

ORIGINAL ARTICLE

Trends in the distribution of body mass index among Chinese adults, aged 20–45 years (1989–2000)

H Wang¹, S Du², F Zhai¹ and BM Popkin²¹Institute of Nutrition and Food Safety, Chinese Center for Disease Control and Prevention, Beijing, China and ²Carolina Population Center, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA**Objective:** To describe body mass index (BMI, in kg/m²) distribution patterns and trends among Chinese adults, aged 20–45 years (1989–2000).**Design:** A descriptive, population-based study of BMI change.**Setting:** Chinese provinces (eight in 1989 and 1997; nine in 2000), representative of the household-based surveys (the China Health and Nutrition Survey, 1989–2000) using multistage, random cluster sampling, supplemented with annual household consumption survey data of the State Statistical Bureau (SSB).**Subjects:** A total of 4527, 4507 and 4046 adults, aged 20–45 years, in 1989, 1997 and 2000, respectively.**Measurements:** BMI (underweight: BMI < 18.5 kg/m² and overweight: BMI ≥ 25 kg/m²). Percentile curves for BMI in 1989 and 2000 were constructed by gender and age using the LMS (lambda, mu, sigma) method.**Results:** Compared with 1989, the 2000 BMI distribution curves flattened at higher levels of BMI (men and women). There was a 13.7% increase in the proportion of men and a 7.9% increase of women who were overweight or obese with a resulting greater change in the annualized prevalence rate for men. This increase in the prevalence of overweight and obesity was far greater than the decrease (2.1% for men; 2.2% for women) in that of underweight. Age-gender-specific percentile curves showed BMI increases mainly among women, aged 35–45 years, and among men at all age groups.**Conclusions:** Chinese BMI dynamics show much greater rates of change among men, aged 20–45 years, than among women, with the increase among women concentrated between ages 35 and 45 years. These changes portend large shifts in other diet-related non-communicable diseases in China over the following decades. Controlling the increasing trends of BMI, especially in men, is an important public health problem facing China.*International Journal of Obesity* (2007) 31, 272–278. doi:10.1038/sj.ijo.0803416; published online 20 June 2006**Keywords:** China; adults; body mass index; overweight; nutrition transition

Introduction

Rapid socio-economic, demographic, nutritional and health changes have occurred in China during the past 15 years.^{1,2} China's economy has grown at an annual 8% gross domestic product increase over the past two decades.³ The proportion of the population residing in urban areas has grown equally rapidly.⁴ Technological shifts have reduced physical activity at work and leisure; diets have also been transformed.² Urban-rural economic differences are shown in Figure 1, where the Engle's coefficient – or the proportion of income

expended on food – is much lower in urban areas and incomes are greater.⁴

Dietary patterns have predominantly changed in composition, with traditional high-carbohydrate diets being replaced by diets higher in fat.^{2,5} At the same time, technological changes in work, travel to work and leisure are personified by large reductions in heavy work and large increases in TV ownership.^{6,7} Moreover, these point toward a change in the long-term positive energy balance with accompanying fat deposition and weight gain occurring in the Chinese population. Many studies have documented the weight gain, the increases in overweight and obesity (BMI ≥ 25 kg/m²), and the greater risk of diet-related non-communicable diseases among adults in China in the past 10 years.^{2,5,8–10}

This paper focuses on an examination of shifts in the overall distribution of BMI, while also examining obesity trends. At the same time, we describe the trends of important factors associated with the trends of BMI distribution; for

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example, the trends of food consumption, physical activity and TV ownership in China.

