

Growing fat on reform – obesity and nutritional disparities among China’s children, 1979-2005

Stephen L. Morgan*

Forthcoming in *The China Quarterly*, 2014

This is the Author Original submitted for the second round review in 2013 and subsequently accepted. It will undergo editorial revisions and formatting for final publication. Readers should consult the *The China Quarterly* journal site at Cambridge Journals Online for the Version of Record with issue number and pagination. The web site is:

<http://journals.cambridge.org/action/displayJournal?jid=CQY>

* Stephen L. Morgan is Professor of Chinese Economic History at the School of Contemporary Chinese Studies, University of Nottingham, UK; Dean of Social Sciences, the University of Nottingham Ningbo China, Ningbo, PRC; and Honorary Fellow, School of Historical and Philosophical Studies, University of Melbourne, Australia. He researches Chinese economic and business development from the eighteenth century to the present.

© Stephen L Morgan, 2013

Keywords: China, nutrition, obesity, inequality, economic development

Growing fat on reform – obesity and nutritional disparities among China’s children, 1979-2005

<authors>

Abstract

Economic growth over the past three decades has greatly improved nutrition and the standard of living of the Chinese. Increasingly, though, the Chinese are becoming heavier. As many as a quarter of Chinese school-age urban boys are overweight or obese, yet a third of Chinese children remain underweight. Drawing on six national surveys of children’s health conducted since 1979, the article reports the trends in nutritional status and regional disparities. We show the drivers for the increase in mean body mass and in nutritional inequality are associated with rising household incomes and associated inequalities between provinces.

Acknowledgements: Comments and suggestions are gratefully acknowledged from two anonymous referees and participants at seminars or conferences at the Australian National University, University of Nottingham, Oxford University, University of South Australia and others via email.

Introduction

Chinese children are better fed, taller and heavier than they were in the past. That is a welcome development. But an increasing number of children are overweight and even obese, especially among those in the affluent cities of East China. As many as one-quarter of 7-18 year-old urban boys were found to be overweight or obese in a 2005 national survey of Chinese school children's health.¹ Leading Chinese nutritional researchers have labeled the "alarming increase" in the prevalence of overweight and obesity in China an "epidemic" and "public health crisis."² The increased prevalence of overweight and obesity among China's children, however, serves to highlight the persistence of high levels of poor nutrition. Up to one-third of school age children and youth are underweight, a level that has barely changed during more than three decades of rapid economic growth. Poor nutrition continues to result in low weight-for-age and the stunting (low height-for-age) of many Chinese children, with profound long-term consequences for health and economic productivity.

The rapid rise in overweight and obesity in China has captured the headlines.³ The more disturbing issue for a State that has espoused the aspiration of making China a "relatively well-off" (xiaokang 小康) society is the increase in the disparities in nutritional status. The article draws on data from national surveys of China's school

¹ Zhongguo xuesheng tizhi 2007, 90. Analysed below in detail.

² Ji and Cheng 2008; Ji and Cheng 2009.

³ The western press has carried many reports about increased overweight and obesity in China, highlighting such initiatives as "fat camps" for children and youth to work off their excess weight. A popular analysis is French 2010. He notes the consequences for health care of increased longevity coupled with obesity: the former is good news, while the latter foreshadows a huge rise in chronic illness and spiraling health costs.

age children conducted between 1979 and 2005. These data show not only a marked increase in the mean weight of children and their average body mass, but also an increase in the relative proportion of children in the upper part of the weight distribution, which varies widely between the provinces. In other words, the dispersion in mean weight has increased as revealed in the rise in the coefficient of variation, a simple measure of inequality.⁴ The maximum weights for each age group have increased faster still. In between, those who are of normal weight have become fewer.

These changes in nutritional status can be attributed to various factors, including the uneven share in the benefits of economic reform. Higher income and the huge change in the socioeconomic environment of China have combined to create what many see as an “obesogenic environment” – greater consumption of energy-dense foods, fewer opportunities for physical leisure and a general trend towards an increased sedentary lifestyle.⁵ A consequence of increased weight is higher morbidity and higher prevalence of preventable diet-related diseases, which will increase future private and public health expenditure.⁶ Meanwhile, economic development has failed some of the most vulnerable children in central and western provinces. In these provinces nutrition availability is less and often inadequate; access to education is constrained in various ways; and life expectancy at birth is lower than those in East China.⁷ The nutritional disparities we discuss in this article are but part of a kaleidoscope of disparities found

⁴ The coefficient of variation is the ratio of standard deviation to the mean. It is a normalized measure of the dispersion of observations relative to the mean.

⁵ James 2008; Gorin and Crane 2009.

⁶ Hu, Liu, and Willett 2011.

⁷ Morgan and Su 2011.

in contemporary China. The stark regional differences in nutritional status across China and the increasing inequality in nutritional status over time we argued are primarily driven by differences in household income and associated lifestyle changes, such as increased food consumption and a more sedentary life.

In the next section, we outline the background to the emerging problem of overweight and obesity in China, which China shares with both developed and developing countries. The third section discusses the data and summarises the national trends, which is followed by an analysis of provincial and regional variations in body weight and mass. The final section identifies potential factors driving the shift in nutritional status and summarises the findings and implications for public health.

Background to nutritional variance in China

Centuries of widespread hunger and frequent famines mean the recent improvements in food security are most welcomed in China. A little over half a century ago China experienced the worse famine in human history, at least in aggregate lost of life.⁸

Chronic under-nutrition was the norm at the start of economic reform in the late 1970s when the per capita availability of grain was about the same as on the eve of the Great Leap Forward (1958-60).⁹ So the nutritional shift among the Chinese is astonishing, from a state of chronic under-nutrition and a population that was lean, to the present state of abundant or over-nutrition for many, with an increasing prevalence of

⁸ A mid-range estimate of the excess deaths is 30 million people. There is a large literature on the topic, but for recent critical assessments, see O Gráda 2008, 2009.

⁹ Lardy 1983; Riskin 1986; Bramall 2008.

overweight and obesity. An editorial in the British Medical Journal asserted, “one fifth of the one billion overweight or obese people in the world are Chinese.”¹⁰ The estimate was derived from the 2002 nutrition and health survey that found 14.7 percent of Chinese were overweight (a body mass index or BMI 25-29.9 – a total of 184 million) and 2.6 percent obese (BMI greater than 30 – a total of 31 million), for an estimated combined overweight and obese population of 215 million, based on World Health Organisation (WHO) standards. But other researchers have criticized such extrapolations from surveys.¹¹ Although the prevalence is less than in the United States, where one in three are obese, China is predicted to catch up rapidly.¹² Numerous studies report the increase in weight among the Chinese, even in rural areas. A recent study of 16,344 Shandong rural residents found that 35 percent were overweight and 15 percent obese.¹³

China is not alone among developing countries. Overweight and obesity has been increasing across the world in rich nations and poor alike, according to the WHO.¹⁴ The progress in our escape from hunger over the past century has come “not without a

¹⁰ Wu 2006.

¹¹ The extrapolation neglects disparate regional variation in China. Ji and Cheng 2008 argued two types of errors are common in estimating the prevalence of obesity. The first is under-estimation using the WHO cut-off instead of the adjusted Chinese cut-off, and the second, over-estimation from extrapolating urban samples to the rest of China.

¹² Morrill and Chinn 2004; Komlos and Brabec 2011; Levine 2007; Popkin 2010.

¹³ Ma, Meng, Yu, Xu, Fan, Lu and Li 2009.

¹⁴ WHO 2000, 2004; Popkin 2001, 2011; Popkin, Lu and Zhai 2002; Rigby, Kumanyika and James 2004;

major cost – in both health and economic terms – of global obesity.”¹⁵ The primary driver of the change is socioeconomic rather than individual behavior.¹⁶ Transition to western urbanised lifestyles in China, India and elsewhere result in higher calorie intake and lower levels of physical activity. In urban China average daily energy needs have declined 400-800 kcal, “so weight gain and obesity are inevitable for most of the population.”¹⁷ Excess weight is an indicator of increased potential morbidity rather than an actual illness. It raises the likelihood of preventable chronic diseases, such as cardiovascular diseases (CVDs) and type-2 diabetes. Non-communicable diseases in China account for more than two-thirds of all deaths, with CVDs the most common cause of death.¹⁸ Type-2 diabetes affected 92 million (7 percent) in 2008, and is expected to double in next decade.¹⁹ The increase in CVDs and diabetes has

¹⁵ Popkin 2009, 3.

¹⁶ People are becoming fatter everywhere not because of a sudden loss of willpower or turn to gluttony, argues Popkin 2009, but because of changes in how we work, we play, and the supply chain for food, which over the past century has increased the variety of foods, changed the composition of food energy through processing, and reduced the relative price of calories. We need to recognize nevertheless that the medicalisation of fat and obesity is a contested terrain. See Gilman 2008.

¹⁷ James 2008.

¹⁸ The leading single cause of death in China is malignant tumors (cancers), which account for 169.2 deaths per 100,000 in urban areas (169.5 in rural areas) in 2010, but CVDs are the major cause of death in China as in the rest of the world. CVDs comprise disorders including heart diseases and cerebrovascular: heart diseases in China account for 154.8 deaths per 100,000 in urban areas (163.1 in rural areas) and cerebrovascular diseases account for 143.5 deaths per 100,000 in urban areas (203.3 in rural areas). NBS, 2011, Table 21-18 and 21-19. WHO, 2013.

¹⁹ Hu, Liu, and Willett 2011. A recent study estimated in 2010 there were 113.9 million with diabetes and 493.4 million were prediabetic. Yu et al 2013.

huge economic implications. CVDs have been estimated to consume 4 percent of China's GDP, which will double by 2025 unless there is intervention, while diabetic patients are 3.5 times more costly to treat than the non-diabetic.²⁰ Obesity and nutrition-related non-communicable diseases are “the largest health-related costs” China and India will face within the next 15 years.²¹ One of the means to contain escalation of future health costs is to control the increase in overweight and obesity among children. Fat children are more likely to become fat and illness-prone adults, thus obesity in childhood is a predictor of many illnesses in later life.²²

The most widely used measure for body fat is the BMI indicator, the weight in kilograms divided by the height in metres (kg/m^2). A measure of body weight adjusted for height, BMI correlates highly with the percentage of body fat and is largely independent of height. It is easy and inexpensive to calculate, and is “an acceptable proxy for thinness and fatness, and has been directly related to health risks and death rates in many populations.”²³ The WHO international standard specifies the normal BMI for adults is between $18.5 \text{ kg}/\text{m}^2$ and $25 \text{ kg}/\text{m}^2$ (15th-85th percentile), overweight $25\text{-}29.9 \text{ kg}/\text{m}^2$ (85-95th percentile) and obese greater than $30 \text{ kg}/\text{m}^2$ (above the 95th percentile). For children, the BMI cut-off points are lower and differ

²⁰ Hu, Liu, and Willett 2011; Zhao, Zhai, Hu, Wang, Yang, Kong, and Chen 2008.

²¹ Popkin 2009, 114.

²² Hu, Liu, and Willett 2011; Ji, Working Group on Obesity in China (WGOC) 2005. In children, excess calories produce new fat cells, whereas in adults excess calories expand existing fat cells, therefore obese children find it harder to lose weight as adults since dieting and exercise merely reduces the size of fat cells, but does not eliminate them.

²³ WHO Expert Consultation Group 2004.

according to age.²⁴ Hereafter the BMI units will be dropped. The WHO international scheme however underestimates the percentage of body fat in Asian populations relative to Europeans. Asian populations show higher risk factors for diabetes and CVDs at BMI less than 25. In 2004, the WHO expert consultation group recommended lower BMI cut-off points for Asian populations of 23, 27.5, 32.5 and 37.5.²⁵ The Working Group on Obesity in China (WGOC) defined BMI 24 and 28 as the cut-offs for overweight and obesity respectively for Chinese males and females older than 18 years, and produced an adjusted sex-age-specific cut-offs for children.²⁶

In this article we use height, weight and BMI to analyse the changes in nutritional status and well being of Chinese. Weight in kilograms and BMI are measures of the current nutritional status of a person. These can change quickly, for example, from transient nutritional shocks such as illness. Height in centimetres is a historical measure of net nutrition of a person during their growth from *in utero* to adulthood, or to the time of measurement for a child. It is a complex trade off between a person's gene endowment and available nutrition after allowance for body metabolism, disease and physical activity.²⁷ Other things held constant, the mean height of a population is a robust measure of both the availability and distribution in a society of nutrition resources; it is highly correlated with secular trends in income and economic

²⁴ The cut-off points for children by year and month are in the WHO 2007 growth reference: http://www.who.int/growthref/who2007_bmi_for_age/en/ (accessed 10 Oct 2011). The cutoff for selected ages is shown in Table 3.

²⁵ WHO Expert Consultation Group 2004.

²⁶ Ji and Working Group on Obesity in China 2005; Wu 2006.

²⁷ Human growth and background to the anthropometric approach can be found in Eveleth and Tanner 1990; Steckel 1995; Steckel and Floud 1997; Bogin 1999.

disparities, as well as morbidity and mortality.²⁸ Severe nutritional shocks or persistent chronic under nutrition on a regional or societal scale will lead to a decline in the mean height of a population or subgroup. Conversely, when average nutrition improves the mean height will rise. This pattern makes height a useful proxy for human welfare in the past for periods where conventional economic data for income are lacking, including studies of China and Taiwan.²⁹ Height, weight and BMI therefore allow us to examine trends in the distribution of nutrition over time and between population subgroups in a country such as China.

