urban adolescents, although their energy and protein intakes were similar. Rural adolescents derived about 70% of their energy from carbohydrates and 20–23% from fat, while urban adolescents derived only about 60% from carbohydrates and 26–29% from fat. The percentage of energy (en%) derived from fat increased by 1993 but decreased for carbohydrate.

We also estimated Chinese adolescents' nutrient intakes using the adjusted mean percentages of energy and protein intakes relative to the American RDA. Controlling for gender, age, residence and family income, Chinese

Table 4 Daily nutrient intakes, by age, residence and gender, China Health and Nutrition Surveys, 1991 and 1993[a,b]

		1991		*1993*	
Age group	*Nutrients*	*Rural*	*Urban*	*Rural*	*Urban*
10–13 y	Sample	760	246	738	231
	Energy (MJ)	9.4 (0.1)	9.1 (0.2)	8.9 (0.1)	8.8 (0.1)
	Carbohydrate (g)	374.8 (4.0)*	334.1 (7.1)*	348.6 (3.6)*	312.1 (6.5)*
	Protein (g)	64.4 (0.8)	65.9 (1.4)	62.5 (0.7)*	66.6 (1.3)*
	Fat (g)	53.9 (1.1)*	64.3 (1.9)*	53.9 (1.0)*	66.1 (1.9)*
	Saturated fat (g)	14.3 (0.4)*	17.5 (0.6)*	14.4 (0.3)*	17.6 (0.6)*
	Cholesterol (mg)	120.3 (6.2)*	211.8 (11.0)*	143.5 (6.5)*	232.4 (11.7)*
	Carbohydrate (en%)[c]	67.2 (0.3)*	61.6 (0.6)*	65.7 (0.4)*	59.4 (0.6)*
	Fat (en%)[c]	21.4 (0.3)*	26.3 (0.6)*	22.6 (0.4)*	28.0 (0.6)*
	Saturated fat (en%)[c]	5.7 (0.1)*	7.1 (0.2)*	6.0 (0.1)*	7.4 (0.2)*
	Animal food (en%)[c]	7.5 (0.3)*	12.6 (0.5)*	9.1 (0.3)*	14.9 (0.6)*
	Cereals (en%)[c]	70.0 (0.5)*	64.9 (0.8)*	68.4 (0.5)*	62.2 (0.8)*
14–18 y	Sample	945	285	798	251
	Energy (MJ)	11.3 (0.1)*	10.6 (0.2)*	10.3 (0.1)	10.0 (0.2)
	Carbohydrate (g)	459.9 (4.1)*	389.1 (7.8)*	410.8 (3.8)*	354.8 (6.9)*
	Protein (g)	76.4 (0.8)	73.8 (1.5)	72.1 (0.8)	74.3 (1.4)
	Fat (g)	60.7 (1.0)*	76.1 (1.9)*	59.9 (1.1)*	76.4 (2.0)*
	Saturated fat (g)	15.8 (0.3)*	19.7 (0.6)*	15.7 (0.4)*	20.6 (0.7)*
	Cholesterol (mg)	115.8 (5.5)*	205.8 (10.5)*	133.1 (6.2)*	227.9 (11.2)*
	Carbohydrate (en%)[c]	68.3 (0.3)*	61.5 (0.5)*	66.5 (0.3)*	59.1 (0.6)*
	Fat (en%)[c]	20.3 (0.3)*	26.9 (0.5)*	21.8 (0.3)*	28.6 (0.6)*
	Saturated fat (en%)[c]	5.2 (0.1)*	7.0 (0.2)*	5.7 (0.1)*	7.6 (0.2)*
	Animal food (en%)[c]	6.7 (0.3)*	12.8 (0.5)*	7.9 (0.3)*	14.4 (0.5)*
	Cereals (en%)[c]	72.3 (0.4)*	64.8 (0.7)*	69.7 (0.4)*	62.1 (0.8)*

[a]Values are mean (s.d.).
[b]The means were adjusted for gender, income and age.
[c]en%, percentage of dietary energy derived from the nutrient or food.
*Differences of nutrient intakes between rural and urban were significant ($P < 0.05$).

adolescents consumed about 20–35% (in the 1991 survey) and 10–24% (1993) above the RDA for energy, while female, young and rural adolescents consumed a greater amount of energy relative to the RDA than male, older and urban adolescents, respectively ($P < 0.05$). Only 2–3% of the participants consumed energy less than 2/3 of the American RDA during 1991–1993. Using the Chinese RDA for comparison, urban girls were found to consume less food energy than recommended, 1–3% less in 1991 and 5–7% less in 1993, and this varied by family income. These figures may suggest the emergence of weight consciousness and dieting among urban girls.