Subjects and methods

Data and study populations

Analysis was based on data of the longitudinal China Health and Nutrition Surveys (CHNS) conducted in 1989, 1997 and 2000. A multistage random-cluster sampling process was used. The survey design was to select a subset of eight of 31 provinces in the mainland of China that varied considerably in their stage of economic development. Data from eight provinces in 1989, 1997 and nine provinces in 2000 were used. Four counties and two cities were selected within each of the provinces. Neighborhoods were randomly selected from cities, suburbs, townships and villages; 20 randomly selected households were targeted within each neighborhood. Although CHNS was not nationally representative, its previous findings regarding trends in diet patterns and body composition were similar to the national cross-sectional surveys.^{5,11}

This study focuses on adults, aged 20–45 years, as this was the only adult group with anthropometric data collected in the initial 1989 survey. This analysis utilizes three cross-sections of this age group of adults in 1989, 1997 and 2000 (Table 1). The total sample of 4527 (2101 men and 2426 women), 4507 (2171 men and 2336 women) and 4046 (1933 men and 2113 women) adults, aged 20–45 years, had their weight and height measured in 1989, 1997 and 2000, respectively.

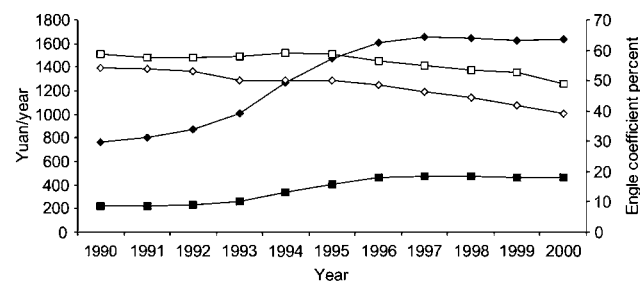


Figure 1 Trends in per capita annual income and Engel's coefficients in China (—◆—annual income of urban households, —■—annual income of rural households, —◇—Engel's coefficient of urban, —□—Engel's coefficient of rural). *Engel's coefficients are the proportion of expenditures spent on food.

Table 1 Number of subjects and their distributions between urban and rural areas, adults aged 20–45 years (1989–2000)

Year	Men			Women			Total		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
1989	662 (31.5%)	1439 (68.5%)	2101	765 (31.5%)	1661 (68.5%)	2426	1427 (31.5%)	3100 (68.5%)	4527
1997	635 (29.3%)	1536 (70.7%)	2171	694 (29.7%)	1642 (70.3%)	2336	1329 (29.5%)	3178 (70.5%)	4507
2000	550 (28.5%)	1383 (71.5%)	1933	617 (29.2%)	1496 (70.8%)	2113	1167 (28.8%)	2879 (71.2%)	4046

Measures and statistical analysis

The main variables measured were the subjects' weight, height, gender, age and urban–rural status. Anthropometrical measurements were conducted by well-trained health workers who followed a reference protocol recommended by the World Health Organization (WHO).^{12,13} Weight was measured to the nearest 0.01 kg with a balance-beam scale, while the subjects were wearing lightweight clothing. Height was measured to the nearest 0.10 cm with a portable stadiometer, while the subjects were barefoot. Further details about the CHNS have been published.^{14,15} Body composition was estimated by determining the subjects' BMI. All analyses were stratified by gender. First, we described the trends of BMI distribution curves in men and women using the WHO defined cutoff points to classify participants into underweight (BMI < 18.5 kg/m²), normal (BMI: 18.5–24.95 kg/m²) and overweight or obese (BMI ≥ 25 kg/m²).¹⁶

Percentile curves were then constructed for BMI values in 1989 and 2000, by gender, using the LMS (lambda, mu, sigma) method.¹⁷ This method summarizes the data in terms of three smooth age-specific curves called L (lambda), M (mu) and S (sigma). The M and S curves correspond to the median and coefficient of variation of BMI at each age, whereas the L curve allows for the substantial age-dependent skewness in the distribution of BMI.^{18,19} The values for L, M and S can be tabulated for a series of ages. This method provides a smooth and understandable BMI percentile curve.

Last, we used the data of the Chinese State Statistical Bureau (SSB) to describe the trends of main factors associated with the change of BMI distribution in China (e.g., TV ownership, the change of occupation and the change of food consumption patterns).

