Original Article

Empirical Changes in the Prevalence of Overweight and Obesity among Chinese Students from 1985 to 2010 and Corresponding Preventive Strategies

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Abstract

Objective To determine the extent of the obesity epidemic in school-aged Chinese children in 2010 and track the increasing trend in different socioeconomic regions over the preceding 25 years. Strategies for preventing childhood obesity are suggested.

Methods We used a dataset provided by the Chinese National Survey on Students' Constitution and Health from 1985-2010. Subjects were 7-18-year-old students randomly selected from urban and rural areas in 30 provinces. Eight subgroups were created according to region and socioeconomic status.

Results Increased rates of the epidemic (overweight and obesity combined) were greatest in large coastal cities-32.6% and 19.1% among males and females, respectively. These rates has neared that of developed countries. Similar increases were found in all other regions, including the once poverty-stricken rural west. The epidemic in most of the rural areas began after 2000, but has spread swiftly over the last decade. In 2010, it was estimated that 9.9% of Chinese school-aged children and adolescents were overweight and that an additional 5.1% were obese, representing an estimated 30.43 million individuals.

Conclusion The prognosis for China's childhood-obesity epidemic is dire. To prevent childhood obesity, we suggest several strategies, including reasonable dietary intake, increase physical activity, a change in sedentary lifestyles and corresponding behavioral modifications.

Key words: Obesity; Chinese school-aged children; Prevalence; Temporal changes; Socioeconomic status

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INTRODUCTION

Obesity is a global public health threat, widely recognized as a risk factor for coronary heart disease, hypertension, diabetes and many other health problems. It is associated with decreased life expectancy, impaired quality of life and a heavy economic burden[1]. Obesity affects virtually every age group in every population, in both developed and developing countries[2]. There are numerous reports on the current epidemic of child and adolescent obesity[3-5]. In the United States in 2009-2010, two out of twelve (16.9%) of those between the ages of 2 and 19 were

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obese; and rates were as high as 24.3% among non-Hispanic black and 21.2% among Hispanic youth. Among school-aged children and adolescents, the overall rates by age groups were 12.3% at or above the 97th percentile[6]. In a cross-sectional survey from 21 European countries, Lobstein and Frelut found a high prevalence of overweight/obesity in western and southern Europe[7]. Rada et al. (2011) demonstrated that several Mediterranean countries had the dubious distinction of holding world records for childhood overweight prevalence and obesity, their rates having remained extremely high as well as fairly stable over the past decade. More than a quarter (26%) of Spanish children were found to be overweight and a fifth (19%) were obese, while Italy, Portugal, Slovenia and Malta are described by the World Health Organization's (WHO) European Childhood Obesity Surveillance as being in an "alarming" situation because of the rate at which their obesity rates are rising[8]. Many developing countries undergoing socioeconomic transitions have also been besieged by an ever-expanding obesity epidemic in recent decades[9]. Guedes et al. (2011) reported that in a developing region of Brazil, the prevalences of overweight and obesity were 11.1% and 2.7%, respectively, among school-aged females and 8.2% and 1.5% among school-aged males; rates for males and females for the two weight categories combined were 2.5 times higher in 1990 than in 1970[10]. According to the WHO, it is not just that the absolute number of children in developing countries joining the overweight-obesity ranks is increasing, the percentage has also increased, to 4.3%. This is admittedly far from the 48.3% and the 10.4% in developed and other transitional countries, respectively, but it is far more than one would reasonably expect in regions where food is relatively scarce[11]. It is unfortunate that this major socioeconomic issue has been largely ignored by the global community of policymakers.

Our previous study in 2007 reported changes in the prevalence of overweight/obesity among Chinese school-aged children between 1985 and 2000, and revealed that it took no more than this brief 15-year period for its population-long associated with a slender and slight build-to join the ranks of the global obese, risking not only short-term but lifelong health problems[12]. By the end of 2000, the obesity rate of male students in Beijing reached 15%, doubling the 1990 rate and becoming close to that of developed countries[13]. However, because socioeconomic status (SES) varies greatly throughout China and because the country consists of many local cultures that each abide by their own customs and traditions, the geographical distribution of this epidemic has not been fully explored. Moreover, our study was limited in that we only focused on urban areas, while the prevalence in rural regions, where more than 70% of the population lives, had not been systemically evaluated. Over the past ten years, several reports indicated that the obesity epidemic was truly national, sparing neither urban nor rural regions; more surprising was the fact that it has spread to once-impoverished rural areas, where the population's diet is barely at subsistence level[14-16]. To estimate the current extent of the obesity epidemic nationwide and to predict its trends, its relationship to the rapid economic development and the regional divergences in SES that have marked the past decade needs to be determined. For this reason, the objectives of the present study are: a) to estimate the prevalence of the epidemic of overweight and obesity among school-aged children throughout the country; b) to compare the temporal changes of the epidemic in various SES regions over the preceding 25 years (1985-2010); and c) to promote strategies corresponding to the epidemiological characteristics of childhood obesity in China, to take more effective measures for obesity control.