Data and national trends

Height, weight and body mass data are drawn from six national level surveys of Chinese school children and youth between 1979 and 2005. The ministries of education, health, science and technology, and the national minorities commission and the sports commission jointly sponsored these studies. The published reports of summary data have had varying but similar titles over the years, the 2005 report rendered as *2005 nian Zhongguo xuesheng tizhi yu jiankang diaoyan baogao* (2005 年中国学生体质与健康调研报告; officially translated as *Report on the Physical Fitness and Health Surveillance of Chinese School Students, 2005*).³⁰ The 1979

²⁸ The profound affect of improved nutrition on health, welfare and productivity over the past 300 years is analysed in Floud, Fogel, Harris and Hong 2011.

²⁹ Piazza 1986; Morgan 2004; Olds 2003; Morgan and Liu 2007; Baten, Ma, Morgan and Wang 2010.

³⁰ The 2005 investigation report was cited above as *Zhongguo xuesheng tizhi 2007*, hereafter abbreviated as *Report 2005*. The other five reports from 1979 to 2000 are: *Zhongguo kexue jishu qingbao yanjiusuo* 1982, hereafter *Report 1979*; *Zhongguo xuesheng tizhi yu jiankang yanjiuzu* 1988, hereafter *Report 1985*; *Zhongguo*

survey reported data for Han Chinese of both gender for 16 provinces from urban (7-25 years) and rural (7-17 years) areas. Subsequent surveys have reported data for Han children and youth aged 7-22 years from every province except Tibet. Data for selected non-Han minority populations are also available from 1985.

Our focus here is on primary and high school students of Han ethnicity. Stratified by gender and rural-urban residence, there are four groups for each age 7-18 years, and the sample for each age group is about equal in size for any particular survey. In the 1985 survey, each sample group was 305 or 306 subjects, with more than half a million measured children, while later surveys have sampled at about half that number – the 2005 survey had 226,602 subjects in groups of about 150 subjects; each age group is further stratified by roughly equal proportions drawn from sampled schools in designated upper, middle and lower socioeconomic areas, though the locations and socioeconomic variables for each area are not revealed.³¹ The surveys are far larger in sample size for each age group than any other that includes anthropometric measures status, such as the frequently used China Health and Nutrition Survey (CHNS).³²

xuesheng tizhi yu jiankang yanjiuzu 1993, hereafter *Report 1991*; Zhongguo xuesheng tizhi yu jiankang yanjiuzu 1996, hereafter *Report 1995*; Zhongguo xuesheng tizhi yu jiankang yanjiuzu 2002, hereafter *Report 2000*.

³¹ The sampling framework is described in detail in *Report 1985* and is discussed in Morgan 2000 and Ji and Cheng 2008.

³² The CHNS covers nine provinces (originally eight) and the current sampling frame includes about 20,000 individuals of all ages. It includes many individual covariates that allow sophisticated statistical analysis, which is not possible with the summary-level student data. Data from CHNS has been used to analyze many dimensions of nutrition, welfare, health, and employment. However, when the data are cut by year, age, gender and place the sample size is invariably very small, which forces

Since the late 1970s, higher income has brought about a strong secular increase in average height-for-age. The Chinese are clearly “richer and taller” than they have ever been.³³ There are though large regional and urban-rural differences – northerners are typically taller (and heavier) than southerners, east coastal urbanites are taller than inland urbanites. To highlight extremes, a 17-year-old Beijing urban male in 2005 was 173.5 cm and 67.6 kg, while a Guizhou rural male was 164.4 cm and 51.8 kg.³⁴ But for a country of continental size such as China similar disparities exist in most social indicators, such as life expectancy at birth.

From Figure 1 we can see that the national mean height-for-age profile for rural males aged 7-22 years, for example, has shifted upwards for each of the reported surveys between 1979 and 2005 (data were not reported in 1979 for rural males aged 18 and older).³⁵ In 1979 the national mean height for seven-year-old rural males was 117.3 cm, which had increased to 122.5 cm by 2005, while for 17-year-olds mean height had increased from 164.4 cm to 169.7 cm, an average rise of more than 5 cm for each age group. The slope of the curve also tells us that nutrition had improved. In 1979, 1985 and 1995 the curve for rural males at 17 years of age had an upward slope indicating these youth were still growing and had not attained their final stature, which was not reached until age 20 in 1985 and 19 in 1995. By 2005, mean rural male

researchers to pool the data across surveys to carry out statistical analysis. See URL <http://www.cpc.unc.edu/projects/china>.

³³ Morgan 2000.

³⁴ The tallest and heaviest 17-year-olds males in 2005 were those from Shandong cities at 176.4 cm and 68.8 kg respectively. *Report 2005*.

³⁵ The rural boys are used to illustrate the height-for-age trends, though the secular trends for urban and rural children of both genders are similar.

height from 18 years of age was around 171.1 cm. Meanwhile, the urban Chinese males on average had stopped growing at age 17-18 by the 1995 survey and for the more developed provinces by 1985 or before.

Insert Figure 1 about here

Stature has improved for both genders. For selected age groups seven, 11 and 17 years, Figure 2 shows the upward shift in the national mean stature for both rural and urban area boys and girls from 1979 to 2005. Girls are on average shorter than boys except for a brief period during their pubertal growth spurt between the age of 10 and 12 years. There are obvious differences in the mean height between rural and urban children. In 1979, seven-year-old urban girls (120.4 cm) were taller than both rural girls (116.3 cm) and boys (117.3 cm), but shorter than urban boys (121.2 cm). The mean height of each group increased over the 26 years to 2005, with rural boys (+5.2 cm) and girls (+4.9 cm) making slightly greater gains than urban boys (+4.5 cm) and girls (+3.7 cm). Similar trends are observed for the other age groups over the period 1979 to 2005. The increase for 11-year old urban and rural boys was 6.8 cm and 8.9 cm respectively, and for girls 6.8 cm and 10.0 cm. For 17-year-olds, rural boys were 5.3 cm taller and urban boys 3.2 cm taller, which halved the rural and urban gap from 4.2 cm in 1979 to 2.1 cm in 2005. For 17-year-old girls the story told by the means is different: the average height of urban girls increased 1.8 cm, rural girls 2.3 cm and the average difference in height narrowed only 0.5 cm, from 2.3 cm in 1979 to 1.9 cm in 2005.

Insert Figure 2 about here

Mean weight can be expected to increase with the rise in mean height, but this does not necessarily translate into a rise in BMI unless mean weight increases faster than mean height. And indeed that is happening in China. Average weight has increased proportionately faster than average height. National changes in mean body mass for Chinese aged 7-22 years between 1985 and 2005 are shown in Table 1. Several changes are conspicuous. The proportion of those who were poorly or severely underweight have increased slightly among urbanites, doubled for rural boys, and slightly declined for the rural girls. Fewer Chinese children and youth were relatively underweight in 2005 than 1985, with a large fall of 11.3 percentage points for urban males, but a far smaller decline for other groups. Between 1985 and 2005 there has been a slight decline in the number of children classed as relatively, poorly and severely underweight (Table 1). Meanwhile, those who are overweight or obese (above the 85th percentile) have had the greatest change, ranging from 3.2 fold rise for rural males to 17.4 fold rise for urban males in the two decades to 2005. The result of these changes at either end of weight distribution is that the proportion in the normal BMI range has contracted for both urban and rural children, from between 60.3 and 67.0 percent to between 53.5 and 60.9 percent.

Insert Table 1 about here

Figure 3 graphically shows the shrinking normal range among Chinese children and youth aged 7-22 years since the mid-1980s and the increasing prevalence of overweight and obese children. In the mid-1980s, the proportion that was heavier than normal comprised only a few percentage points. By 2005, nearly a quarter of urban boys were overweight or obese, more than 13 percent of rural boys and urban girls were too, and only among rural girls was the prevalence of overweight and obesity less than 10 percent. Most striking is the persistence of a large portion of underweight children and youth that remain stubbornly above 20 percent, and for some groups more than 30 percent, of the population. In the mid-1990s, the proportion of underweight children and youth was higher than the mid-1980s or the mid-2000s. The late-1980s to mid-1990s witnessed a marked rise in economic disparities in China that these body mass data capture very well.³⁶ Underweight was more common among both rural and urban Chinese girls than boys, and in 1995 comprised 40 percent or higher of these groups. The gender differences point to the within-household inequalities where there are both boys and girls, notwithstanding the one-child policy, but the high level of aggregation of the summary statistics does not permit analysis that would clarify the reason for this apparent bias against girls.

³⁶ The gap between rural and urban households has long been evident in the rural-urban household consumption index. In 2005, the national average ratio was 3.7 but above 4.0 in Guizhou (4.8), Yunnan (4.3), Shaanxi (4.1) and Gansu (4.1). See various issues, National Bureau of Statistics 1983-2006. Increased inequality is examined in, among other studies, Riskin, Zhao, and Li 2002.

Insert Figure 3 about here

The aggregate change in the prevalence of obesity is evidence of profound changes in nutrition and lifestyle in contemporary China, though obesity rates are still low in many provincial populations, as will be shown. Table 2 shows obesity was nearly non-existent among children in 1985.³⁷ The prevalence was less than one percent in 1985 for all groups except 10-12 year old rural males, of whom 1.37 percent was obese. Over the next decade 1985-95 the prevalence increased rapidly, and in the following decade to 2005 the prevalence doubled or tripled again.

Insert Table 2 about here

The prevalence of obesity varies according to age group, with higher levels in the younger ages, though the rate of change between 1985 and 2005 is fastest for the older teenagers, as shown in Table 2. Among urban boys, in 2005 more than 15 percent of 10-12 year olds were obese, as were about 12 percent of the 7-9 and 13-15 year olds. Obesity among 7-9 year-old urban boys has increased 97 fold between 1985 and 2005; for the 16-18 and 19-22 age groups the increase is 211 and 240 times over

³⁷ The focus of most Chinese researchers was on underweight not overweight until the late-1990s. Such was the insignificance of overweight and obesity that the BMI for children was not separately reported in the surveys until *Report 2000*.

the same period, albeit from a very low starting level. While the prevalence of obese children among rural males, and urban and rural females, is far less than urban males, the pace of change is nonetheless fast. On a population-weighted basis for 7-22 year olds, there was an average 5.8 fold increase in obese rural males, an 8.0 fold increase in obese rural females and a 9.5 fold increase in obese urban females; among urban males, the prevalence increased 59.9 fold, from a mean of 0.19 percent in 1985 to 11.39 percent in 2005.

Provincial and regional disparities

We now turn from the national trends in height, weight and body mass to look at the urban-rural and regional variations in body mass. Our comparative reference standard is the WHO 2007 BMI-for-age recommended body mass for these selected ages (see Table 3). We use the WHO standard rather the Chinese WGOC standard to ensure international comparability, though for clinical intervention the WHO standard under-reports the prevalence of childhood obesity in China. The 1-standard deviation (SD) level is the cutoff for overweight, equivalent to the 85th percentile, while the -1 SD is the 15th percentile, below which the children are light though not usually considered underweight or excessively thin (clinical thinness and severe thinness correspond to -2 SD and -3 SD respectively).³⁸

Insert Table 3 about here

³⁸ WHO Growth Reference 2007; Cole et al 2007.

Between 1979 and 2005, the mean BMI for both rural and urban boys and girls increased for every age group (Figure 4 and Figure 5).³⁹ The national average in the late 1970s and early 1980s was below the WHO 2007 recommended median BMI for all age groups. For example, there was little difference between urban and rural seven-year old boys and girls at the time who were in the range 14.2-14.8 compared with the WHO recommended median BMI of 15.5-15.6. Figure 4 shows the secular change for boys aged seven, 12 and 17 years of age. In the early years of the reform period, rural boys were as heavy if not heavier than urban boys. Apart from 17-year-old rural youth in 1991, urban boys have been consistently heavier than their rural counterparts since the 1990s, and the gap has steadily widened. By 2005, seven-year-old urban boys had an average BMI 16.3 and rural boys 15.5, compared with the WHO recommended median 15.6. Twelve-year-old urban boys in 2005 averaged BMI 19.0, which exceeded the recommended BMI 17.9, while rural boys at 17.7 were slightly below the WHO median. Among 17-year-olds, urban boys at 20.9 were BMI 1.0 heavier than rural boys. Both groups were below the WHO recommended median BMI 21.1.

³⁹ The 1979 survey comprised 16 provinces and the 1985 comprised 28. One can question the representativeness of the 1979 sampling frame and argue the 1979 and 1985 means for height, weight and BMI are not comparable. I re-estimated the national means for 1985 using the 1979 sampling frame, and conducted a difference of means (t) test, which showed the 1979-frame 1985 means were not statistically different from the 28-province national means.

Insert Figure 4 about here

For girls (Figure 5) the trend is similar. The BMI of rural girls exceeded urban girls in the 1980s, but from the 1990s, the average BMI of seven- and 12-year-old urban girls was above their rural sisters. The gap between rural and urban girls in 2005 was BMI 0.4 for seven-year-olds and BMI 0.8 for 12-year-olds. By 2005, seven-year-old urban girls on average attained the WHO recommended median BMI 15.5, though rural girls were BMI 0.4 below. Similarly, 12-year-old girls at 18.2 were near the WHO recommended median 18.4, though rural girls were BMI 0.9 below. Rural 17-year-old girls on average were heavier than urban girls until the last two surveys when the gap closed. In 2005, both had a BMI 20.3, which was just BMI 0.9 below the WHO recommended median 21.2.