Results

Trends of BMI distribution among men and women in 1989 and 2000

The shape of the BMI distribution curves among men and women changed over the 11-year period, 1989–2000 (Figure 2). The main characteristics of the changes were the shift in the curves (man and woman) to the right between 1989 and 2000. The mean BMI increased from 21.3 to 22.4 kg/m² for men and from 21.8 to 22.4 kg/m² for women. The dispersion of the BMI distributions was also greater

during this period. The standard deviation increased from 2.3 to 3.1 for men and from 2.7 to 3.2 for women. Comparing the changes of BMI distribution curves (men and women) from 1989 to 2000 reveals (a) the mean of BMI for women was significantly higher than for men in 1989 ($P < 0.0001$) and (b) the difference of BMI distribution between genders disappeared in 2000 ($P = 0.29$), because the rate of change for men was significantly faster than for women.

Trends of underweight and overweight among men and women in 1989, 1997 and 2000

BMI distribution curves for men and women leveled off in the midrange of BMI at higher levels of BMI (Figure 2). This phenomenon implied that the increase in overweight for men and women was greater than the decrease in underweight. This observation is clearly shown in the comparison of underweight, normal weight and overweight proportions for these years (Table 2).

Income, education, activity level and food consumption patterns were largely different between urban and rural populations in China, which should cause important differences in the body composition trends of the Chinese population. We divided the population into urban and rural groups. Table 2 shows the change in the nutrition status (i.e., underweight, normal and overweight) of men and women in urban and rural areas from 1989 to 2000. The proportion of underweight among men decreased 5.1 and 0.9% in urban and rural areas, respectively, and decreased 1.9 and 2.2% among women in urban and rural areas, respectively. The overall proportion of underweight (man, woman, rural and urban) was 6.5% in 2000. Conversely, the proportion of overweight or obesity among men increased 21.9% (from 10.1 to 32%) and 10.8% (from 4.7 to 15.5%) in urban and rural areas, respectively – an increase of more than threefold over the 11-year period – and the difference between urban and rural areas increased 11.1% (from 5.4% in 1989 to 16.5% in 2000). In women, the prevalence of overweight obesity

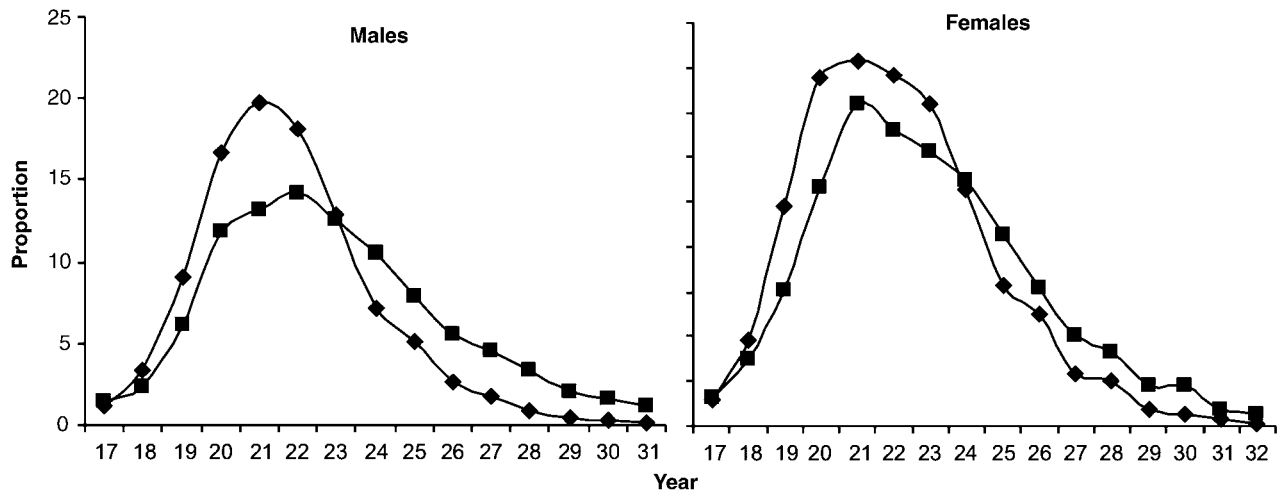


Figure 2 Shifts in the BMI distribution for Chinese men and women aged 20–45 years, 1989–2000 (—◆—1989, —■—2000).