METHODS

Data Sources and Sampling

Data were obtained from the 1985, 1995, 2000, 2005, and 2010 cycles of the Chinese National Survey on Students' Constitution and Health (CNSSCH), a joint project of the Ministries of Education, Health, Science and Technology, the State Ethnic Affairs Commission and the State Sports General Administration, China[17-22]. This is a multi-province survey rather than a classical epidemiological one, but it comprises the largest national-representative sample of school-aged children and has been widely used to estimate the prevalence for a variety of health indicators at the national and provincial levels. The subjects are primary and secondary school students aged 7-18 years randomly selected from 30 of the 31 mainland provinces, excluding Tibet, the only one in which Han Chinese do not constitute an ethnic majority. Each province was considered an independent subpopulation and the local institutes of school

health collected a province-wide sample by means of a three-stage clustering process. In each of the provinces, the subjects were classified by gender and region (urban or rural), and each of the four groups consisted of equal numbers of individuals from three SES classes (upper, middle, and lower). The five indices constituting the criteria for defining the three classes were made province-specific in 1985: the regional gross domestic product, the total yearly income per capita, the average food consumption per capita, the natural growth rate of the population and the regional social-welfare index[17]. During the second sampling step, three urban and three rural residential areas were selected. Next, several primary and secondary schools were randomly selected from a list compiled by each area's Educational Committee. A list of students from grades 1-12 was compiled, and a random selection of two or three classes (depending on their size) was made from each grade level.

Ethical approval was obtained from Peking University's Medical Research Ethics Committee and informed consent was obtained verbally. The students were informed that their privacy would be respected. To ensure the validity of comparisons among samples, the subjects in each group were selected at random at various time periods. Because all the subjects in the 1991 cycle were drawn only from the upper class, these data were excluded from the study[18]. In addition, over the course of the entire series of cycles from 1985-2010, not only were the subjects drawn from the same set of urban and rural areas, but 86.6% and 78.9%, respectively, of those schools remained in the sample. All of the subjects were Han Chinese (along with 92.7% of the population nationwide) and had lived for at least one year in the local area. By means of this process, each province provided suitable subjects, for a total of 359 946 (294-306 in each gender-age subgroup) in 1985; 204 977 in 1995; 216 654 in 2000; 234 421 in 2005 (155-169 in each subgroup); and 297 062 in 2010 (162-181 in each subgroup).

Classification of SES Subgroups

To permit a comparison of SES-specific temporal changes in the prevalence of overweight/obesity, all subpopulations were further divided into eight groups: I (Large coastal city), II (Other upper class/large city), III (Middle class/city), IV (Lower class/city), V (Upper class/rural), VI (Middle class/rural), VII (Lower class/rural), and VIII (western/lower class/rural). Group I included the nine largest cities (Beijing, Shanghai, Tianjin, Shijiazhuang, Shenyang, Dalian, Jinan, Qingdao and Nanjing) and like Group II, represented the upper urban class. Group VIII constituted the other extreme: rural regions in western provinces, home to the lowest SES class. Table 1 represents the sample sizes of each group in different cycles. Since 1985, each of these groups represented a single province. However, by the end of the study period, this was no longer the case, but the groups remained unmodified, to permit an analysis of the evolution of the overweight/obesity epidemic at the national level over the course of the entire 25-year period.

Table 1. The Sample Sizes of Each Regional Group in Different Cycles[§1], 1985-2010

Regional Group	in 1985		in 1995		in 2000		in 2005		in 2010	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Group I (Large coastal city)	16 324	16 314	8 693	8 688	11 400	11 396	12 208	12 196	15 170	15 162
Group II (Other upper class/large city)	20 227	20 222	13 191	13 183	13 238	13 233	13 771	13 764	19 028	19 014
Group III (Middle class/city)	27 544	27 478	13 515	13 507	14 255	14 247	14 656	14 651	20 151	20 146
Group IV (Lower class/city)	26 354	26 364	11 860	11 867	14 729	14 737	11 608	11 602	15 061	15 043
Group V (Upper class/rural)	17 382	17 377	13 963	13 956	12 816	12 811	14 534	14 529	19 023	19 011
Group VI (Middle class/rural)	21 200	21 193	14 424	14 418	12 891	12 885	14 849	14 856	24 025	24 032
Group VII (Lower class/rural)	27 497	27 494	14 897	14 887	14 965	14 969	16 001	16 011	20 277	20 265
Group VIII (Western/lower class/rural)	23 496	23 480	11 964	11 964	14 044	14 038	19 549	19 636	15 831	15 823
Total	359 946		204 977		216 654		234 421		297 062	

Note. [§1] Including all urban and rural gender-age subgroups in all 30 provinces.

Physical Measurement

All subjects underwent a thorough medical examination before measurement and the data of those suffering from obvious diseases or physical/mental deformities were excluded.

Stature (cm) and weight (kg) were measured by the same technicians, all of whom had passed a rigorous one-week training session. All measurements were taken according to a standardized procedure by means of a uniformly recommended apparatus. The subjects were asked to use the restroom before being measured. Metal column height measuring stands (each 200 cm long with 0.1 cm precision) were used to measure stature. The subjects were required to stand straight on the instruments, barefoot and at ease. Weight was measured with lever scales (each weighing 120 kg with 0.1 kg precision), while the subjects wore only their underwear. Rigid quality control measures were enforced in the field. After the completing the daily measurements, 3% of the subjects were asked to be measured again (86.2% of the students agreed to do so). Subjects whose measurements had disparities exceeding the limiting scores were considered invalid cases. The coefficients of variations among provinces ranged from 1.5% to 2.1% in 1985, 1.5% to 2.1% in 1995, 1.7% to 2.2% in 2000, 1.6% to 2.0% in 2005, and 1.7% to 2.1% in 2010. Each of the samples was collected independently to minimize the risk of overlap. Therefore, in testing the differences among different groups and within two cycles, a covariance of zero was assumed.