On average, Chinese adolescents consumed about twice as much protein as the American RDA, and their protein consumption varied by gender, age and residence. Boys consumed more protein relative to the RDA than girls ($P < 0.05$). Young adolescents consumed especially large amounts of protein. The gap between rural and urban adolescents had declined by 1993, but high-income adolescents were found to consume more protein than low- and middle-income adolescents in 1993 ($P < 0.05$). Very few adolescents (about 1%) consumed protein below 2/3 of the American RDA during 1991–1993. However, unlike the American diet, plant food is a major component of the Chinese daily diet and an important source of protein.

Table 5 shows the distribution of population by the percentages of energy derived from total fat, saturated fat and cholesterol consumption by residence and income. Marked difference by residence and income is suggested. About 23% of the participants derived more than 30% of their dietary energy (> 30 en%) from fat, and 12% derived over 10% of their energy from saturated fat in 1991; these proportions rose to 27% and 16% respectively, by 1993. In 1991, among rural adolescents, the percentage of those who had a high-fat diet (> 30 en%) rose from 8% to 29% for low-income to high-income groups; 6% to 14% for high-saturated fat intake (> 10 en%); and 4% to 18% for high cholesterol consumption (> 300 mg). A similar trend was shown among urban adolescents. In the high-income group, 56%, 28%, and 37% of the subjects had a high-fat, high-saturated fat, or high-cholesterol diet, respectively. By 1993, in general, these percentages increased relative to 1991, especially in rural areas. In high-income groups, 39% of rural adolescents and 60% of urban adolescents had a high-fat diet.

Discussion

Our principal finding is that Chinese adolescents experienced an improvement of diet and nutritional status. Chinese adolescents had relatively adequate food intakes, on average, with energy and protein intakes higher than the American RDA; the prevalence of stunting declined from 23% in 1991 to 19% by 1993; but under-nutrition is still the most important nutritional problem even though the prevalence (13%) is relatively low. However, overweight or obesity is emerging as a problem associated with young, high-income, and urban adolescents, but the prevalence (4%) is quite low compared with developed countries.

One of the difficulties in studying adolescent nutrition relates to the selection of standards. The indicators used to define overweight or obese adolescents have not been standardized. Various measures recommended include weight-for-age, weight stature indices, skinfold thicknesses, body circumference, and body mass index (BMI). BMI has been recommended as the best standard for measuring overweight among adolescents and it is widely used by most researchers (Himes & Dietz, 1994; Poskitt, 1995; WHO Expert Committee, 1995; Power *et al*, 1997). Even though it is argued that BMI does not distinguish fat body mass and lean body mass, the recommended NHCS/WHO gender-specific BMI-for-age cut-offs (WHO Expert Committee, 1995) were used as standards in our study based on the following additional considerations. (a) BMI has been found significantly correlated with body fatness in adolescents (Deurenberg *et al*, 1991; Goulding *et al*, 1996; Meisler & St Jeor, 1996). (b) For adolescents, BMI may be more nutritionally than genetically related, and therefore the choice of local versus international standards for BMI is not so crucial as it is for weight and height (Rolland-Cachera, 1993), although some researchers suggest that race-specific standards should be used (Hammer *et al*, 1991; Ellis, 1997; Ellis *et al*, 1997; Yanai *et al*, 1997). (c) Although skinfold thickness is viewed by some researchers as the best measurement of adiposity among adolescents (Sangi and

Table 5 Distribution of population by percentage of energy derived from total fat, saturated fat and cholesterol consumption, and by residence and income, China Health and Nutrition Surveys, 1991 and 1993[a]

	1991				*1993*			
	Total fat		*Saturated fat*	*Cholesterol*	*Total fat*		*Saturated fat*	*Cholesterol*
Residence/income	*< 10%*	*> 30%*	*> 10%*	*> 300 mg*	< 10%	> 30%	> 10%	*> 300 mg*
Total	9.2	22.8	12.4	14.0	9.5	26.6	15.5	17.5
Rural								
Low	16.4*	8.4*	5.6*	3.8*	18.9*	8.7*	6.1*	6.4*
Middle	11.4*	13.8*	8.5*	9.0*	10.1*	19.7*	9.5*	12.3*
High	3.6*	29.1*	14.0*	17.9*	4.9*	38.9*	23.7*	23.9*
All	11.3**	15.8**	8.8**	9.4**	12.0**	20.8**	12.1**	13.3**
Urban								
Low	5.9*	25.1*	14.6*	11.6*	3.8*	20.3*	12.3*	14.4*
Middle	3.8*	34.6*	19.3*	22.3*	1.5*	37.4*	17.7*	24.8*
High	0.9*	55.8*	28.4*	36.9*	0.5*	59.7*	37.0*	40.5*
All	2.4**	45.2**	23.8**	29.0**	1.5**	44.9**	26.1**	30.4**

[a]The distributions were adjusted for age and gender.
*Within each column, differences among low, middle, and high income were significantly different from each other ($P < 0.05$).
**The differences between rural and urban areas were significant ($P < 0.05$).