Table 2 Nutrition status of men and women (adults aged 20–45 years) in different areas from 1989 to 2000

Year	Nutrition status	Men			Women			Total		
		Urban (%)	Rural (%)	Total (%)	Urban (%)	Rural (%)	Total (%)	Urban (%)	Rural (%)	Total (%)
1989	Underweight	10.7	7.4	8.4 ^a	9.8	8.4	8.9 ^a	10.2 ^b	7.9 ^b	8.7
	Normal	79.2	87.9	85.1 ^a	76.2	81.3	79.7 ^a	77.6 ^b	84.4 ^b	82.2
	Overweight	10.1	4.7	6.5 ^a	14	10.2	11.4 ^a	12.2 ^b	7.7 ^b	9.1
1997	Underweight	6.8	6.2	6.4	6.5	5.9	6	6.6 ^c	6.0 ^c	6.2
	Normal	70.4	82.9	79.2	75.4	78.4	77.3	73.0 ^c	80.6 ^c	78.2
	Overweight	22.8	10.9	14.4	18.2	15.8	16.7	20.4 ^c	13.4 ^c	15.6
2000	Underweight	5.6	6.5	6.3	7.9	6.2	6.7	6.9 ^d	6.4 ^d	6.5
	Normal	62.4	78	73.5	72.1	74.8	74	67.5 ^d	76.3 ^d	73.8
	Overweight	32	15.5	20.2	20	19	19.3	25.6 ^d	17.3 ^d	19.7

^aSignificant difference between men and women in 1989 ($P < 0.001$). ^bSignificant difference between urban and rural in 1989 ($P < 0.001$). ^cSignificant difference between urban and rural in 1997 ($P < 0.001$). ^dSignificant difference between urban and rural in 2000 ($P < 0.001$).

increased 6.0 and 8.8% in urban and rural areas, respectively, between 1989 and 2000. From 1989 to 1997, the proportion of underweight adults, aged 20–45 years, dropped 2.5%. Concurrently, although the proportions of obesity (defined as BMI ≥ 30 kg/m²) were very low in both men and women, there was a 13.7% (6.5–20.2%; a threefold increase) increase in the proportion of men and a 7.9% (11.4–19.3%) increase in the proportion of women who were overweight or obese.

Annual changes in nutritional status

Moreover, the annual increase in the prevalence of overweight and obesity in men was greater than in women. In men (total), the annual increase was 1.3% but was only 0.7% for women (total) from 1989 to 2000. The nutrition status of men was significantly different from that of women in 1989; however, the difference disappeared in 1997 and 2000. In men, there was an accelerated trend of increased prevalence

of overweight and obesity. The average annual increase of the prevalence of overweight and obese men increased 1% over the 8-year period (1989–1997) and nearly 2% over the 3-year period (1997–2000). In women, the average annual increased prevalence for overweight and obese was stable at 0.6% over this 11-year period (1989–2000) in urban areas. It also showed an accelerated trend for overweight or obese women in rural areas, increased from 0.7% (1989 to 1997) to 1.1% (1997 to 2000), much higher than that in urban areas of 0.5% (1989–1997) to 0.6% (1997–2000) (Table 3).

Shifts in the 15th, 50th and 85th percentile BMI curves (1989 and 2000)

Figure 3 shows the 15th, 50th and 85th percentile BMI curves constructed using the LMS method for the years 1989 and 2000, by gender and age. The curves, from bottom to top (black-filled: 1989; white-filled: 2000), are the

Table 3 Annual Changes in nutritional status of men and women (adults aged 20–45 years) in different areas from 1989 to 2000