Definitions for Overweight and Obesity

Body mass index (BMI) is calculated by dividing weight in kilograms by stature in meters squared (kg/m^2). Overweight and obesity were defined by using WGOC criteria ('Body Mass Index Reference for Screening Overweight and Obesity in Chinese School-aged Children'). A BMI of 24 and 28 were cutoffs for overweight and obesity for both males and females over 18 years of age[23]. The national and regional percentages of overweight, obesity, and overweight and obesity combined were estimated. Based on one-year estimates, we made two broad cross-sectional categories, for children (7-12 years of age) and for adolescents (13-18 years of age).

Statistical Analysis

Data input was performed by using Epidata 3.1 software, and calculations were conducted using the SPSS/PC 16.0 package. In each of the groups, pair-wised chi-square tests were used to determine the significance ($P<0.01$ or $P<0.001$) of any difference between two successive years.

RESULTS

Prevalence of Overweight and Obesity in 2010

In 2010, a large-disparity in the prevalence of overweight/obesity was found among the eight SES groups. The highest rates for overweight and obesity combined (the percentages that follow are for males and females) were in Group I (32.6% and 19.1%), followed by Groups II, III, and V (20% or above and 12% or above), Groups IV, VI, and VII (13% or above and 8% or above), and finally Group VIII (8.2% and 5.3%). When it came to obesity, the pattern was the same from Group I (13.7% and 7.9%) to Group VIII (2.2% and 1.2%). For both obesity and overweight and obesity combined per municipality, Group I placed first, followed by the others, generally in the order of Group II to Group VIII. The only exceptions were that the rates for the males and females in Group V were significantly higher than the respective rates in Groups III and II (Table 2).

Table 2. Prevalence of Overweight and Obesity in Eight Regional Groups of Students Aged 7-18, 2010

Populations	Males			Females		
	Overweight (%)	Obesity (%)	Overweight+ Obesity (%)	Overweight (%)	Obesity (%)	Overweight+ Obesity (%)
Group I (Large coastal city)	18.9	13.7	32.6	11.2	7.9	19.1
Group II (Other upper class/large city)	15.8	10.2	26.1	9.1	5.0	14.1
Group III (Middle class/city)	15.1	8.3	23.4	9.0	3.8	12.8
Group IV (Lower class/city)	11.6	6.0	17.6	6.6	2.8	9.4
Group V (Upper class/rural)	15.5	8.9	24.4	9.5	5.2	14.7
Group VI (Middle class/rural)	9.8	5.3	15.1	6.1	2.6	8.8
Group VII (Lower class/rural)	9.4	4.0	13.4	6.3	2.3	8.6
Group VIII (Western/lower class/rural)	6.0	2.2	8.2	4.0	1.2	5.3
Total	12.3	6.7	19.0	7.5	3.4	10.9

Whether for obesity or overweight and obesity combined, the rates were markedly higher among children than among adolescents; this feature was most significant in the obesity rates among the four rural groups (Figures 1 and 2). It was clear that males living in the large coastal cities belonged to the highest risk subpopulation.

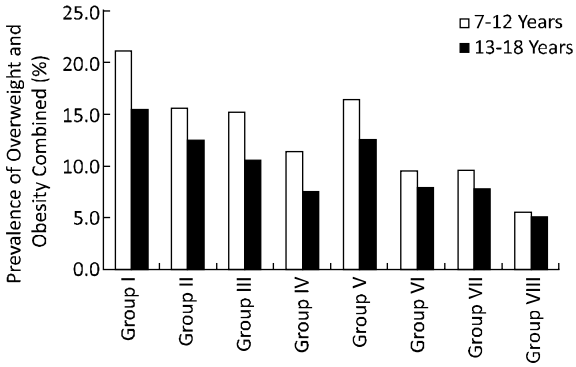

Figure 1. Comparison of prevalence of overweight and obesity combined category between females aged 7-12 years and 13-18 years in different groups.

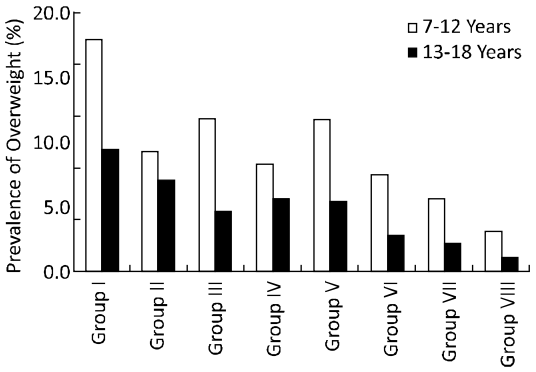

Figure 2. Comparison of obesity prevalence between males aged 7-12 years and 13-18 years in different groups.