Mueller, 1991), there are many well recognized limitations of the method (Lohman, 1981; Power *et al*, 1997). (d) The advantages of using a single index throughout life are sufficient to support BMI as a good indicator of fatness at all ages (Cole, 1991).

This study found that 13% of Chinese adolescents were under-nourished, but the prevalence was as high as 18% among younger adolescents aged 10–13 years. Under-nutrition, even moderate and mild forms, has many significant adverse effects. Under-nutrition affects not only children's and adolescents' physical and mental development, but also their emotional stability and behavioral development (Pollitt, 1994; Agarwal *et al*, 1995; Brown & Sherman, 1995; Gorman, 1995; Grantham-McGregor, 1995; Wachs, 1995). However, there is minimal published research on adolescents' nutritional status in developing countries. In contrast, there is an extensive literature that documents serious under-nutrition problems among preschoolers (de Onis *et al*, 1993).

Few published nationally representative studies about under-nutrition are available for Chinese adolescents. Previous studies found that, on average, 21% of Chinese preschool children and 24% of rural preschool children were of low weight-for-age (de Onis *et al*, 1993). A 5-year monitoring project in poor rural areas in China found 24–28% of 10 000 preschool children were of low weight-for-age in the late 1980s (Chang *et al*, 1994). There is some economic evidence that there may be a widening of the income differences in China, especially between rural and urban populations, and this might exacerbate the under-nutrition situation we found (World Bank, 1995). Attention needs to be focused on this problem, especially among particular groups such as children and adolescents in poor rural areas and urban low-income groups.

However, our findings suggest that under-nutrition among Chinese adolescents is not as serious as the problem in most developing countries, especially those in Asia. Only 19% of Chinese adolescents were found to be stunted by 1993; in contrast, 47% of adolescents in Nepal (Regmi & Adhikari, 1994), 43–65% in the Philippines (Bouis *et al*, 1994; Roldan *et al*, 1994), and 32% in India (Kurz, 1996) were found stunted. The prevalence of underweight among Chinese adolescents (13%) is also lower than in some other developing countries in Asia, such as India (53%) and Nepal (36%). In contrast to other developing countries, we find that only about 1.5 times more boys were under-nourished than girls while Kurz reported that at least twice as many boys as girls were under-nourished in seven of the eight studies he reviewed. Studies from India, Nepal, Indonesia, Bangladesh, and the Philippines found that Asian girls were at increased risk of under-nutrition and mortality rates, which may be the result of their lesser access to a variety of services, lower priority for food than their male siblings, and other forms of discrimination (Waslien & Stewart, 1994). The one-child policy might lead to Chinese parents to provide more equitable care to their daughters.

In our study, 4% of adolescents were found overweight or obese, and younger (< 14 years), higher-income and urban adolescents were most likely to be overweight. As is well known, adolescent obesity has important health consequences and is a major antecedent of adult obesity (Sorensen & Sonne-Holm, 1988; Manson *et al*, 1990; Must *et al*, 1992; Williams *et al*, 1992; Guo *et al*, 1994; Lusky *et al*, 1996; Must, 1996; Srinivasan *et al*, 1996; Lake *et al*, 1997; McGill, 1997). In many industrialized countries, prevention of obesity is a public health priority with much of the concern focusing on children and adolescents (Power *et al*, 1997). Although compared with adolescents in the United States (over 20%) and many other industrialized countries (Troiano *et al*, 1995; Mahan & Escott-Stump, 1996; Popkin & Udry, 1998), the prevalence is very low, the increase of obesity among Chinese children and adolescents should be highlighted. A few small-scale surveys among Chinese school students indicate an increase of the prevalence of overweight and obesity, especially among urban adolescents. A study in Heilongjiang province found that 5% of urban school students were obese in 1991, 6% in 1992, and 15% by 1993 (Liu & Yuan, 1995). Some other nonrepresentative surveys suggest that the prevalence of overweight might have reached 6–9% in several coastal provinces in the north by the early 1990s (Fan *et al*, 1995; Wang & Liu *et al*, 1995; Liu, 1996). The prevalence we present is lower than these findings. This might be explained by different standards as well as the use of weight-for-age data, and different sampling in our eight-province urban and rural survey as compared with these much more limited surveys, mainly conducted in higher-income regions. In particular, failure to use BMI might lead to considerable misclassification.