Insert Figure 5 about here

As with so many socioeconomic variables for China, there are huge differences between provinces as well as between rural and urban areas. Figures 7-11 show the provincial differences in mean BMI in 2005 for boys and girls aged seven, 12 and 17, distinguished by urban and rural place of residence. Overlaid on each figure is the

WHO recommended median and, as required, other lines showing the BMI level that is 1-SD above or below the median, which is labeled +1 or -1 z-score on the figures.⁴⁰

In many provinces of China in 2005, seven-year-old boys from both urban and rural populations exceeded the WHO recommended median BMI (Figure 6). The mean BMI for Tianjin and Shanghai urban boys were more than 1-SD above the recommended median. In other words, more than half the boys in these two metropolitan cities were overweight. At the other extreme, rural boys in Guangxi and elsewhere were nearly 1-SD below the median BMI, which corresponds to being very light on average, if not necessarily underweight, though clearly many boys in this province would have been underweight. Rural seven-year-old girls from many provinces were nearer the -1 SD line than the median, though about half of the urban girls were around the recommended median or slightly above (Figure 7). This figure for girls brings out the variation in the provincial distribution of BMI and underscores the aggregate data summarized in Figure 3, which showed one-third of 7-22 year-old girls were relatively-to-severely underweight in 2005.

Insert Figure 6 about here

Insert Figure 7 about here

⁴⁰ In a normalised distribution, where the mean is set to zero, the 1-SD point is the 1-z score. The z-score is useful for comparing change in values for a measure that differs greatly in variance between different ages such as height, weight and BMI. For example, a 1-kg difference in weight at seven years of age is quite different relative to the mean compared with the same change for a 17-year old.

A similar pattern is seen for 12-year-olds (Figures 8 and 9). Among the boys, Beijing urban boys were more than 1-SD above the recommended median BMI, and Hebei and Shandong urban boys were almost 1-SD above the median. Urban 12-year-old boys in 26 of the 30 provinces exceeded the recommended median BMI, but only in 11 provinces were rural boys on or above the median (Figure 8). Meanwhile, rural boys in nine provinces were quite light, with the mean for four provinces barely above the -1 SD line. Among the 12-year-old girls, the majority were lighter than the recommended median BMI (Figure 9). In eight provinces, however, urban girls were heavier than the recommended median BMI, including girls in Beijing, Tianjin, Hebei, Henan, Jiangsu, Shandong and Heilongjiang. Han rural girls in Qinghai were on average light or slightly underweight, more than -1 SD below the median, which means more than half the population ranged from very light to severely underweight.

Insert Figure 8 about here

Insert Figure 9 about here

As we might expect from the national mean BMI for 17-year-olds discussed above (Figure 4 and 5), which showed the average BMI was below the WHO recommended median for this age group, few provinces exceeded the WHO median. Only in several north China provinces were urban boys above the WHO median, such as Hebei,

Henan and Shandong (Figure 10). None of the rural 17-year-old boys exceeded the recommended median. Some were very light, nearly -1 SD below the median (Anhui, Guangdong, Guizhou and Gansu) and two were below (Hainan and Qinghai). Among 17-year-old girls (Figure 11), only those in the urban Tianjin and Shandong exceeded the recommended median. The others were below the median, irrespective of urban or rural residence. None were less than 1-SD below the median.

Insert Figure 10 about here

Insert Figure 11 about here

Despite the gains in average height and weight, the relative disparities in average BMI between children in different provinces for 2005 above have worsened over the past three decades. As shown in Figure 3, an increased in the prevalence of overweight and obesity has occurred with little change in the prevalence of underweight among China's children. The average of provincial mean BMI has risen, but that is seemingly the result of the more rapid increase in the weight of children in better off provinces, which has pulled up the overall mean. This trend is graphically apparent in Figure 12 and 13, which show the overall mean (a triangle marker) along with the range of provincial mean BMI from minimum to maximum.⁴¹ Over time, the maximum provincial mean BMI has increased proportionally more than the national BMI mean.

⁴¹ These figures report the range of provincial means for BMI, from minimum to maximum, and not the range of absolute BMI scores, which are much wider.

In some survey years and for some age groups, the minimum reported mean BMI even declined. For all age groups, the distance between the average and the maximum mean BMI among China's provinces became wider between 1979 and 2005 – that is, the length of the line above the triangle has grown. The increase in the length of the line below the overall mean to the minimum mean BMI indicates that many Chinese children and youth are not simply missing out on the nutritional improvement that economic reform and growth has brought to those in the more developed provinces, but may have become worse off than those growing up in the same province in the early years of economic reform.

Insert Figure 12 about here

Insert Figure 13 about here

The regional variations in mean BMI from 1979 to 2005, Table 4, underscore the disparities indicated in the national trends (Figures 12 and 13). A modified form of the official Chinese four-region classification is used.⁴² It divides China into four zones – northeast, east, central and western – but with the three east China province-level municipalities moved into a metropolitan region since their rural areas are unlike the rural areas of other provinces; most residents have access to the same the services and possess similar income to their urban neighbors. In 1979, there was little

⁴² The four-region classification was introduced with the western region development policy in 2000. For details, see Fan and Sun 2008.

difference among the regions in the average BMI of children 7-17 years (Table 4). This reflected the broad egalitarian distribution of nutrition (and also low level), though the children in the metropolitan cities were distinctly heavier by 0.2-0.4 BMI. By 2005, the regional differences were clearly discernible. The western region was lightest for both boys and girls, while the average BMI increased greatest for the metropolitan region, and boys gained more weight on average than girls. Western region boys were on average 1.2-1.9 BMI lighter than metropolitan boys and 0.5-1.0 BMI lighter than those in east China; for girls the difference was 0.5-1.3 BMI and 0.1-0.7 BMI respectively. The increase in mean BMI between 1985 and 2005 was largest for each age group in the metropolitan cities and smallest for those in the west.

Insert Table 4 about here

Another way to examine the increased disparities is to calculate the increase in the dispersion around the mean rather than the absolute differences in the mean. This measure of disparity or inequality is known as the coefficient of variation (CV), which is the ratio of the standard deviation to the mean. We cannot calculate the CV for the BMI directly for the survey years before 2000 because for each province only the summary mean and standard deviation for height and weight were released, but not the mean and standard deviation of the BMI. Although we can calculate the mean BMI using the summary mean height and weight for each province, as we have done above, we cannot estimate correctly the standard deviation for the BMI derived from these summary data. Due to this data constraint, we report instead the change in the

CV of the weight, which is the key driver of the change in BMI, though both the CV for weight and height has risen over time. Figures 14-16 report the national trend in CV of weight for urban and rural boys and girls aged seven, 12 and 17 years.

Figure 14-16 about here

For all age groups and provinces, the increase in the CV for both boys and girls demonstrates a marked rise in the level of disparities in nutritional status among Chinese children. Among seven-year-old boys (Figure 14), between 1979 and 2005 the CV has increased about 85 percent and for girls increased about 60 percent. For 12-year-olds (Figure 15), the CV for boys has increased 70 percent from 14.9 to 25.3 and for rural boys the rise has been 85 percent, from a lower starting level of 12.9 to 23.6. The relative increase in CV for girls is lower in both urban and rural groups, about 40 percent and 30 percent respectively. Among 17-year-olds (Figure 16), the largest increase in the CV is for the urban boys, about 71 percent, compared with 34 percent for rural boys, 36 percent for urban girls and 22 percent for rural girls.

Across the three selected age groups, provincial disparities in mean weight are higher among boys than girls, and highest among urban boys. The reasons for these differences are unclear. Some urban centres such as the provincial-status metropolitan cities of Beijing, Tianjin and Shanghai have not only seen rapid increase in incomes and thus a capacity to buy more calories, but also a more rapid transition in diets and lifestyle than other urban centres, which combine to lead to over nutrition. But why

increasing urbanization and wealth in the better off cities should have pushed up the weight of boys relatively more than girls is an intriguing question. In cities where many children are without siblings because of the one-child policy, a simple gender bias in within-household allocation of resources does not explain the differences in weight. Increasing incomes of urban households would reduce the likelihood of gender biases in the presence of mixed-sex siblings. A possible explanation is the influence on older urban girls of the media's promotion of fashionable thinness that impels them to moderate their consumption of calories. Body dissatisfaction, concerns about weight, dieting fads and eating disorders are on the rise among Chinese, from developed Hong Kong through to rural China.⁴³ This is more acute among young women in more developed and urbanised communities. More research is needed to clarify how fashion trends might influence weight of young Chinese women, but as Paul French noted recently: "Urban China is getting fatter while its personal body image is getting thinner."⁴⁴

Discussion and conclusion

Explaining the trends in nutritional status in China is seemingly not difficult at first glance. Increased income, increased consumption and changed lifestyle over the past three decades have all contributed to increase overweight and obesity among the Chinese. But identifying specific causal relationships at a provincial level with any statistical reliability using the summary data from the student surveys has proved

⁴³ Lee and Lee 2000; Luo, Parish, and Laumann 2005; Xu, Mellor, Kiehne, Ricciardelli, McCabe, Xu 2010.

⁴⁴ French 2010, 157.

intractable. Conventional approaches such as regression analysis disappoint because both the anthropometric data and the covariates are provincial-level summary means, rather than data for individuals. As a consequence the statistical significance of the explanatory variables disappeared in regression analyses. Therefore, below we report the pairwise correlation coefficients for selected explanatory variables (Table 5 and 6). Correlational associations, however, are not the same as a causal relationship.

Insert Table 5 about here

Insert Table 6 about here

Table 5 reports the correlation coefficients and their significance between the mean BMI of Chinese children of selected ages and selected explanatory variables related to socioeconomic structure, income and lifestyle. The mean BMI of children is strongly correlated (>0.5) and significantly so (>0.01 level) for most income-related variables (5, 6, 7 and 9). Household income (6) shows the highest correlation (0.67 for boys and 0.64 for girls). Children from higher mean income provinces had higher mean BMI. The correlation is stronger for boys than girls. The relationship with the economic structure in a province – the relative share of primary and secondary industry contribution to regional domestic product (RGP) – is as expected: primary industry is negatively correlated and significantly so (a higher share of primary industry means lower level of development and value added in the economy and correspondingly lower incomes). The coefficient for life expectancy at birth is low and not significant

(even at the 0.05 level), which indicates the investment in health and sanitation has had little bearing on BMI levels. While the coefficient for expenditure on food is significant and correlated with mean BMI at 0.53 for boys and 0.49 for girls, the coefficient for eating out is not only small and insignificant, but the sign is negative, the opposite to that expected. The eating out coefficient is as expected correlated strongly with provincial income, household income and food expenditure. The other lifestyle variable – the spending on transport and communications (6) – is second only to household income in the size of the coefficient. This indicator in particular can be interpreted to emphasize that higher incomes and urban residency is highly correlated with a rise in average BMI (see the high cross-correlation coefficients for transport and communications with variables 6-8).

To improve the sensitivity of the correlation analysis, in Table 6 we report the coefficients estimated for the same set of variables for the share of the population in each age group who were above the WHO cutoff for overweight and obese. These differ intriguingly from the coefficients for mean BMI. Firstly, the coefficients for provincial industry structure are smaller and for secondary industry these are no longer significantly correlated with the proportion of the overweight and obese children. Regional gross income is still significant but the coefficient lower. However, the coefficients for those variables related to discretionary consumption expenditure within the household – variables (6), (7) and (9) – clearly point to higher household incomes being more closely associated with overweight and obese children. For example, household income was correlated at 0.75 for boys and 0.73 for girls. The eating out coefficient was still negative, tiny and insignificant.

Although correlations are not necessarily causal, the results in Table 5 and 6 lend support to the view that the increase in overweight and obesity in China is driven by a change in the socioeconomic environment, which has increased the availability of food, reduced the relative price of foods, changed the types of foods consumed, and reduced the demand for food energy in work or leisure activity. Those with higher income in the more developed parts of China face an oversupply of nutrition relative to body requirements, which predict inevitable increase in body mass. Studies have shown the physical activity of urban Chinese halved in the 1990s, which doubled or tripled their likelihood of becoming overweight.⁴⁵ Increasing use of motorized transport plays a part too. Chinese men who acquired a motor vehicle were found to increase their weight 1.8kg and had 2-to-1 odds of becoming obese.⁴⁶ Even rural Chinese in the more prosperous east are increasing their waistlines rapidly.⁴⁷

Increased food consumption explains a lot, but by no means all. The amount of food consumed has clearly increased. Average urban per capita household purchase of meat (pork, beef, mutton and poultry) in the 10 years to end-2004 increased five kg to 29.2 kg, edible oil from 7.5 kg to 9.3 kg and milk from 5.3 kg to 18.8 kg.⁴⁸ But these averages conceal both income group and regional differences. The highest income group in 2004 bought 33.5kg of meat and the lowest 21.7kg.⁴⁹ Dining out has risen

⁴⁵ Popkin 2009, 79.

⁴⁶ Bell, Ge and Popkin 2002.

⁴⁷ Ma et. al 2009.

⁴⁸ Year-end 2004 data are used as the most appropriate to correlate with the 2005 anthropometric data. The data are from National Bureau of Statistics 1995, 2005, Table 9-7 (1995) and Table 10-13 (2005).

⁴⁹ NBS 2005, Table 10-13.

quickly in China, which accounted for 20 percent of urban household's expenditure on food in 2004, compared with only 8 percent in 1994.⁵⁰ Regional variation is huge. Dining out in Beijing was 27 percent of urban household food expenditure, 24 percent in Tianjin, and 26 percent in Shanghai. For urbanites in less developed provinces the change has been even greater: in 1994, Anhui urban households spent only 5 percent of their food budget outside the home, but 20 percent in 2004, while in Shanxi dining out increased nearly six-fold, from 3 percent in 1994 to 17 percent in 2004. These changes in spending and dining habits can be expected to affect individuals, but the data at the aggregate provincial level is seemingly too blunt a measure to capture these effects, which probably explains the lack of correlation reported (Table 5 and 6).

A striking consequence of the transition in economic and nutritional status in China is the reversal of the BMI and socioeconomic status (SES) relationship. In China high SES children and adults are more likely to be overweight and obese than their lower SES counterparts in contrast to developed countries where the middle-to-low income groups are more likely to be obese.⁵¹ Other developing regions have similar pattern. A recent study of half a million women in 54 low- and middle-income countries has found a quartile increase in wealth results in a 33 percent increase weight in urban and rural areas, though the SES gradient was steeper in urban areas.⁵² Ji and Cheng concluded there is an "alarming increase in the prevalence of childhood obesity/overweight throughout China, except for the poverty (sic) western rural

⁵⁰ Estimated from NBS 2005, Table 10-16.