Steep Epidemic Increases among the Urban and Affluent Rural Regions

Tables 3 and 4 present an overview of the overweight and obesity rates for all subjects throughout the entire study period, by region. They are graphically shown in Figures 1-4. Compared with the prevalence of overweight and obesity combined in 1985, Group I was 5.0 and 3.7 fold higher for males and females, respectively, in 1995, 6.7 and 4.8 fold higher in 2000, 8.1 and 5.4 fold higher in 2005, and 8.8 and 6.3 fold higher in 2010. Although the social status of Group II is the same (upper class/city) as that of Group I, the obesity epidemic had yet to occur in 1985-as opposed to Group V (upper class/rural), in which the obesity epidemic occurred at the same time as Group I and before all other rural groups. Thus, Groups II, III (middle class/city), IV (lower class/city) and V made up the second gradient and were characterized by a relatively late onset followed by a steep increase in the combined rates. Compared with statistics for 1995, there were 1.6 and 1.6-fold increases for males and females, respectively, in Group II in 2000, 1.7 and 1.1-fold increases in Group V, 2.1 and 1.9-fold increases in Group III, and 2.4 and 1.8-fold increases in Group IV. In 2010, there were 2.6 and 2.7-fold increases in Group II, 3.6 and 2.6-fold increases in Group V, 3.3 and 2.8-fold increases in Group III, and 4.2 and 2.8-fold increases in Group IV (Figure 3).

The Sustained and Swift upward Trend among the Vast Rural Regions

The third gradient is made up of three rural groups (VI, VII, and VIII) and was characterized by a significantly later onset (after 2000), with an epidemic increase that was less steep than in the other two gradients. However, it was swift and sustained throughout the final ten years of the study period, while most of the cases in the combined categories among which are overweight rather than obesity (Figure 4). Compared with the rates of overweight and obesity combined in 2000, there were 1.5 and 1.4-fold increases in Group VI and 1.7 and 1.3-fold increases in Group VII in 2005, and were 2.7 and 2.2-fold increases in Group VI and 2.4 and 1.8-fold increases in Group VII in 2010, for males and females, respectively. As in Group VIII, the epidemic for both overweight and obesity was just beginning in 2000; the rates accelerated quickly thereafter, leading to 1.7 and 3.3-fold increases for males and 1.5 and 2.0 fold increases for females, during 2000-2005 and 2005-2010, respectively.

Figure 5 shows the geographic distribution of different urban and rural groups (here, the groups III and IV, VI and VII are temporarily combined, respectively). Displaying the prevalence of overweight and obesity combined in 2010 and the annual increases during the 25 years together reveals the association between the epidemic rates and the socioeconomic regions.

DISCUSSION

The nationwide comparisons in this study suggest that regional epidemic rates of overweight

Table 3. Prevalence and Trends of Overweight and Obesity in Eight Groups of Chinese Male Students Aged 7-18 Years

Population	Overweight[§1]					Obesity[§1]				
	1985	1995	2000	2005	2010	1985	1995	2000	2005	2010
7 to 12-year-old Males										
Group I (Large coastal city)	3.40	11.9**	16.1**	19.9**	20.7*	1.0	7.3**	12.3**	16.2**	17.8**
Group II (Other upper class/large city)	0.71	6.6**	11.5**	14.4**	17.0**	0.2	2.3**	5.7**	8.6**	9.3*
Group III (Middle class/city)	0.86	6.2**	10.1**	14.3**	16.9**	0.2	1.9**	5.8**	9.2**	11.8*
Group IV (Lower class/city)	0.50	3.8**	8.6**	10.4**	13.3**	0.1	0.9**	3.4**	5.7**	8.3*
Group V (Upper class/rural)	0.67	4.5**	7.6**	12.7**	16.2**	0.1	2.2**	3.6**	8.4**	11.7**
Group VI (Middle class/rural)	0.35	1.4**	4.2**	6.2**	11.2**	0.1	0.4*	2.3**	3.5*	7.6**
Group VII (Lower class/rural)	0.24	1.8**	4.0**	7.5**	10.5**	0.1	0.5*	1.9**	3.5**	5.7*
Group VIII (Western/lower class/rural)	0.31	1.0*	1.8*	3.8**	7.5**	0.1	0.3*	0.9*	1.7*	3.2**
Average	0.90	5.1**	8.0**	11.2**	14.2**	0.23	2.0**	4.5**	7.1**	9.4**
13 to 18-year-old Males										
Group I (Large coastal city)	2.70	12.5**	15.0**	17.0**	17.2	0.40	5.4**	6.6*	7.8*	9.5**
Group II (Other upper class/large city)	0.71	6.2**	10.7**	13.0**	14.7**	0.04	1.3*	3.2**	5.4**	7.1**
Group III (Middle class/city)	0.84	5.3**	9.2**	10.8*	13.2**	0.04	0.9*	3.8**	4.4*	4.8*
Group IV (Lower class/city)	0.60	3.6**	6.6**	7.5**	9.9**	0.10	0.5*	1.7**	2.0*	5.7**
Group V (Upper class/rural)	1.00	5.0**	7.6**	10.2**	14.1**	0.03	1.5*	2.3**	4.0**	5.5**
Group VI (Middle class/rural)	0.34	2.3**	3.6**	5.2**	8.3**	0.01	0.1*	0.8*	2.2**	2.9**
Group VII (Lower class/rural)	0.40	2.0*	4.0**	5.6**	8.4**	0.02	0.2*	1.1**	1.6*	2.3**
Group VIII (Western/lower class/rural)	0.37	0.8	1.8*	2.6*	4.5**	0.01	0.1*	0.4*	0.5	1.2*
Average	0.90	4.7**	7.3**	9.0**	11.3**	0.08	1.3*	2.5**	3.5**	4.9**
7 to 18-year-old Males										
Group I (Large coastal city)	3.10	12.2**	15.5**	18.2**	18.9*	0.70	6.3**	9.6**	12.0**	13.7**
Group II (Other upper class/large city)	0.71	6.4**	11.1**	13.7**	15.8**	0.10	1.8**	4.5**	7.0**	10.2**
Group III (Middle class/city)	0.85	5.7**	9.9**	12.6**	15.1**	0.10	1.4**	4.8**	6.8**	8.3**
Group IV (Lower class/city)	0.57	3.5**	7.6**	9.0**	11.6**	0.10	0.7*	2.5**	3.8**	6.0**
Group V (Upper class/rural)	0.84	4.7*	7.6**	11.5**	15.1**	0.10	1.9**	3.9**	6.2**	8.6**
Group VI (Middle class/rural)	0.35	1.6**	3.9**	5.7**	9.8**	0.00	0.2	1.6*	2.8**	5.3**
Group VII (Lower class/rural)	0.32	1.9*	4.0**	6.6**	9.4**	0.05	0.3*	1.5**	2.6**	4.0**
Group VIII (Western/lower class/rural)	0.34	0.9*	1.8*	3.2**	6.0**	0.04	0.2*	0.7*	1. 1*	2.2*
Average	0.90	4.6**	7.7**	10.1**	12.7**	0.15	1.5*	3.6**	5.3**	7.3**