Year	Nutrition status	Men			Women			Total		
		Urban (%)	Rural (%)	Total (%)	Urban (%)	Rural (%)	Total (%)	Urban (%)	Rural (%)	Total (%)
Annual change (1989–1997) ^a	Underweight	-0.5**	-0.2**	-0.3**	-0.4*	-0.3**	-0.4**	-0.5**	-0.2**	-0.3**
	Normal	-1.1**	-0.6**	-0.7**	-0.1*	-0.4**	-0.2**	-0.6**	-0.5**	-0.5**
	Overweight	1.6**	0.8**	1.0**	0.5*	0.7**	0.6**	1.1**	0.7**	0.8*
Annual change (1997–2000) ^a	Underweight	-0.4**	0.1**	-0.03**	0.5	0.1*	0.2*	0.1*	0.1**	0.1**
	Normal	-2.7**	-1.6**	-1.9**	-1.1	-1.2*	-1.1*	-1.8*	-1.4**	-1.3**
	Overweight	3.1**	1.5**	1.9**	0.6	1.1*	0.9*	1.7*	1.3**	1.2**
Annual change (1989–2000) ^a	Underweight	-2.7**	-0.1**	-0.2**	-0.2*	-0.2**	-0.2**	-0.3**	-0.1**	-0.2**
	Normal	-1.5**	-0.9**	-1.1**	-0.4*	-0.6**	-0.5**	-0.9**	-0.7**	-0.7**
	Overweight	2.0**	1.0**	1.3**	0.6*	0.8**	0.7**	1.2**	0.8**	0.9**

^aSignificant change between years. **P*<0.05, ***P*<0.001.

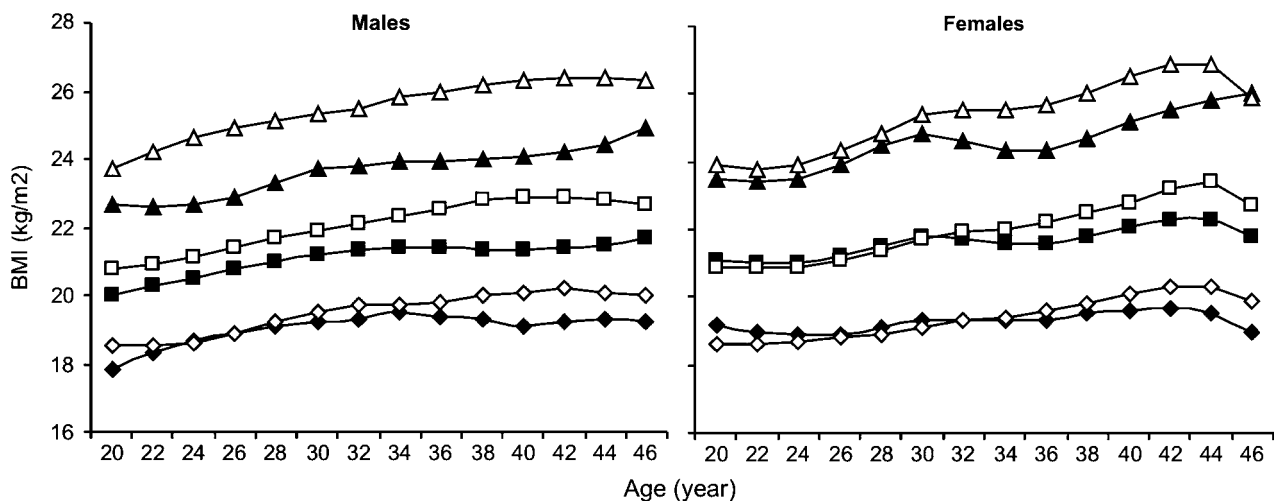


Figure 3 Shifts in the BMI percentile curves for Chinese men and women aged 20–45 years, 1989–2000* (—◆—15 (1989), —■—50 (1989), —▲—85 (1989), —◇—15 (2000), —□—50 (2000), —△—85 (2000)). * Modeled with the LSM technique.

15th, 50th and 85th percentile curves, respectively. For men, the 15th, 50th and 85th percentile curves show increasing trends from 1989 to 2000, except the 15th percentile curve for those younger than 35 years. The levels increased more at higher percentile levels. Age did matter for men; in the same percentile curve, for example, in the 15th or 50th percentile curves, the part of the curves – which correspond to men older than 35 years – increased more than the part corresponding to younger men.