⁵¹ Ji and Cheng 2008; Ma et. al 2009.

⁵² Subramanian, Perkins, O'zaltin, and Smith 2011.

areas.”⁵³ The primary explanation for these differences in the prevalence of over nutrition and under nutrition in China is the SES inequalities, especially between east and west China, though we need more research to tease out the many interaction affects at the individual level that influences weight.

To conclude, China faces two major issues related to the nutritional status of its children. The persistence of still high levels of under nutrition among the urban poor and those in rural areas, which is evident in the prevalence of underweight and stunting. Between 22 percent and 34 percent are under- or severely under-weight, varying somewhat depending on gender and rural-urban residence (Figure 3). At the other end of the weight-nutrition spectrum is the increase in overweight and obesity that is truly startling for a country, which half a century ago experienced the worse famine in human history and which only three decades ago had widespread chronic hunger. Urban boys are most likely to be overweight or obese, and more so those living in east China and the metropolitan cities of Beijing, Tianjin and Shanghai. The coexistence of these huge disparities needs explanation; they also need a better response from the Chinese State in the delivery of public health and its development goals, though it is unclear how this response may come about.

What is not in doubt is that the prevalence of overweight and obesity among Chinese school children has increased quickly. That increase in body weight foreshadows big changes in morbidity and a rise in health expenditures. Less certain is the reason why the increase has been so rapid. The paper has explored some explanations. Many observers point to economic reform creating an obesogenic environment in China. This manifests itself in the increase in consumption of energy-dense foods, eating out

⁵³ Ji and Cheng 2008, 5.

and the proliferation of fast food restaurants in urban China, and the broad socioeconomic changes that have made for a more sedentary lifestyle. Fewer adult Chinese are engaged in manual work, fewer children walk or cycle to school, and outdoors recreation has been replaced by those indoor in front of electronic devices.

There can be little doubt that economic reform has had a positive effect on net nutrition levels of the Chinese, which is evident in the secular increase in the height-for-age of children (see Figure 1). But such improvement should not necessarily have led to an increase in overweight and obesity. While the socioeconomic changes are part of the explanation, there are also deep-seated cultural influences interacting with these to encourage over-eating among the young. Fat is associated with bounty and happiness. Plump babies “were much admired as symbols of goodness and luck” and to be emulated, while thinness represented “bad luck, illness and early death.”⁵⁴ We see images of plumpness in Buddhist iconography, the traditional New Year prints (*nianhua* 年画) of rotund babies and fat fish, and the chubby child faces of posters singing the praises of happier, well-fed and educated children that come to parents who observe the one-child policy.⁵⁵ This policy has probably influenced fatness among urban children – grandparents and parents lavish gifts and food upon these “little emperor” only children. Whatever the merits of the policy in the past, its retention is a liability. As China’s population ages, and becomes still fatter and suffers from weight-induced chronic diseases, future productivity growth is imperiled. As for under nutrition, the story is probably one of the continuing urban-oriented State biases that has long characterized Chinese economic development. The State and its agents

⁵⁴ Watson 2000, quote 207-8.

⁵⁵ See the many posters on Chinaposternet (<http://chinese posters.net/>).

have failed repeatedly to deliver the benefits of economic reform to the poorest of the Chinese, who mostly live in inland and less-developed provinces. In short, we see a complex interaction of State policies, socioeconomic change and cultural predispositions combining to influence the pace of change in the prevalence of overweight and obesity, the rise of which have long-term implications for human welfare and economic prosperity in contemporary China.

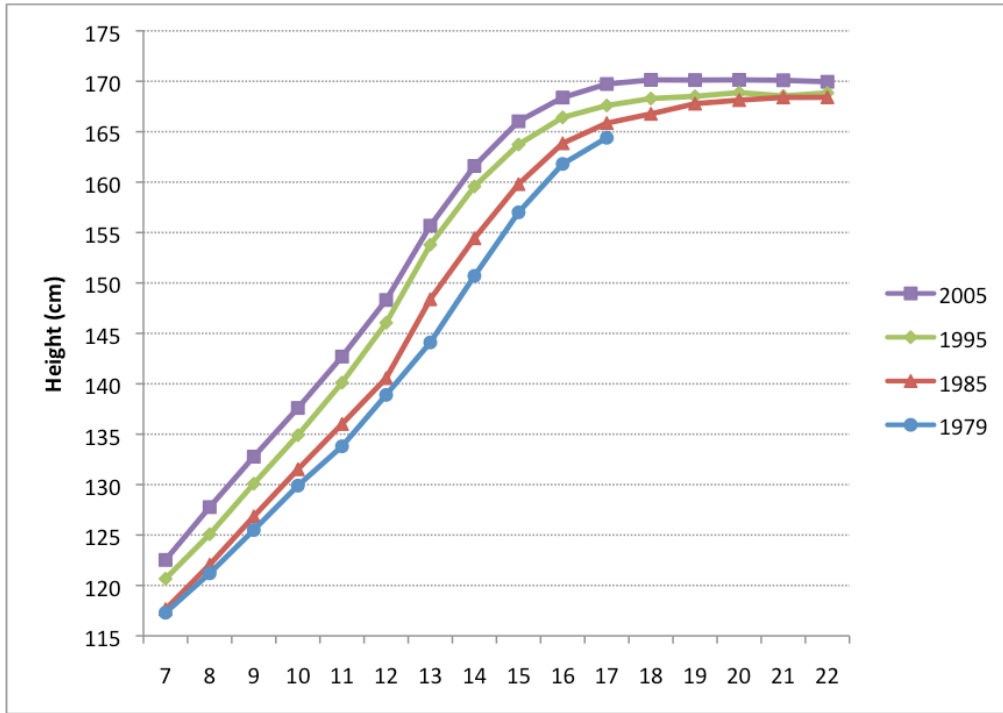


Figure 1: Change in height-for-age profile of Chinese rural boys, 1979-2005

Source: *Report 1979*, *Report 1985*, *Report 1995*, and *Report 2005*. See text for details of the sources.

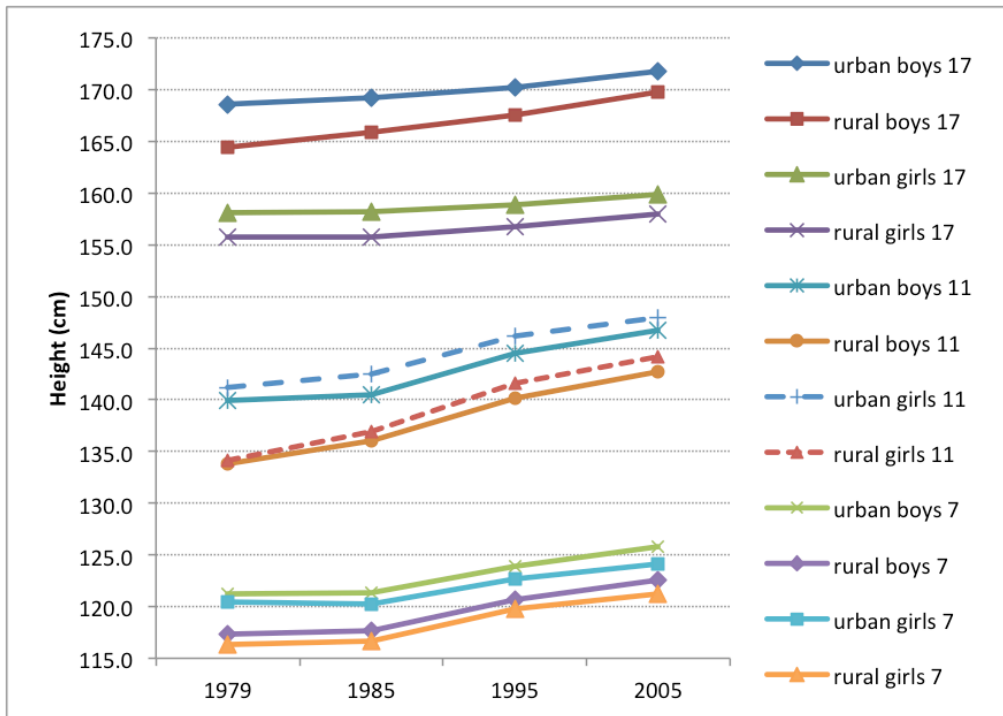


Figure 2: Change in height-for-age for Chinese boys (m) and girls (f) aged 7-, 11- and 17-years between 1979 and 2005.

Source: See Figure 1

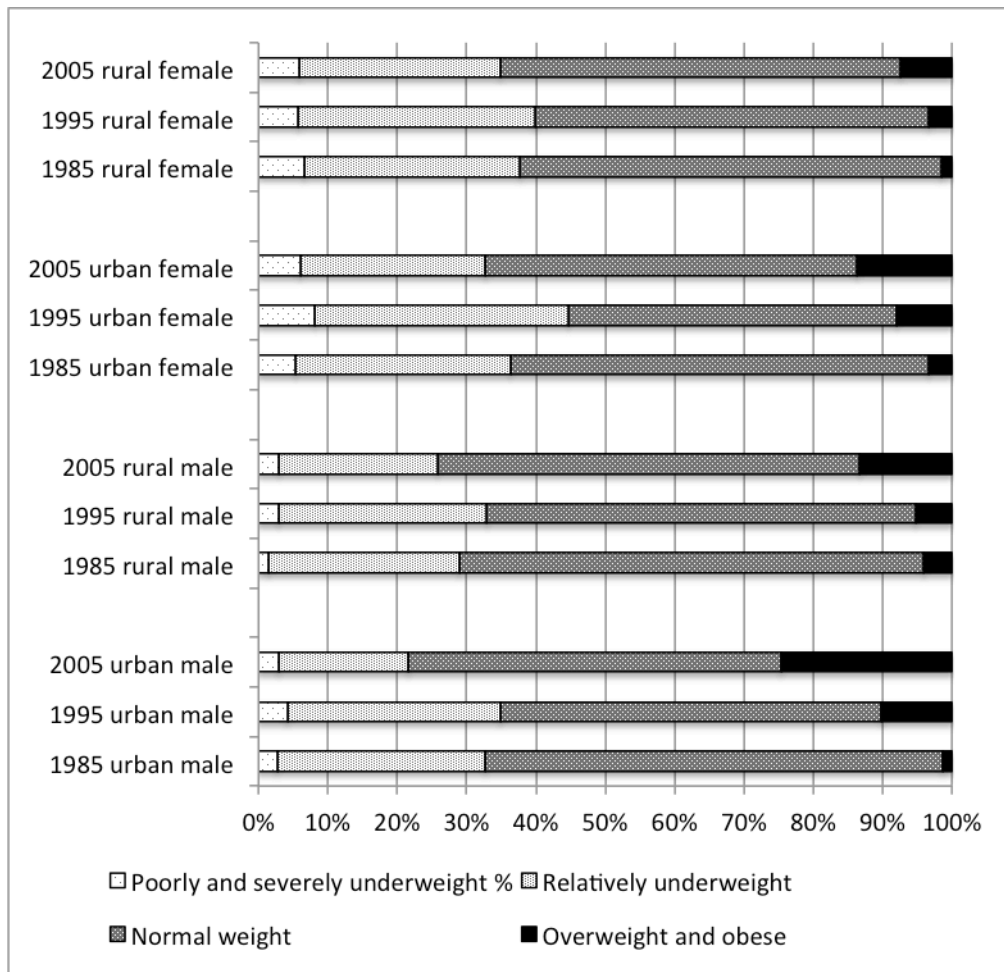


Figure 3: Change in the distribution of BMI status among Chinese 7-22 years, 1985-2005

Source: *Report 2005*, pp. 90-92.

Note: The BMI standard used in the report is the Chinese BMI reference standard of 1985. In percentiles, poorly and severely underweight is < 5th percentile, relatively underweight (very light) is < 15th percentile, and overweight and obese >85th percentile.