Note. [§1] Significance of difference between the two successive years in the same group by the pair-wised χ^2 test: $^{*}P<0.01$, $^{**}P<0.001$.

Table 4. Prevalence and Trends of Overweight and Obesity in Eight Groups of Chinese Female Students Aged 7-18 Years

Population	Overweight[§1]					Obesity[§1]				
	1985	1995	2000	2005	2010	1985	1995	2000	2005	2010
7 to 12-year-old Females										
Group I (Large coastal city)	1.90	6.7**	9.1**	10.6**	11.1*	0.68	4.9**	6.7**	7.6*	9.8**
Group II (Other upper class/large city)	0.58	3.2**	5.2**	7.3**	8.9**	0.13	1.5**	3.3**	4.2*	6.7**
Group III (Middle class/city)	0.63	3.0**	5.5**	7.3**	9.4**	0.16	1.2**	3.5**	5.4**	5.6
Group IV (Lower class/city)	0.45	1.9**	4.5**	5.7*	7.1**	0.10	1.0**	1.9**	2.6*	4.3**
Group V (Upper class/rural)	0.60	3.5**	5.0**	7.7**	9.2**	0.14	1.2**	2.4**	5.6**	7.2**
Group VI (Middle class/rural)	0.25	0.9*	2.5**	3.6*	5.8**	0.14	0.4*	1.4*	2.0**	3.8**
Group VII (Lower class/rural)	0.26	0.9*	2.6**	4.4**	6.0**	0.07	0.4*	1.4*	2.2*	3.6**
Group VIII (Western/lower class/rural)	0.19	0.7*	1.2**	2.4**	3.7**	0.10	0.2	0.7*	1.2*	1.8*
Average	0.60	2.6**	4.5**	6.1**	7.7**	0.19	1.4**	2.7**	3.9**	5.4**
13 to 18-year-old Females										
Group I (Large coastal city)	3.1	8.1**	9.3*	10.2*	11.4**	0.35	2.6**	3.4*	4.1*	4.1
Group II (Other upper class/large city)	1.6	5.0**	7.0**	7.7*	9.2*	0.09	0.9**	1.7**	2.5*	3.2*
Group III (Middle class/city)	1.7	4.4**	7.0**	7.3	8.6**	0.08	0.6*	1.9**	2.1	1.9
Group IV (Lower class/city)	1.8	3.4**	4.4**	5.1*	6.1*	0.05	0.4*	0.7*	1.0*	1.4*
Group V (Upper class/rural)	3.0	5.6**	6.0	9.2**	9.5*	0.08	1.0**	1.6*	2.1*	3.0**
Group VI (Middle class/rural)	2.2	3.2*	3.7*	4.7*	6.4**	0.02	0.2*	0.5*	1.0*	1.5**
Group VII (Lower class/rural)	2.9	3.1	4.8**	4.8	6.7*	0.03	0.1*	0.8*	0.8	1.0
Group VIII (Western/lower class/rural)	3.0	3.3	3.0	3.7*	4.4*	0.01	0.1	0.3	0.3	0.7*
Average	2.4	4.5**	5.7*	6.6*	7.8*	0.09	0.7**	1.4*	1.7*	2.1*
7 to 18-year-old Females										
Group I (Large coastal city)	2.5	7.5**	9.2**	10.4*	11.2*	0.51	3.7**	5.2**	5.9*	7.9**
Group II (Other upper class/large city)	1.1	4.2**	6.1**	7.5**	9.1**	0.11	1.1**	2.5**	3.3**	5.0**
Group III (Middle class/city)	1.2	3.7**	6.2**	7.3**	9.0**	0.12	0.9**	2.7**	3.8**	3.8
Group IV (Lower class/city)	1.1	2.6**	4.5**	5.4*	6.6**	0.08	0.7*	1.3*	1.8*	2.8**
Group V (Upper class/rural)	1.8	4.5**	5.5*	8.4**	9.4**	0.11	1.1**	2.0**	3.9**	5.1**
Group VI (Middle class/rural)	1.2	2.1*	3.1*	4.1**	6.1**	0.08	0.3*	0.9*	1.5*	2.6**
Group VII (Lower class/rural)	1.6	2.0	3.7**	4.6*	6.3**	0.05	0.2*	1.1**	1.5*	2.3**
Group VIII (Western/lower class/rural)	1.6	1.9	2.1	3.1*	4.0**	0.05	0.2*	0.5*	0.7	1.2*
Average	1.5	3.6**	5.1**	6.4**	7.7**	0.14	1.0**	2.0**	2.8*	3.8**

Note. [§1] Significance of difference between the two successive years in the same group by the pair-wised χ^2 test: *P<0.01, **P<0.001.