For women, all three BMI percentile curves in the age group younger than 35 years were stable over the 11-year period (1989–2000). The 15th, 50th and 85th percentile curves show the increasing trends from 1989 to 2000 only in the age group older than 35 years. Moreover, the increased levels of the high percentile curves (e.g., the 85th percentile) were greater than the levels of the low percentiles (e.g., the 15th percentile). Comparing the changes of the percentile curves of women with that of men, we can see that the BMI percentile curves of women were more stable than those of men. For each percentile curve, the changes in women were less than in men.

Food consumption changes

The food supply improved quickly and diverse foods became available with the development of economic policies and a series of food policies inaugurated in the beginning of the 1980s. These changes also provided the basis of the food consumption and dietary pattern shifts of the Chinese population in the past two decades.^{1,5} The Chinese SSB, using the per capita data from the annual household survey series in China, provided data about food consumption in China (Figure 4). Cereal consumption declined slowly in urban and rural areas from 1981 to 2001. In urban areas, cereal consumption declined from 145.4 to 79.7 kg/capita/year, and in rural areas, raw cereal consumption declined from 256.0 to 238.0 kg/capita/year. The consumption of fresh vegetables stabilized in these years at 110–130 kg/capita/year in urban and rural areas. At the same time, the consumption of animal foods, including meat and meat

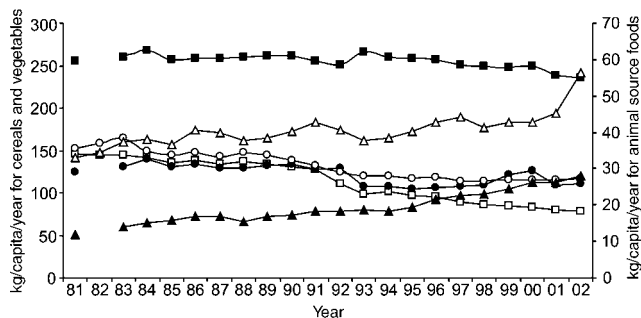


Figure 4 Chinese household food consumption trends (kg/capita/year) (—□—urban cereals, —■—rural raw cereals, —●—rural vegetable, —○—urban vegetable, —△—urban animal source foods, —▲—rural animal source foods).

products, poultry and poultry products, milk and milk products, eggs and egg products, fish, shellfish and mollusk, increased 12.2 and 14.3 kg/capita/year from 1981 to 2001 in urban and rural areas, respectively. Meat and eggs were the main animal food sources in China. The CHNS data showed similar changes in food consumption between 1989 and 2000.⁵ The food consumption pattern of the Chinese population was shifting from the traditional pattern – characterized by the consumption of rice, wheat and wheat products – toward high animal food consumption. Moreover, the food consumption pattern changes in the urban population were larger than in the rural population.

Physical activity and TV ownership

Activity levels and the proportion of TV ownership were used to measure the changes in daily physical activities of the population. The SSB data provide the information of the long-term trends of occupations proportion. Occupations were divided according to the categories (Figure 5). It shows the proportion of persons engaged in agriculture, forestry and fishing decreased 33 percentage points from 1952 to 2000. At the same time, the proportion of the persons engaged in industry and service occupations increased 15.1 and 18.4%, respectively.^{1,4}

Moreover, large changes in workplace technology decreased the energy expenditure required at work. The CHNS data also show that the proportion of persons engaged in light or medium activity increased 7.6 percentage points and 6.3 percentage points from 1989 to 2000, respectively.

TV utilization represents a potential source of inactivity. TV ownership increased considerably in the past 20 years. The CHNS data also provided information about the increasing TV ownership in China. In urban areas, 88.2% of households owned a TV set in 1989 and increased to 96.4% in 2000. In rural areas, the proportion increased from 52.5 to 89.0% in the same period. The report of the SSB showed the number of color TVs in 100 households increased from 17.21 to 116.56 in urban areas and from 0.8 to 48.74 in rural areas from 1985 to 2000.^{1,4}