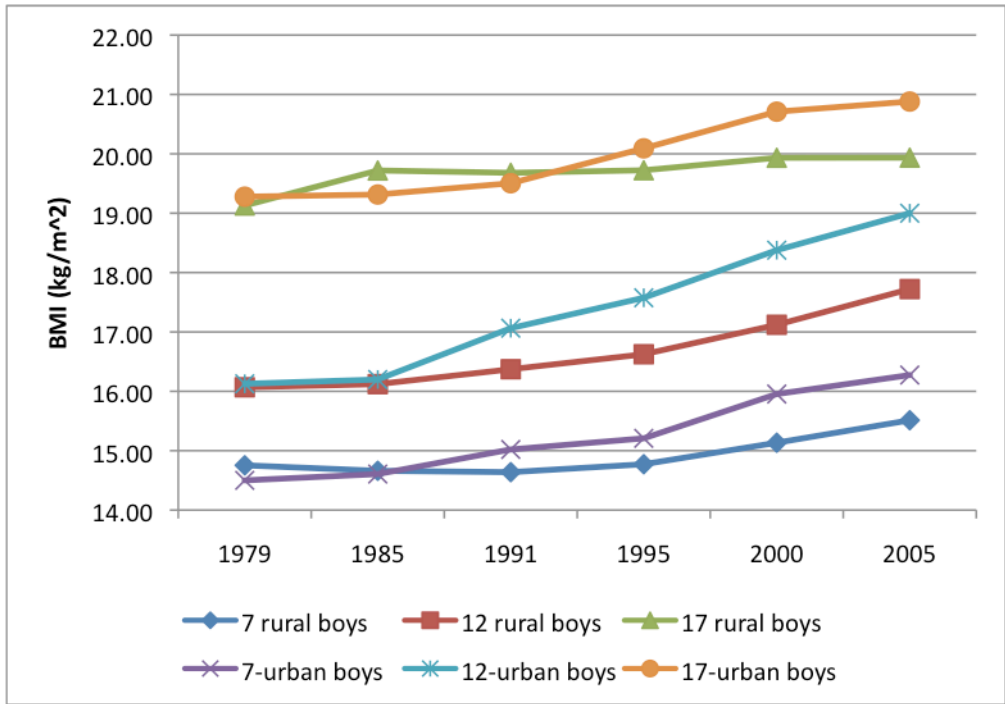


Figure 4: Mean BMI of Chinese boys 7-17 years old, 1979-2005
 Sources: *Report 1979, Report 1985, Report 1991, Report 1995, Report 2000, and Report 2005.*

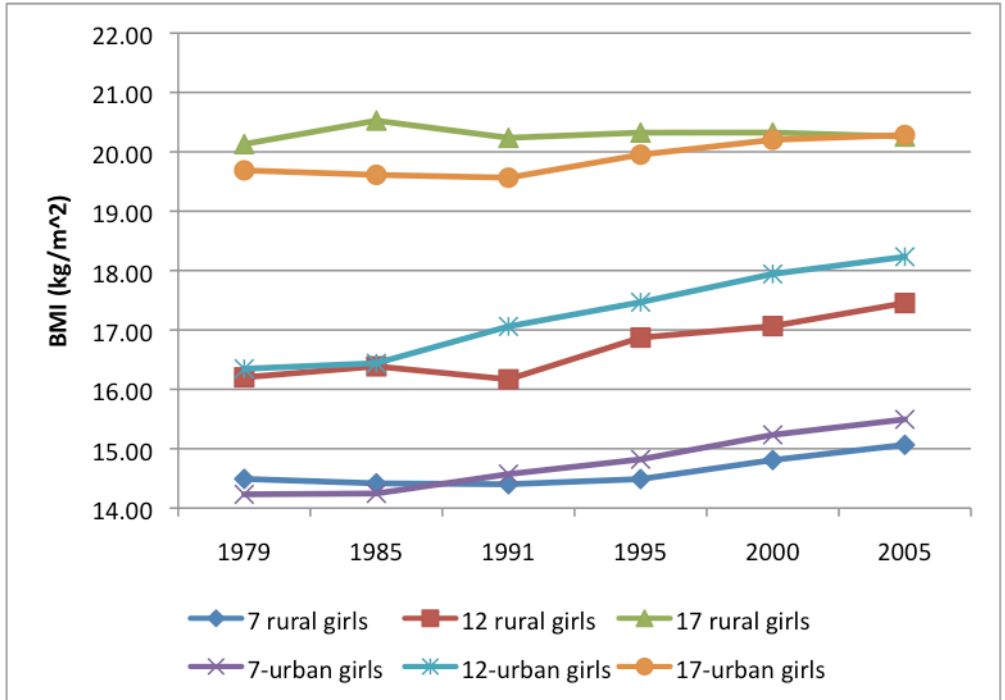


Figure 5: Mean BMI of Chinese girls 7-17 years, 1979-2005
 Sources: See Figure 4.

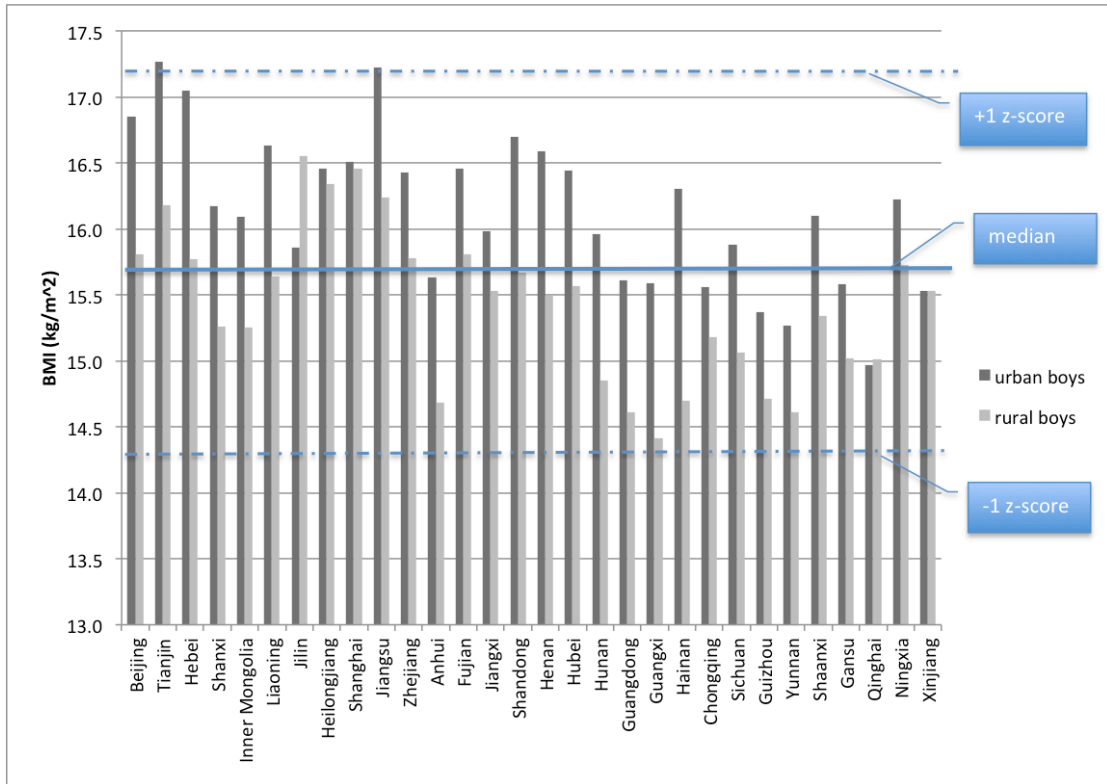


Figure 6: Regional mean BMI of 7-year-old urban and rural boys, 2005
 Source: Report 2005.

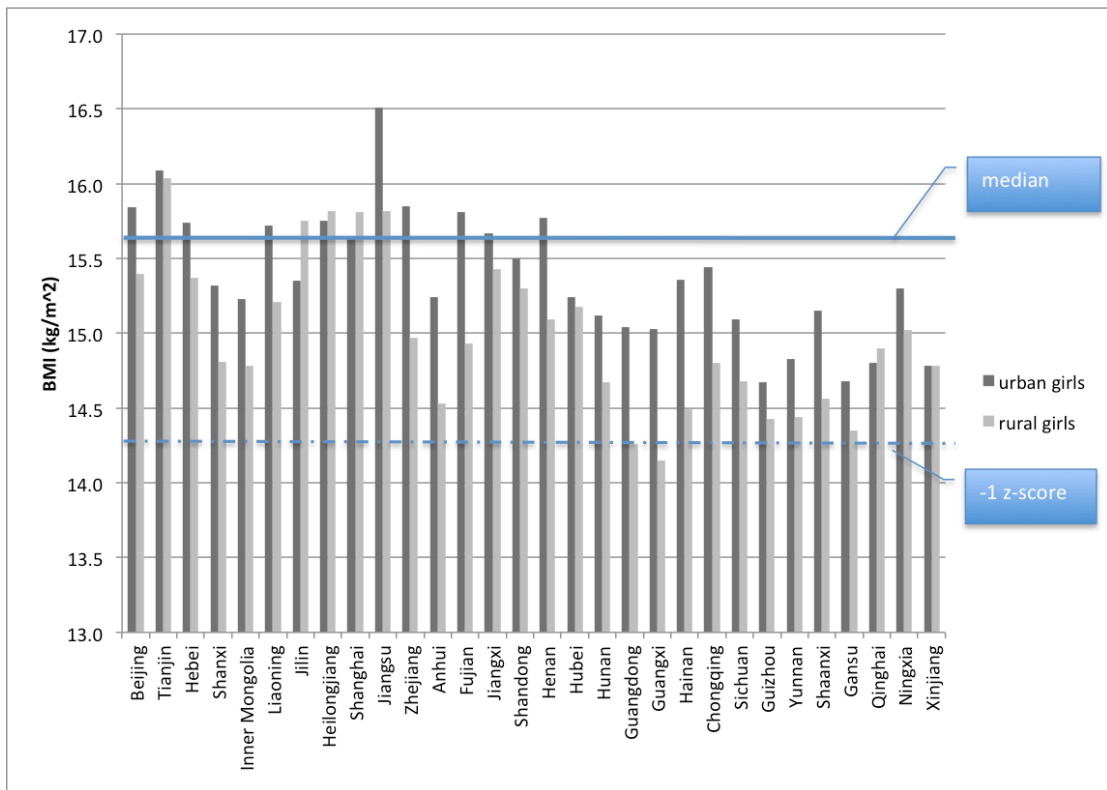


Figure 7: Regional mean BMI of 7-year-old urban and rural girls, 2005
 Source: See Figure 6.

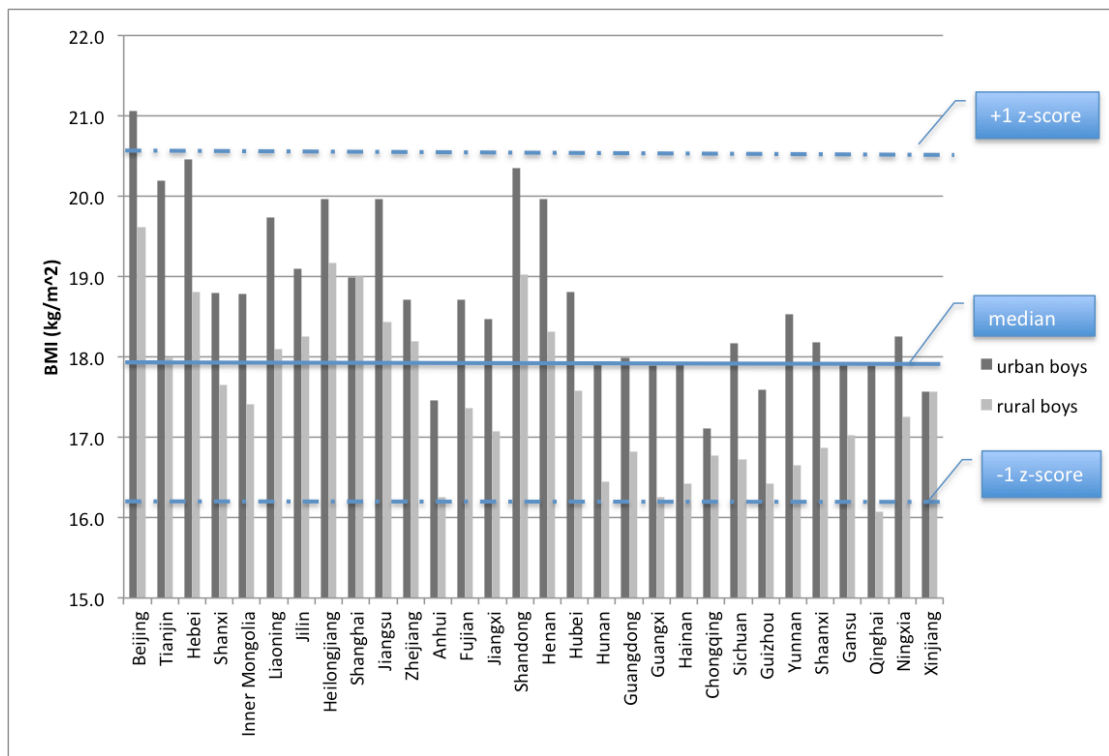


Figure 8: Regional mean BMI of 12-year-old urban and rural boys, 2005
Source: See Figure 6.

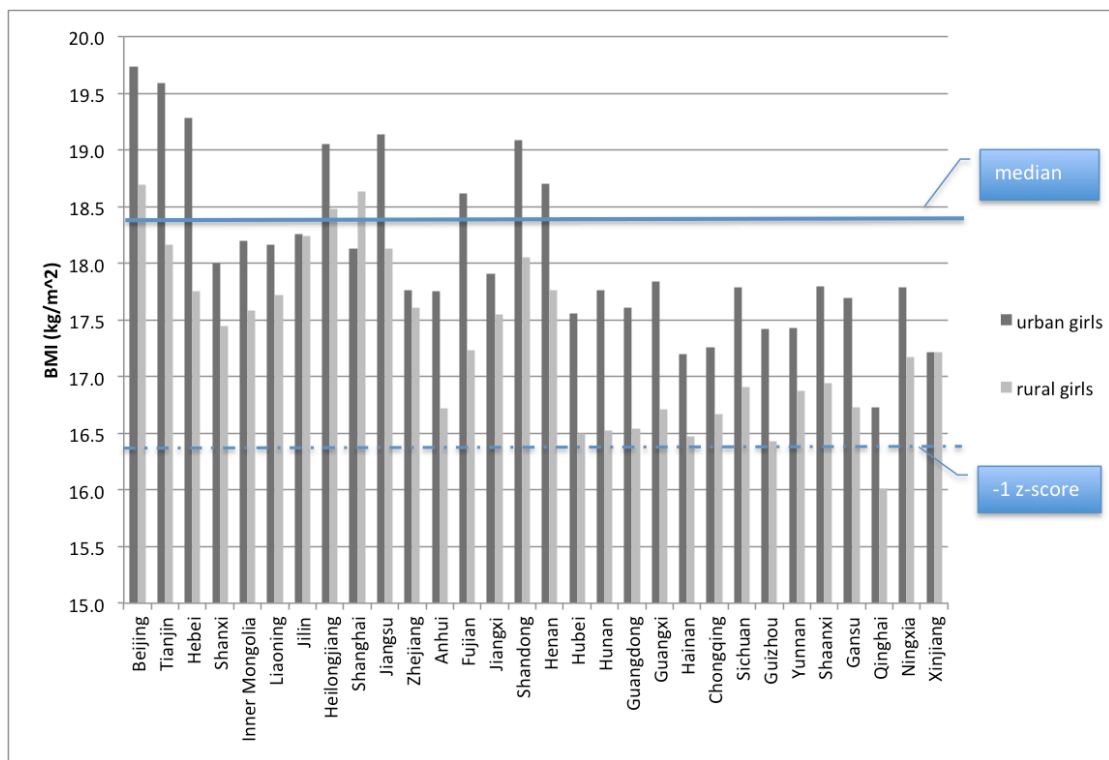


Figure 9: Regional mean BMI of 12-year-old urban and rural girls, 2005
Source: See Figure 6.