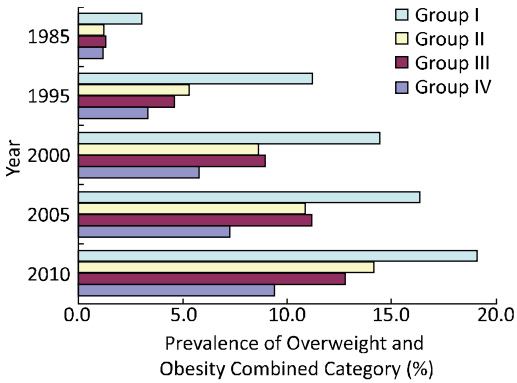

Figure 3. Empirical changes in the prevalence of overweight and obesity combined category among females aged 7-18 years in four city groups.

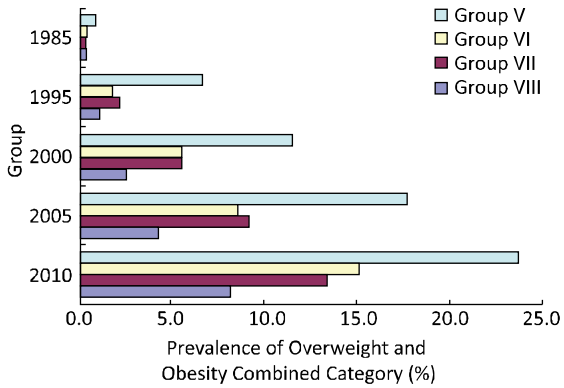

Figure 4. Empirical changes in the prevalence of overweight and obesity combined category among males aged 7-18 years in four rural groups.

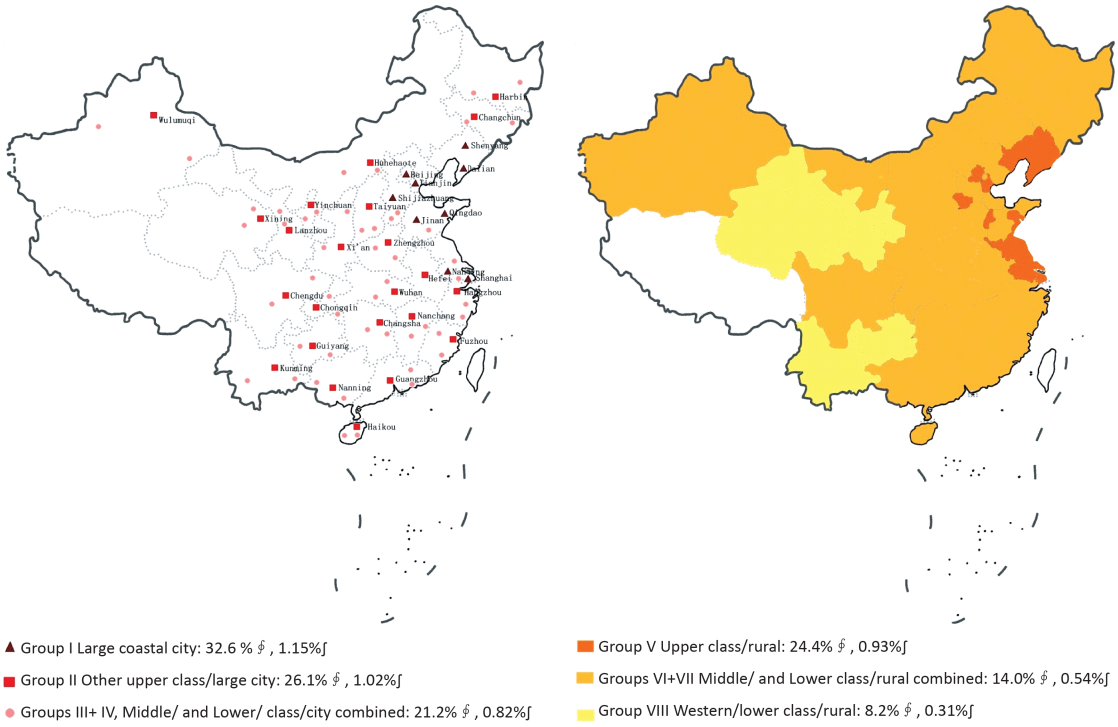

Figure 5. The geographic distribution of (left) urban groups and (right) rural groups with different epidemic rates of overweight and obesity; note: ∮ the prevalence of overweight and obesity combined in 2010; ∫ the annual increase of overweight and obesity combined during the period of 1985-2010.