The escalating obesity among children in China has drawn increasing attention, but little attention has been focused on adolescents. One of our previous studies shows that the prevalence of overweight among Chinese children increased to 10% by 1993 from 9% in 1991 based on the CHNS data (Popkin *et al*, 1996). It is likely that a similar situation will emerge in China among adolescents to match the large increase in obesity found among younger Chinese children (Popkin *et al*, 1996). Of great concern is that these examples may suggest, with the development of China's economy and changes of people's diet and lifestyles, that more adolescents in China will become overweight if no effective approaches are adopted in time.

Our findings suggest an increase of dietary fat intake and a decrease in consumption of grain and cereal products among Chinese adolescents, particularly among the urban, and high-income groups. We find that, on average, urban adolescents obtained 26–29% of their calories from fat and 7–8% from saturated fat (the recommended levels are 30% and 10%, respectively). Furthermore, among urban adolescents, 37% of he middle-income group and 60% of high-income adolescents had a high-fat diet by 1993. Dramatic changes in the Chinese people's diets and their nutritional habits in urban and rural areas have been well addressed (Popkin *et al*, 1993; Smith, 1993; Chen & Xu, 1996). The long-term health impact of the changes of dietary fat intake and grain and cereal consumption among Chinese adolescents needs to be highlighted in further research.

Finally, we found marked differences between urban and rural adolescents as well as among adolescents from families with different income levels regarding their dietary patterns and nutritional status, but the gap of under-nutrition between urban and rural adolescents has been narrowed. This may indicate short-term impacts of the economic transition on adolescent nutrition in China. In general, urban adolescents were of better nutritional status as they suffered from less stunting, which marked their past experience, and they were taller and heavier than their rural counterparts; but they may face more problems of obesity and other risks related to the increase of fat intake and

decrease of cereal and grain consumption. Adolescents from high-income families suffered from fewer problems of stunting as well as underweight, but from more overweight than low-income adolescents. These may suggest that nutrition-related efforts should focus on specific problems among different groups.

One limitation of this analysis is that we did not adjust for adolescents' maturational status when using the WHO-recommended BMI-for-age cut-offs to assess overweight. Ideally, sexual maturation should be adjusted for in studying the nutritional status of adolescents (de Onis & Habicht, 1996; Power *et al*, 1997). However, techniques for doing this are not well established and other studies that present national data on adolescents have ignored sexual maturation, therefore, we follow the same practice of presenting unadjusted patterns based on age- and gender-specific BMI cut-offs. A WHO Expert Committee recommended that when population estimates of maturational status were available, age-specific means or medians for anthropometry might adjust for rates of maturation that differ from the reference data (de Onis & Habicht, 1996). However, few current nationally representative data on maturational events among Chinese adolescents, particularly boys, are available, although some data suggest that the average and median ages at menarche among Chinese girls are later than that for American girls, in spite of marked changes during the past several decades and variation among girls in different areas in China (Yie, 1991; Lin *et al*, 1992a; Liu, 1997). It is known that the adiposity of adolescent males and females will increase with the onset of puberty—girls gaining more fat and boys gaining more lean tissue. Therefore, considering the possible different maturational status of Chinese adolescents, it could be the case that the prevalence of overweight among our study population has been underestimated by using the NCHS/WHO reference without adjusting for maturity.

Adolescence is an important period for a person to form dietary habits and lifestyle, and adolescents are more free to accept new information. Furthermore, adolescents have the potential to pass nutritional knowledge to their current and future families to improve their diet and health. Therefore, adolescence is an important target of nutrition education efforts. Nutritional knowledge focusing on a balanced diet of plenty of vegetables, fruits, grains, cereals, protein, and moderate amount of fat is of great interest for adolescent development and health in China.

In conclusion, based on our findings and results from previous research, Chinese adolescents have experienced an improvement of diet and nutritional status, but undernutrition is still an important nutritional problem especially among young and poor adolescents. More attention should be focused on the increase of dietary fat intake and obesity, particularly among urban and high family income groups. Nutritional education focusing on health, diet and lifestyles should be carried out on a broad basis in China.

Acknowledgements—The study was supported in part by grants from the National Institutes of Health (R01 HD30880). The China Health and Nutrition Survey data were collected under NIH funding. Collaborative training and development work has been funded by the Fogarty Center, NIH, National Science Foundation (HSF-INT-8922588 and NSF-INT-9215398), and the Ford Foundation. This article is part of a collaborative research project between the Institute of Nutrition and Food Hygiene, the Chinese Academy of Preventive Medicine, and a group from the University of North Carolina at Chapel Hill and the Carolina Population Center. We thank Frances Dancy for her administrative assistance and Lynn Igoe for her editorial assistance.

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