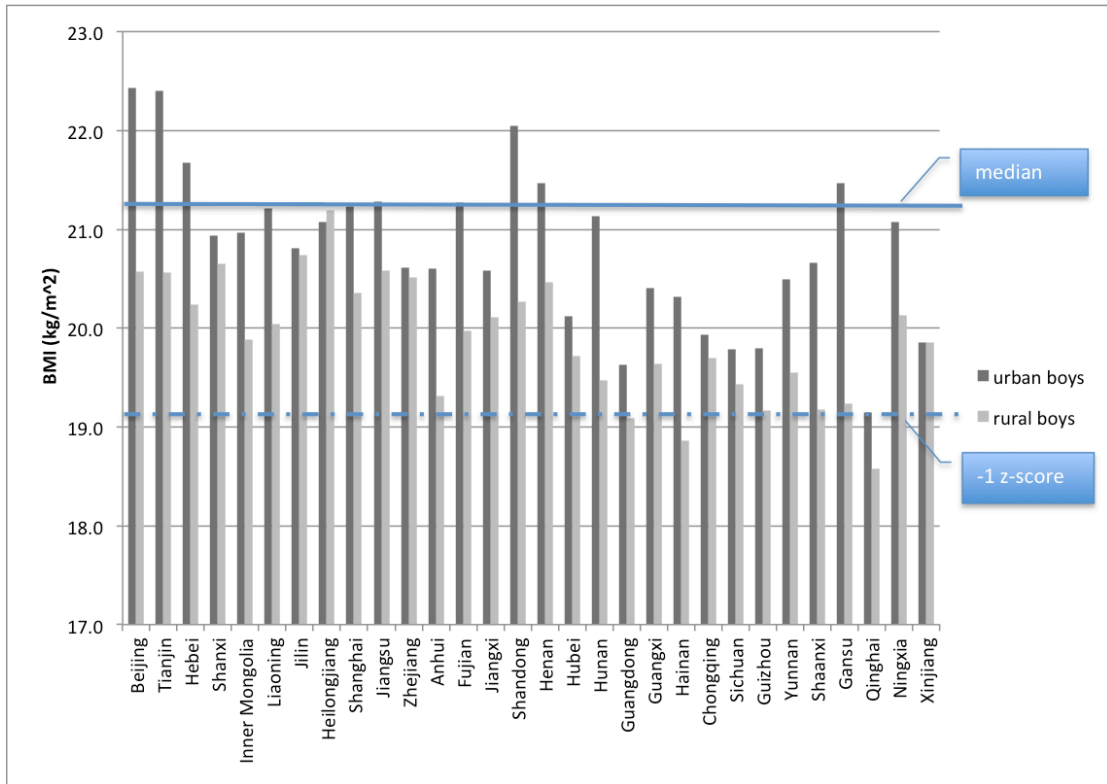


Figure 10: Regional mean BMI of 17-year-old urban and rural boys, 2005
 Source: See Figure 6.

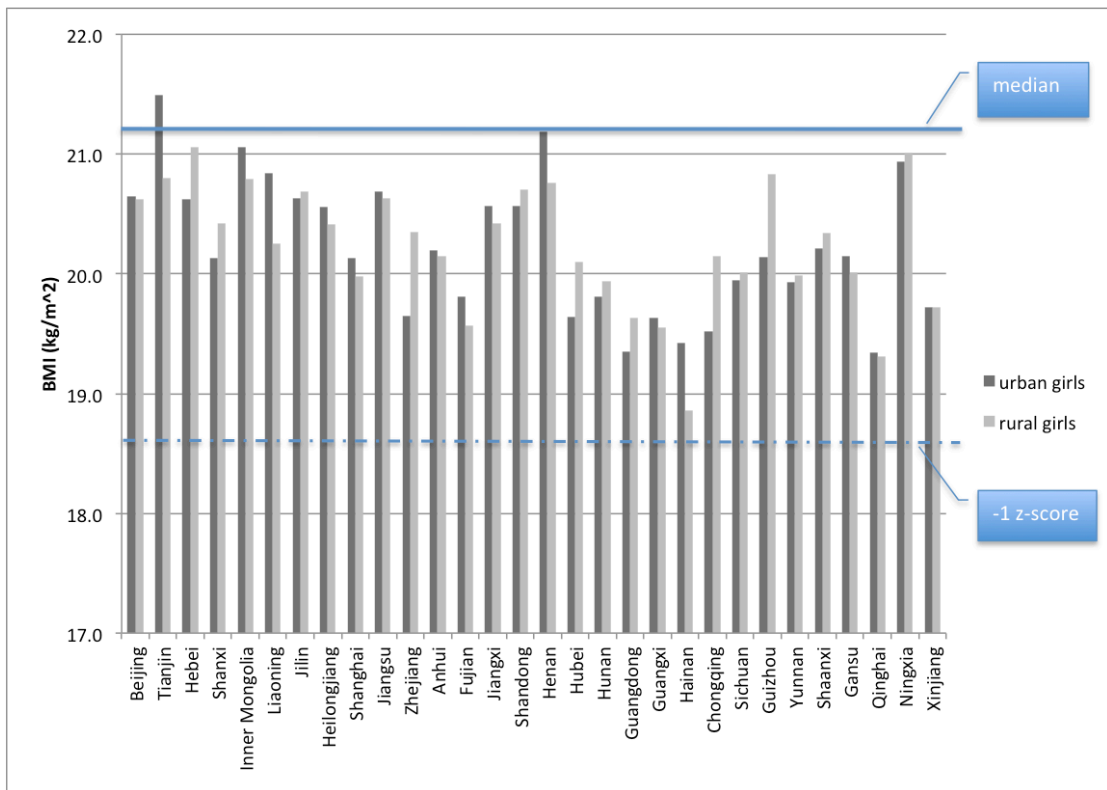


Figure 11: Regional mean BMI of 17-year-old urban and rural girls, 2005
 Source: See Figure 6.

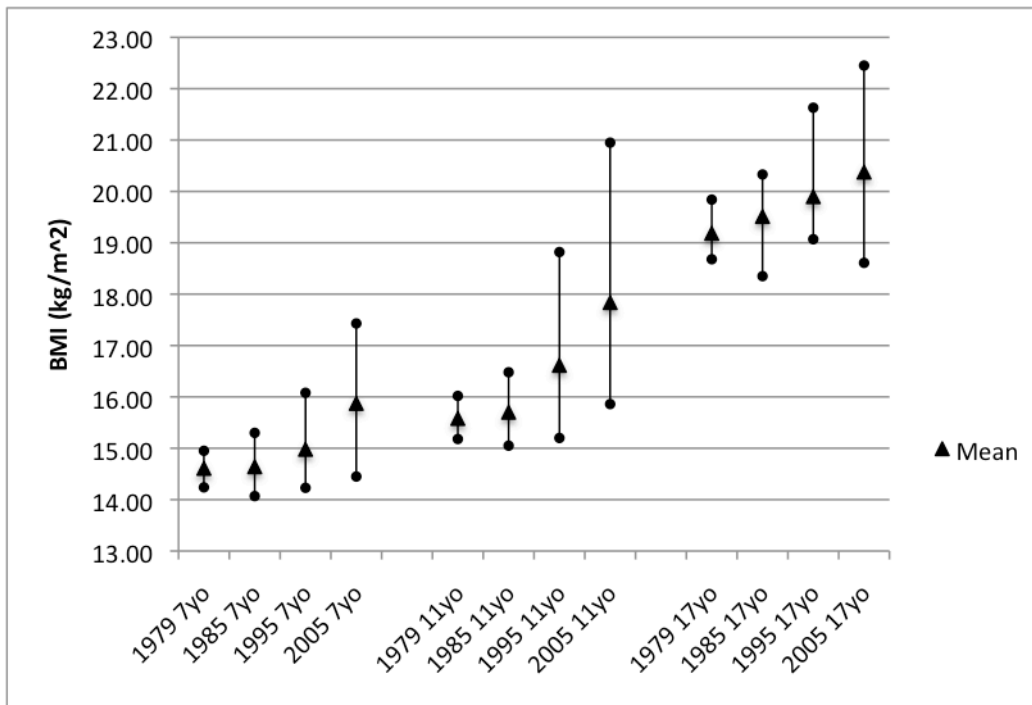


Figure 12: Increasing disparities in provincial BMI, 1979-2005: minimum, mean and maximum (boys) [change to 12 year olds for consistency]
 Source: See Figure 1.

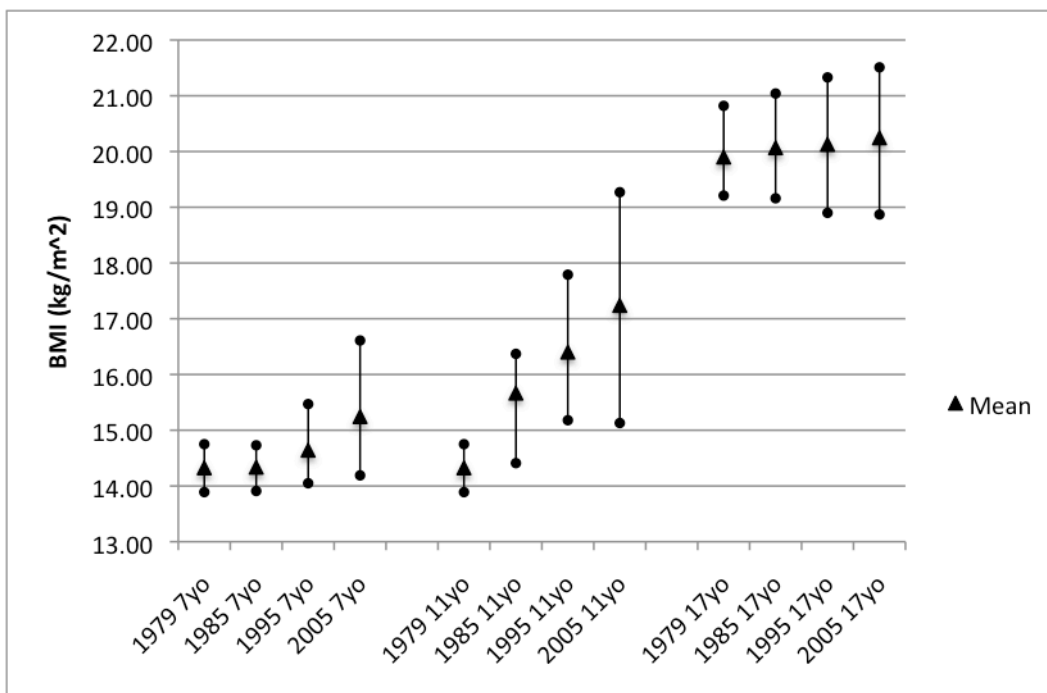


Fig 13: Increasing disparities in provincial BMI, 1979-2005: minimum, mean and maximum (girls)
 Source: See Figure 1.

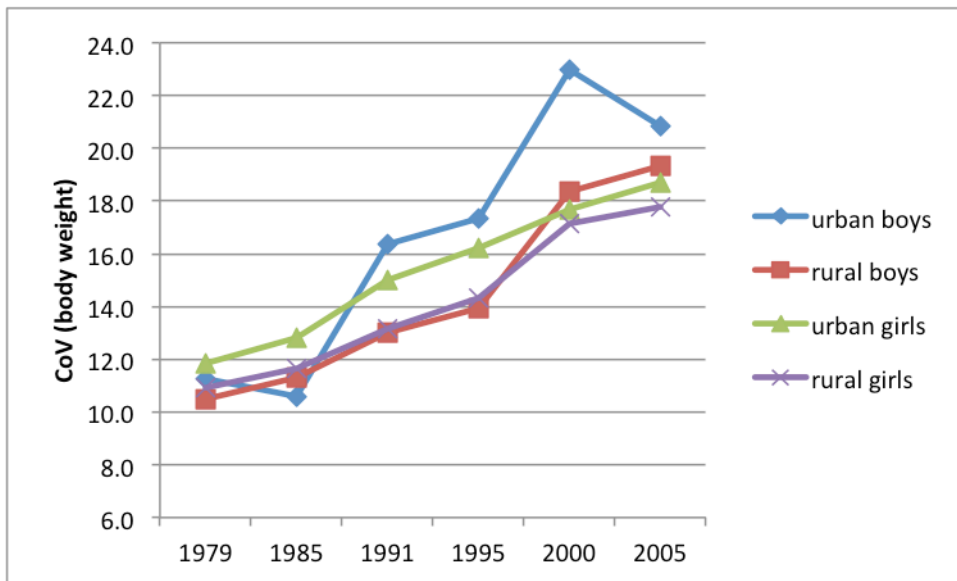


Figure 14: Increase in coefficient of variation of weight of 7-year-old boys and girls, 1979-2005
 Source: See Figure 4.