and obesity are in direct proportion to regional developmental processes. However, regional disparities in both prevalence and empirical trends make it difficult to develop reliable national estimates using the overall criteria[24]. For this reason, we applied a gradient analysis to the gender-age subgroups (Tables 3 and 4) and then extrapolated them to the regional level. Only then were we able to estimate the proportions in each of the eight regions (separately for the two gender-age groups) according to the percentage of the total Chinese population represented by each region. This resulted in estimates for the national population as a whole. The overall prevalence for overweight in 2010 was 9.9% (12.3% for males and 7.5% for females) and 5.1% (6.7% for males and 3.4% for females) for

obesity in Chinese school-aged children. In 2010, there were 202 850 000 children and adolescents (7-18 years old), accounting for 14.7% of the total population (1.38 billion)[25]. Thus, the national estimates are 20.08 million overweight children/ adolescents (12.37 million males and 7.71 million females) and 10.35 million obese children/adolescents (6.80 million males and 3.55 females). The number of overweight and obese young people (30.43 million) has almost doubled (about 89%) from the 16.11 million (9.91 million males and 6.20 million females) in 2000.

It is well known that overweight/obesity is caused by the interactions of genetic, biological and environmental factors. The swift increase of the epidemic among the Chinese in such a brief period of time (25 years) suggests that environmental factors play a critical role, mediated by caloric intake (especially calorie-laden food), energy expenditure (especially physical activity) and lifestyle changes. Based on these factors (the root causes), we suggest some strategies for controlling childhood obesity below[26-28].

The first essential task is to set up a reasonable dietary regime, abiding by the principles of a "balanced diet" and cultivating healthy eating habits. Multiple sources of nutrients are necessary, based on the "child- and adolescent-specific dietary guidance", which refers to the "recommended daily dietary allowances for children and adolescents" established by the Chinese Nutrition Society[29]. Meals should consist approximately of 12%-14% protein, 25%-30% fat, and 55%-65% carbohydrates. Young people should be encouraged to return to traditional ingredients, recipes and menus; fresh fruits and vegetables should be reintroduced into the diet; and each day should begin with a nutritious breakfast[30]. A systematic weight-control program for the obese should be followed; to ensure normal growth, the total calories consumed must be reduced, they must have a daily portion of protein, and vitamins and minerals must be included. Crash diets or losing weight using riskier methods (i.e., laxatives to induce diarrhea) are discouraged[31].

The above strategy increases the nutritional knowledge among parents with different SES backgrounds and encourages them to help their children establish healthy dietary habits: a) to limit their intake of Western-style snacks and soft drinks and avoid high-fat, high-sugar and other high-calorie fast foods; b) to incorporate healthy habits into daily life, i.e., decrease the number of times they eat out, avoid snacking while watching TV or binge eating/drinking; and c) to reward and support their children's positive behavior and habits[32].

Another essential task is to encourage all students to make physical activity a required part of their daily lives. Absence of physical activity has been widely recognized as one of the root causes of the obesity epidemic[33]. According to Arnett's health risk behavior theory, the absence of physical exertion combined with sedentary habits constitutes a major component of adolescent health risk behaviors, and has become a global health and social threat[34]. The 2005 National Youth Risk Behavior Surveillance (NYRBS) in China demonstrated a significant trend of decreasing physical activities among the upper-level students during the previous 12 months: 6.6% of junior high and 11.2% of senior high school students did not take part in any physical education classes; 3.3% of students only had sufficient, intense physical exertion fewer than 3 days a week; 50.2% of students had fewer than 3 days of outdoor physical exercise, and 12.5% of students did not participate in any kind of outdoor physical activities[35]. It was roughly estimated that during the period of 1990-2005, energy expenditure among Chinese adolescents declined by 42% (males) and 28% (females)[36]. These statistics caused a great deal of concern among government leaders, prompting them to create a series of policies promoting physical activity. According to these policies, the following strategies will strengthen three targeted areas. First, as a rule, students should participate in their school's physical education classes and outside exercise for at least 60 min per day. Several appealing in-class exercises, such as the "Happy 10 Minutes", should be used in all primary schools[37]. Each individual should be encouraged to join a school sports program, perform mid-intensity muscle exercises, stretch and tone muscles or play ball games 20-40 min per day. Second, equal emphasis should be placed on daily participation in both outside-school physical activities and in-school physical exercise. For example, engaging in household chores such as cleaning one's room, washing dishes and sweeping floors, among others, can contribute to weight control by increasing energy expenditure. Students should also be encouraged to walk to and from school as well as up and down stairs. Li et al. proved a positive correlation between a healthy BMI and commuting on foot, versus using either public or private motorized transport[38]. In contrast, consuming more

high-fat and high-sugar snacks accompanied by a shift from walking or bicycling to motorized transportation results in an increase in calories retained. Third, the policies call for the creation of incentives for obese students to regularly engage in aerobic exercise such as riding bicycles, walking, climbing hills, swimming or dancing. Measures such as the amount of time spent, physical abilities, strengths and levels of intensity of the exercise routines should be specially designed based on an individual's situation and health conditions and should be supervised by an instructor. To ensure the successful achievement of these goals, several supportive measures should be taken: a) the parents should be fully motivated to provide their children with effective support; b) schools should try their best to create suitable playing fields, apparatuses and exercise equipment; c) the students should learn from school health education to master the life skills that enable them to resist enticing but harmful eating and social habits; d) a safe environment should be provided for various kinds of physical activities[39]. Nevertheless, decreasing sedentary lifestyles is the most important element in decreasing epidemics of overweight and obesity.