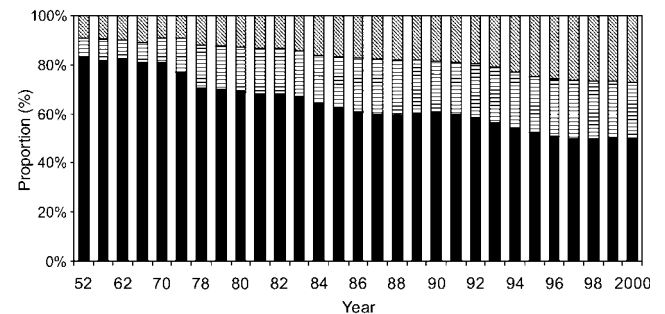


Figure 5 Shifts in the proportion of Chinese adults in different occupation categories from 1952 to 2002 (■, farming, fishing and forestry; ▨, industry; ▩, service).

Discussion

Body composition shifts in China are having major health implications in terms of shifts in the prevalence of nutrition-related noncommunicable diseases (NR-NCDs) and increased medical care costs.^{5,10} This study shows a faster rate of increase in overweight of urban Chinese, especially among men. The decline in underweight status has also been faster among men. The LMS method was used to construct 15th, 50th and 85th percentile curves that show – across the full age distribution and at all percentiles – that BMI increased more in men than in women. Furthermore, there were larger increases at the 85th percentile than lower percentiles. The 15th, 50th and 85th percentile curves of men, older than 35 years, increased more than younger men.

There is the possibility that the gender-related body composition changes in China may be different than most other countries.^{20–22} Not only were the body composition shifts across all ages and percentiles greater in men, between 1989 and 2000, but also the annualized rate of change in prevalence was faster in men. Interestingly, the trends were reversed and overweight increased faster in women than in men in the 1980s.^{11,23} This may relate to higher levels of market and home production work among Chinese women. For instance, there is evidence, in rural areas, that women work in more strenuous occupations, are more likely to work multiple jobs and are also undertaking the bulk of housework in the home.^{24,25}

The increase in BMI among women aged 35 years and older, but not among younger women, requires further research to understand; there is the possibility that a focus on thinness might explain part of this shift. Another hypothesis to be explored relates to the types of shifts in energy expenditures for women at work. There might be important age-related employment and occupational patterns that can explain this issue.

Urban men became the population sector with the highest prevalence of overweight and obesity among the four groups (rural men, rural women, urban men and rural women) because of the large increase from 1989 to 2000. Although the prevalence of overweight and obesity in rural men remained the lowest of the four groups in 2000, the rapidly increasing rate of prevalence in this group is sufficient to deserve increased attention. The prevalence of overweight and obesity in rural women increased faster than urban women. Our findings provide further evidence that increased income might have affected diets and body composition in a detrimental manner to health, with those in low-income groups having the largest increase in detrimental effects owing to increased income.

Our research has indicated that the rate of change in dietary intake toward a more energy-dense diet may be increasing in China, particularly among the poor,²⁶ but it is less clear for the changes in activity levels. Increases in TV viewing and automobile ownership are accelerating in

China and may be indicative of more rapid shifts in activity levels.

Studies in China have carefully documented the dietary and activity changes and their effects on obesity patterns and have shown both dietary and activity shifts are equally important in explaining these trends.^{6,8,15,23,27} The patterns of diet and activity presented here are not discussed in detail in this paper and it is necessary to investigate the longitudinal literature on these various shifts in diet and activity to further understand these issues. This study has demonstrated that there is clearly an increase in the rate of change in overweight status in China.

The health-care costs of these changes in China are enormous with medical expenditures skyrocketing and many experts predicting increases in overall mortality related to obesity and its comorbidities.^{5,28} Research in China has documented major shifts in adult onset diabetes, hypertension, stroke, heart disease and cancer. To date, little systematic work has been carried out nationally to address the key issues related to energy imbalance and poor diets that face China. The key dietary components include huge increase in edible oil intake, large increases in animal source food intake and declines in complex carbohydrates, fruits and vegetables.² New initiatives being contemplated include a program to reduce intake of edible oil and find ways to increase activity patterns.

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