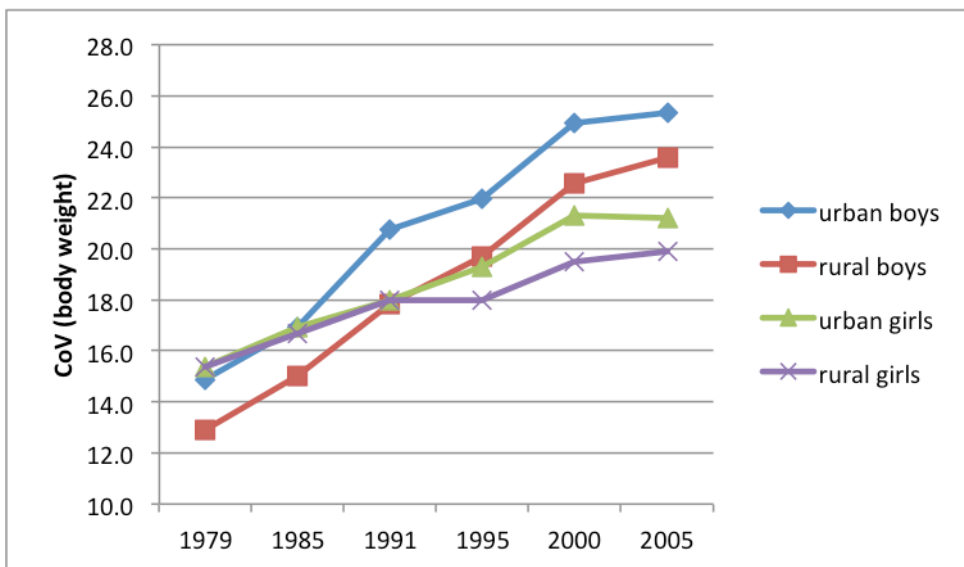


Figure 15: Increase in coefficient of variation of weight of 12-year-old boys and girls, 1979-2005
 Source: See Figure 4.

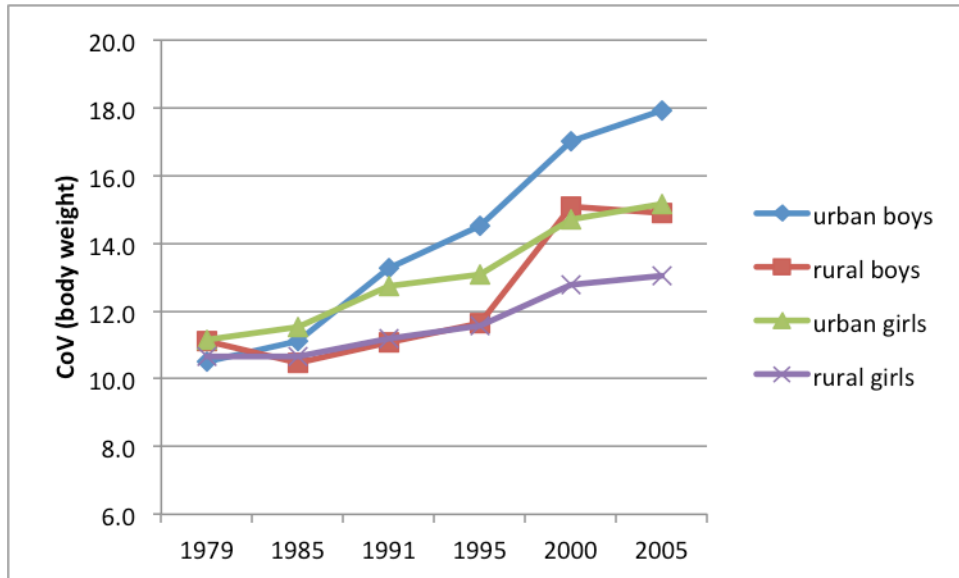


Figure 16: Increase in Coefficient of Variation of weight of 17-year-old boys and girls, 1979-2005

Source: See Figure 4. [note: need to change um to urban boys, etc]

Table 1: Summary of bodyweight changes for 7-22 year-olds, 1985-2005 (%)

	Poorly and severely underweight ¹			Relatively underweight		
	1985	2005	Change ²	1985	2005	Change
Urban males	2.7	2.9	1.1	30.0	18.7	0.6
Rural males	1.5	3.0	2.0	27.4	22.8	0.8
Urban females	5.3	6.0	1.1	31.0	26.7	0.9
Rural females	6.5	5.7	0.9	31.0	28.4	0.9

	Normal weight			Overweight and obese		
	1985	2005	Change	1985	2005	Change
Urban males	65.9	53.8	0.8	1.4	24.6	17.4
Rural males	67.0	60.9	0.9	4.1	13.3	3.2
Urban females	60.3	53.5	0.9	3.4	13.7	4.1
Rural females	60.3	56.6	0.9	1.6	7.2	4.6

Source: *Report 2005*, pp. 90-92.

Notes: 1. The weight classifications use the Chinese 1985 BMI reference. Poorly and severely underweight is less than -2 standard deviations (SD) from the mean, relatively underweight is -1 SD, overweight and obese is greater than +1 SD.

2. Change shows the change between 1985 and 2005 as an increase/decline ratio. For example, a change of less than 1.0 means there was a relative decline in prevalence, and a change of 3.0, a three-fold increase.

Table 2: Change in prevalence of obesity among Chinese 7-22 year-olds, 1985-2005 (%)

	Urban males				Rural males			
	1985	1995	2005	Change ¹	1985	1995	2005	Change
7~9	0.12	5.88	11.69	97.4	0.86	1.24	5.37	6.2
10~12	0.41	8.92	15.33	37.4	1.37	2.08	7.09	5.2
13~15	0.32	6.74	12.09	37.8	0.97	1.82	5.35	5.5
16~18	0.05	3.63	10.57	211.4	0.65	1.22	4.09	6.3
19~22	0.03	0.88	7.20	240.0	0.53	0.81	3.43	6.5
Mean (p-w) ²	0.19	5.08	11.39	59.9	0.88	1.45	5.07	5.8

	Urban females				Rural females			
	1985	1995	2005	Change	1985	1995	2005	Change
7~9	0.55	2.32	5.18	9.4	0.55	0.74	2.97	5.4
10~12	0.80	4.04	8.08	10.1	0.80	1.64	4.24	5.3
13~15	0.64	3.91	6.33	9.9	0.64	1.74	3.07	4.8
16~18	0.33	1.58	3.69	11.2	0.33	0.76	1.63	4.9
19~22	0.39	0.61	1.89	4.8	0.39	0.47	1.18	3.0
Mean (p-w) ²	0.53	2.55	5.01	9.5	0.33	1.09	2.63	8.0

Source: *Report 2005*, pp. 90-92.

Notes: 1. Change is the increase between 1985 and 2005. For example, a change of 3.0 means there was a three-fold (300 percent) increase in prevalence.

2. The mean is the population-weighted (p-w) for age 7-22 years.

Table 3: WHO Reference Standard BMI-for-age, selected ages

Age (year-month) ¹	-2 SD ² (-2 z)	-1 SD (-1 z)	Mean (0 z)	1 SD (+1 z)	2 SD (+2 z)
Boys					
7 - 6	13.2	14.3	15.6	17.2	19.3
12 - 6	14.7	16.1	17.9	20.4	24.2
17 - 6	17.1	19.0	21.4	24.6	29.0
Girls					
7 - 6	12.8	14.0	15.5	17.5	20.1
12 - 6	14.7	16.3	18.4	21.3	25.6
17 - 6	16.4	18.5	21.2	24.6	29.4

Source: WHO, 2007 *WHO Reference*.

Notes: 1. The BMI-for-age is for the 6th month of the respective age year

2. SD is standard deviation. A change of 1-SD is the same as 1 z-score unit where the mean is normalized (set to zero), which is more useful for comparison between age or population groups than the absolute change. The 1-SD and 2-SD levels approximates the 85th and 98th percentiles that correspond to the WHO cutoff for overweight and obese respectively. Below -1 SD is relatively underweight and those who are -2 SD or less would be poorly to severely underweight for age (severe thinness). The -2 score is defined as the critical thinness threshold for clinical intervention for children rather than -1, the usual cutoff for underweight in adults. See Cole et. al 2007.

Table 4: Change in BMI for 7, 11 and 17 years old children by region, 1979-2005

Boys	Age	1979	1985	1995	2005	BMI change 1979-2005
Northeast	7	14.6	14.8	15.3	16.3	1.7
	11	15.6	15.8	17.0	18.6	3.0
	17	19.0	19.6	19.9	20.9	1.8
East	7	14.5	14.6	15.1	16.1	1.6
	11	15.4	15.7	16.8	18.2	2.7
	17	19.0	19.6	20.0	20.5	1.5
Central	7	14.6	14.6	14.9	15.7	1.2
	11	15.6	15.6	16.3	17.6	2.0
	17	19.2	19.6	19.8	20.4	1.2
Western	7	14.6	14.6	14.7	15.5	0.9
	11	15.5	15.6	16.2	17.2	1.7
	17	19.2	19.4	19.6	20.0	0.7
Metropolitan	7	14.8	14.9	15.5	16.6	1.9
	11	15.8	16.1	17.6	19.1	3.3
	17	19.4	19.6	20.7	21.3	1.9
Girls	Age	1979	1985	1995	2005	BMI change 1979-2005
Northeast	7	14.3	14.4	14.9	15.5	1.2
	11	15.5	15.9	16.7	18.0	2.5
	17	19.7	20.1	20.2	20.6	0.9
East	7	14.2	14.3	14.8	15.4	1.2
	11	15.4	15.7	16.6	17.5	2.1
	17	19.7	19.9	19.9	20.1	0.4
Central	7	14.3	14.4	14.6	15.2	0.9
	11	15.5	15.7	16.1	17.1	1.5
	17	20.0	20.2	20.1	20.3	0.2
Western	7	14.3	14.3	14.4	14.9	0.6
	11	15.4	15.4	16.0	16.8	1.4
	17	20.0	20.1	20.1	20.1	0.1
Metropolitan	7	14.5	14.5	15.0	15.9	1.4
	11	15.9	16.0	17.3	18.0	2.2
	17	19.9	20.0	20.7	20.6	0.7

Sources: Estimated from *Report 1979*, *Report 1985*, *Report 1995* and *Report 2005*.

Note: Metropolitan is the Beijing, Tianjin and Shanghai municipalities; the northeast comprises Liaoning, Jilin and Heilongjiang; east comprises Hebei, Jiangsu, Zhejiang, Fujian, Guangdong and Hainan; central comprises Shanxi, Henan, Anhui, Jiangxi, Hubei and Hunan; and the western comprises Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, Chongqing municipality, Guangxi and Inner Mongolia (Tibet is excluded from this analysis).

Table 5: Correlations Matrix for Body Mass Index of Chinese Children aged 7, 12 and 17 years

	1) Mean BMI	2) Primary industry (share)	3) Secondary industry (share)	4) Life expectancy 2000	5) Regional gross product per capita (log)	6) Household income (log)	7) Food Expenditure (log)	8) Eating out expenditure (log)	9) Transport and comms spending (log)
Males									
1) Mean BMI	1.0000								
2) Primary industry (share)	-0.4840*	1.0000							
3) Secondary industry (share)	0.3503*	-0.6777*	1.0000						
4) Life expectancy 2000	0.1552	-0.4423*	0.1190	1.0000					
5) Regional gross product per capita (log)	0.5581*	-0.7455*	0.2688	0.7041*	1.0000				
6) Household income (log)	0.6735*	-0.3411*	0.0697	-0.0746	0.4899*	1.0000			
7) Food Expenditure (log)	0.5287*	-0.2084	-0.0486	-0.1946	0.3451*	0.9506*	1.0000		
8) Eating out expenditure (log)	-0.0323	-0.4130	-0.1205	0.3728	0.5493*	0.7375*	0.8532*	1.0000	
9) Transport and comms spending (log)	0.6196*	-0.3177	0.0721	-0.1501	0.4248*	0.9652*	0.9568*	0.8276*	1.0000
Females	1)	2)	3)	4)	5)	6)	7)	8)	9)
1) Mean BMI	1.0000								
2) Primary industry (share)	-0.4809*	1.0000							
3) Secondary industry (share)	0.3366*	-0.6777*	1.0000						
4) Life expectancy 2000	0.2211	-0.4423*	0.119	1.0000					
5) Regional gross product per capita (log)	0.5681*	-0.7455*	0.2688	0.7041*	1.0000				

9) Transport and comms spending (log)	0.5794*	-0.3177	0.0721	-0.1501	0.4248*	0.9652*	0.9568*	0.8276*	1.0000
---------------------------------------	---------	---------	--------	---------	---------	---------	---------	---------	--------

Notes:

1. * indicates significance at the 1% level (0.01).
2. The data for variables 2-3 and 5-9 are for year-end 2004. The BMI data are for 2005.
3. The logs of income and expenditure data are used because these are linearly related to height, weight and BMI.

Sources: NBS, Chinese Statistical Yearbook 2004, online edition www.stats.gov.cn; Report 2005.