The aim of our third strategy is to help rural students prevent obesity by improving their immediate environments. The objectives of intervention can be divided into two aspects of regional urbanization**.** In this survey, many students in Group V who emigrated from rural to urban areas seem to have fallen into an "obesogenic environment"[40]. Characterized by the availability of a new range of foods, a vast offering of electronic gadgets and an increase in car ownership. The rapid pace of economic change over the past 25 years has transformed most of these once-rural areas into cities that mirror urban ones in many respects, from increases in income to unprecedented health problems, chiefly overweight and obesity. The emigration is accompanied by a decline in physical activity, since the high-rise apartments reserved for these newcomers are nearly devoid of attractive outdoor spaces where families might feel inclined to stroll together in agreeable and safe surroundings, or where young people could engage in organized sports[41]. Children and adolescents in such environments are more vulnerable than others to the shift from energetic to sedentary pastimes. Take the 2005 NYRBS as an example: in the previous 30 days, 34.3% of secondary school students spent ≥ 2 h/day (13.5% ≥ 4 h/d) watching TV; 21.2% of primary school students spent ≥ 2h/day (3.3% ≥ 4 h/day) playing electronic games; 25.6% of senior high students spent ≥ 2 h/day (5.5% ≥ 4 h/day) on the internet. The highly competitive upper-level and college-entrance examinations added to students' heavy workloads, especially for these new emigrants: 62.4% of the senior high students in grade 12 had to spend ≥ 3 h/day (20.7% ≥ 4-5 h/day) doing homework[35]. Clearly, the increase seen in Chinese young people's BMI levels can be directly correlated not only with a decrease in the average amount of physical, and by extension, outdoor activity, but with an increase in sedentary pursuits. Of special note are lifestyle changes evident in everything from transportation (commuting by car instead of on foot) to the workplace (desk jobs instead of manual labor).

Another significant feature in Group V is that many younger people have fallen into the habit of eating fast food from carryout shops or sidewalk stands. Since these dishes tend not only to have a high calorie count, but also to be served in larger portions than dishes prepared at home, it is not surprising that these new eating habits are correlated with excess weight[42]. In addition to the educational campaigns, many other measures should be taken to improve these conditions. For example, establish more public areas for physical exercise, so that younger generations can enjoy the same benefits as more experienced athletes and improve suburban roads to help young people return to active lives out in nature. Many efforts must also be focused on improving living conditions in rural areas. It is well known that not only does an urban-rural disparity exist in China, but also this disparity is not a clear-cut one because rural areas are undergoing urbanization in a piecemeal way, and thus no longer constitute a uniform economic stratum. China's rapid urbanization rate does not mean that its vast rural regions have disappeared, but that different regions are burdened by distinctive problems. It is vital that any program designed to prevent the obesity epidemic should be tailored to the specific strengths, weaknesses, needs and capacities of the region in question, and consider not only environmental constraints but also existing societal institutions, chiefly the family and the educational system. Therefore, comprehensive measures are needed to improve the situation. The first is to combine efforts to control obesity and decrease protein-energy malnutrition and iron-deficient anemia. The main problem today among China's underdeveloped rural populations

such as that of Group VIII, for whom the SES is lowest, is no longer that of going hungry, but rather a paradoxical sort of malnutrition that thrives on ignorance as well as poverty. In other words, obesity and malnutrition co-exist. For this reason, developing and executing intervention programs to prevent and manage obesity in these rural areas first requires identifying the area-specific nutrition status[43]. Second, nutrition education programs should be launched to counteract, at least, the effects of the mass media's commercial campaigns promoting the consumption of high-fat, high-calorie fast foods and soft drinks. Third, communities and schools have a duty to supply health services and consultations on the early prevention of overweight and obesity. School nurses should be encouraged to screen for overweight/obesity, set up datasets for borderline cases and predict whether an individual has fallen into the obesogenic category by appraising his/her health risk behaviors. Fourth, begin early prevention of childhood obesity from the start, that is, by ensuring reasonable nutrition during a mother's pregnancy, insisting on six months of breast feeding, as well as adding supplementary foods after an appropriate weaning time[32]. To reduce the early potential of childhood obesity, the institutes of maternal-child care in the rural areas should play an important role in preventing and treating growth-delayed fetuses, low birth-weight newborns, and stunted infants[44].

There are some limitations in this study. First, its cross-sectional design does not permit the establishment of a causal relationship between independent variables and overweight/obesity. Second, because BMI does not distinguish between fat and fat-free mass, there is a risk that reliance on this index may lead to a false attribution of overweight in the case of large-boned, normal-weight adolescents. Third, the study is based on a dataset that does not account for environmental variables at the individual level - a deficiency common to all such datasets. However, this study, with its nationally representative and broad sample size, advocates formulating the above evidence-based strategies and measures to prevent childhood obesity. The chief finding-overweight and obese rates among Chinese young persons (9.9% and 5.1%, including the rural regions)-is alarming and the prognosis is worrisome. We suggest a model to control childhood obesity, and the only way to combat this epidemic is to immediately address it on the described behavior-modification fronts. We maintain that investments promoting school health and infrastructure designed to halt and then reverse the trend from physically active to sedentary pastimes are the most effective weapons available to policymakers.

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