Table 6: Correlation Matrix for Overweight and Obese Proportion of Chinese Children aged 7, 12 and 17 years

Males	1) Overweight & obese (share)	2) Primary industry (share)	3) Secondary industry (share)	4) Life expectancy 2000	5) Regional gross product per capita (log)	6) Household income (log)	7) Food Expenditure (log)	8) Eating out expenditure (log)	9) Transport and comms spending (log)
1) Overweight & obese (share)	1.0000								
2) Primary industry (share)	-0.3842*	1.0000							
3) Secondary industry (share)	0.2649	-0.6777*	1.0000						
4) Life expectancy 2000	-0.0116	-0.4423*	0.1190	1.0000					
5) Regional gross product per capita (log)	0.4540*	-0.7455*	0.2688	0.7041*	1.0000				
6) Household income (log)	0.7532*	-0.3411*	0.0697	-0.0746	0.4899*	1.0000			
7) Food Expenditure (log)	0.6391*	-0.2084	-0.0486	-0.1946	0.3451*	0.9506*	1.0000		
8) Eating out expenditure (log)	-0.0540	-0.4130	-0.1205	0.3728	0.5493*	0.9652*	0.9568*	1.0000	
9) Transport and comms spending (log)	0.7055*	-0.3177	0.0721	-0.1501	0.4248*	0.9652*	0.9568*	0.8276*	1.0000

Females	1)	2)	3)	4)	5)	6)	7)	8)	9)
1) Overweight & obese (share)	1.0000								
2) Primary industry (share)	-0.3428*	1.0000							
3) Secondary industry (share)	0.2090	-0.6777*	1.0000						
4) Life expectancy 2000	-0.0524	-0.4423*	0.1190	1.0000					
5) Regional gross product per capita (log)	0.3981*	-0.7455*	0.2688	0.7041*	1.0000				
6) Household income (log)	0.7317*	-0.3411*	0.0697	-0.0746	0.4899*	1.0000			
7) Food Expenditure (log)	0.6378*	-0.2084	-0.0486	-0.1946	0.3451*	0.9506*	1.0000		
8) Eating out expenditure (log)	-0.0723	-0.4130	-0.1205	0.3728	0.5493*	0.7375*	0.8532*	1.0000	
9) Transport and comms spending (log)	0.6791*	-0.3177	0.0721	-0.1501	0.4248*	0.9652*	0.9568*	0.8276*	1.0000

Notes:

1. * indicated significance at the 1% level (0.01).
2. The data for variables 2-3 and 5-9 are for year-end 2004. The overweight and obese (share) is the estimated proportion of the population for any age group whose BMI is 1 SD or higher than the WHO recommended median BMI. BMI is assumed to be more or less normally distributed for estimation of this proportion or share of the population overweight and obese.
3. The logs of income and expenditure data are used because these are linearly related to height, weight and BMI.

Sources: NBS, Chinese Statistical Yearbook 2004, online edition www.stats.gov.cn; Report 2005.

CQ revised bibliography

- Baten, Joerg, Debin Ma, Stephen Morgan and Qing Wang. 2010. "Evolution of Living Standards and Human Capital in China in the 18-20th Centuries: Evidences from Real Wages, Age-heaping, and Anthropometrics." *Explorations in Economic History* 47 (3), 347-59.
- Bell, A. Colin, Keyou Ge and Barry M. Popkin. 2002. "The road to obesity or the path to prevention: motorized transportation and obesity in China." *Obesity Research* 10 (4), 277-283.
- Bogin, Barry. 1999. *Patterns of Human Growth*. 2nd edition. New York: Cambridge University Press.
- Bramall, Chris. 2008. *Chinese Economic Development*. London: Routledge.
- Chinaposternet (<http://chinese posters.net/>).
- Cole, Tim J., Flegal, Katherine M., Nicholls, Dasha, and Jackson, Alan A. 2007. "Body mass index cut offs to define thinness in children and adolescents: international survey." *British Medical Journal*, 335: 194 (<http://dx.doi.org/10.1136/bmj.39238.399444.55>).
- Eveleth, Phyllis B. and James M. Tanner. 1990. *Worldwide Variation in Human Growth*. 2nd edition. Cambridge: Cambridge University Press.
- Fan, Cindy C. and Mingjie Sun. 2008. "Regional Inequality in China, 1978-2006." *Eurasian Geography and Economics* 49 (1), 1-18.
- Floud, Roderick, Robert W. Fogel, Bernard Harris and Sok Chul Hong. 2011. *The Changing Body: Health, Nutrition and Human Development in the Western World since 1700*. New York: Cambridge University Press.
- French, Paul. 2010. *Fat China: How Expanding Waistlines are Changing a Nation*. London: Anthem Press.
- Gilman, Sander L. 2008. *Fat: A Cultural History of Obesity*. Cambridge: Polity Press.

- Gorin, Amy A. and Melissa M. Crane. 2009. "The Obesogenic Environment." In Elissa Jelalian and Ric G. Steele (eds.), *Handbook of Childhood and Adolescent Obesity*. New York: Springer, 145-161.
- Hu, F. B., Y. Liu, W. C. Willett. 2011. "Preventing chronic diseases by promoting healthy diet and lifestyle: public policy implications for China." *Obesity Reviews* 12 (7), 552-559.
- James, W. P. T. 2008. "The fundamental drivers of the obesity epidemic." *Obesity Reviews* 9 (Supplement 1), 6-13.
- Ji, Chengye, and Working Group on Obesity in China (WGOC). 2005. "Body mass index reference for screening overweight and obesity change in Chinese school-age children." *Biomedical and Environmental Science*, 18, (xxxxxx), 390-400.
- Ji, Chengye and Tsung O. Cheng. 2008. "Prevalence and geographic distribution of childhood obesity in China in 2005." *International Journal of Cardiology* 131 (1), 1-8;
- Ji, Chengye and Tsung O. Cheng. 2009. "Epidemic increase in overweight and obesity in Chinese children from 1985 to 2005." *International Journal of Cardiology*, Vol. 132 No. 1 (2009), pp. 1-10.
- Komlos, John and Marek Brabec. 2011. "The trend of BMI values of US adults by deciles, birth cohorts 1882-1986 stratified by gender and ethnicity." *Economics and Human Biology* 9 (3), 234-250.
- Lardy, Nicholas. 1983. *Agriculture in China's Modern Economic Development*. New York: Cambridge University Press.
- Lee, Sing and Antoinette M. Lee. 2000. "Disordered eating in three communities of China: A comparative study of female high school students in Hong Kong, Shenzhen, and rural Hunan." *International Journal of Eating Disorders* 27 (3), 317-327;

- Levine, James A. 2007. "Obesity in China: Causes and solutions." *Chinese Medical Journal* 120 (11), 1043-1050.
- Luo, Ye, William L. Parish, Edward O. Laumann. 2005. "A population-based study of body image concerns among urban Chinese adults." *Body Image* 2 (4), 333-345.
- Ma, Jixiang, Meng Qingyue, Yu Yang, Xu Aiqiang, Fan Jie, Lu Zilong and Li Weika. 2009. "Shandong sheng nongcun jumin chaozhong ji feipang yingxiang yingsu fenxi" (Analysis of risk factors for overweight and obesity in rural Shandong). *Zhongguo gonggong weisheng* (Chinese Journal of Public Health), Vol. 25, No. 7, 820-822.
- Morgan, Stephen L. 2000. "Richer and Taller – Stature and the Standard of Living in China, 1979-1995." *The China Journal* 44, 1-39.
- Morgan, Stephen L. 2004. "Economic Growth and the Biological Standard of Living in China, 1880-1930." *Economics and Human Biology* 2 (2), 197-218.
- Morgan, Stephen, and Shiyung Liu. 2007. "Was Japanese Colonialism Good for the Welfare of the Taiwanese? Stature and the Standard of Living." *The China Quarterly* 192, 990-1017.
- Morgan, Stephen and Fang Su. 2011. "Regional inequalities in China – A non-monetary view." In Shujie Yao, Bin Wu, Stephen Morgan and Dylan Sutherland (eds.), *Sustainable Reform and Development in Post-Olympic China*. London: Routledge, 38-59.
- Morrill, Allison C. and Christopher D. Chinn. 2004. "The Obesity Epidemic in the United States." *Journal of Public Health Policy* 25 (3/4), 353-366.
- National Bureau of Statistics (NBS). 1983-2011. *Chinese Statistical Yearbook*. Beijing: Tongji chubanshe. Those consulted for years 2005 and 2011 were the online editions available at www.stats.gov.cn.

- Ó Gráda, Cormac. 2008. "The ripple that drowns? Twentieth century famines in China and India as economic history." *Economic History Review* 61 (supplement), 5-37.
- Ó Gráda, Cormac. 2009. *Famine: A Short History*. Princeton: Princeton University Press.
- Olds, Kelly. 2003. "The biological standard of living in Taiwan under Japanese occupation." *Economics and Human Biology* 1 (2), 187-206.
- Piazza, Alan. 1986 *Food Consumption and Nutritional Status in the People's Republic of China*. Stanford: Stanford University Press.
- Popkin, Barry M. 2001. "Nutrition in transition: The changing global nutrition challenge." *Asia Pacific Journal of Clinical Nutrition* 10 (1), 13-18;
- Popkin, Barry M., Bing Lu and Fengying Zhai. 2002. "Understanding the nutrition transition: measuring rapid dietary changes in transitional countries." *Public Health Nutrition* 5 (6A), 947-953.
- Popkin, Barry M. 2009. *The World is Fat: The Fads, Trends, Policies and Products that are Fattening the Human Race*. New York: Avery.
- Popkin, Barry M. 2010. "Recent dynamics suggest selected countries catching up to US obesity." *American Journal of Clinical Nutrition* 91(suppl), 284S-8S.
- Popkin, Barry M. 2011. "Does global obesity represent a global public health challenge?" *American Journal of Clinical Nutrition* 93 (2), 232-233.
- Rigby, Neville J., Shiriki Kumanyika and W. Phillip T. James. 2004. "Confronting the Epidemic: The Need for Global Solutions." *Journal of Public Health Policy* 25 (3), 418-434.
- Riskin, Carl. 1986. *China's Political Economy: The Quest for Development Since 1949*. Oxford: Oxford University Press.
- Riskin, Carl, Zhao Renwei, Li Shi (eds). 2002. *China's retreat from equality: Income distribution and economic transition*. Armonk/London: M.E. Sharpe.

- Steckel, Richard H. 1995. "Stature and the Standard of Living." *Journal of Economic Literature* 33 (4), 1903-1940.
- Steckel, Richard H. and Roderick Floud. 1997. "Introduction." In Richard H. Steckel and Roderick Floud, (eds), *Health and Welfare during Industrialization*. Chicago: University of Chicago Press, 1-16.
- Subramanian, S.V., Jessica M. Perkins, Emre O'zaltin, and George Davey Smith. 2011. "Weight of nations: a socioeconomic analysis of women in low- to middle-income countries." *American Journal of Clinical Nutrition* 93 (2), 413-21.
- Watson, James L. 2000. "Food as a lens: The past, present and future of family life in China." In Jun Jing (ed.), *Feeding China's little emperors: Food, children and social change*. Stanford University Press, 199-212.
- WHO (World Health Organisation). 2000. *Obesity: Preventing and Managing the Global Epidemic*. Geneva: World Health Organisation.
- WHO. 2004. *Global Strategy on Diet, Physical Activity and Health*. Geneva: WHO.
- WHO. 2007. WHO 2007 growth reference.
http://www.who.int/growthref/who2007_bmi_for_age/en/ (accessed 10 Oct 2011).
- WHO. 2013. Cardiovascular Diseases (CDVs), Factsheet No. 317.
<http://www.who.int/mediacentre/factsheets/fs317/en/> (accessed 26 August 2013).
- WHO Expert Consultation Group. 2004. "Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies." *Lancet* 363, 157-63.
- Wu, Yangfeng. 2006. "Overweight and obesity in China." *British Medical Journal* 333 (17 August), 362 (doi: 10.1136/bmj.333.7564.362).

Xu, Xiaoyan, David Mellor, Melanie Kiehne, Lina A. Ricciardelli, Marita P. McCabe, Yangang Xu. 2010. "Body dissatisfaction, engagement in body change behaviors and sociocultural influences on body image among Chinese adolescents." *Body Image* 7 (2), 156–164.

Yu Xu et al (2010 China Noncommunicable Disease Surveillance Group). 2013. "Prevalence and control of diabetes in Chinese adults." *JAMA* 310 (9), 948-958.

Zhao, W., Y. Zhai, J. Hu, J. Wang, Z. Yang, L. Kong, and C. Chen. 2008. "Economic burden of obesity-related chronic diseases in Mainland China." *Obesity Reviews* 9 (Suppl. 1), 62–67.

Zhongguo kexue jishu qingbao yanjiusuo [China scientific and technical intelligence research institute] (ed.), *Kexue jishu chengguo baogao: Zhongguo qingshaonian ertong shenti xingtai, jineng yu suzhide yanjiu* [*Scientific-technical report: Research on the body build, functions and quality of Chinese youth and children*], (Beijing: kexue jishu wenxian chubanshe, 1982), hereafter *Report 1979*;

Zhongguo xuesheng tizhi yu jiankang yanjiuzu [Chinese student physique and health research group], (eds), *Zhongguo xuesheng tizhi yu jiankang yanjiu* [*Research on the physique and health of Chinese students*], (Beijing: renmin jiaoyu, 1988), hereafter *Report 1985*;

Zhongguo xuesheng tizhi yu jiankang yanjiuzu [Chinese student physique and health research group], (eds), *Zhongguo xuesheng tizhi yu jiankang jiance baogao, 1991* [*Report on the physique and health surveillance of Chinese school students, 1991*], (Beijing: Beijing kexue jishu, 1993), hereafter *Report 1991*;

Zhongguo xuesheng tizhi yu jiankang yanjiuzu [Chinese student physique and health research group], (eds), *Zhongguo xuesheng tizhi yu jiankang jiance baogao, 1995* [*Report on the physique and health surveillance of Chinese school students, 1995*], (n.p.: Jilin kexue jishu, 1996), hereafter *Report 1995*;

Zhongguo xuesheng tizhi yu jiankang yanjiuzu [Chinese student physique and health research group], (eds), *2000 nian Zhongguo xuesheng tizhi yu jiankang jiance baogao* [Report on the physique and health surveillance of Chinese school students, 2000], (Beijing: Gaodeng jiaoyu, 2002), hereafter *Report 2000*.

Zhongguo xuesheng tizhi yu jiankang diaoyanzu, ed, *2005 nian Zhongguo xuesheng tizhi yu jiankang diaoyan baogao* (Report on the Physical Fitness and Health Surveillance of Chinese School Students, 2005), (Beijing: Gaodeng jiaoyu, 2007), p.90, hereafter abbreviated *Report 2005*.